

ADDIS ABABA UNIVERSITY



**GROWTH AND YIELD PERFORMANCE OF BREAD WHEAT
(*Triticumaestivium* L.) GROWN IN VERTISOL AND NITOSOL IN
GOZAMIN WEREDA, NORTH WESTERN ETHIOPIA**

BY

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Addis Ababa University, Department of Zoological sciences

Addis Ababa, Ethiopia

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GRADUATE PROGRAMMES

DECLARATION

This is to certify that the thesis prepared by Zebider Tibebe, entitled: Growth and yield performance of bread wheat (*Triticum aestivum* L.) grown in vertisol and nitosol and submitted in fulfillment of the requirements for the degree of Master of Science in Biology complies with the regulations of the University and meets the accepted standards with respect to originality and quality

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Growth and Yield performance of bread wheat (*Triticum aestivum* L.) grown in vertisol and nitosol in Gozamin wereda, north western Ethiopia

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ABSTRACT

Wheat (*Triticum aestivum* L.) is one of the most important food grain sources of the livelihood farmers of the Gozamin Wereda in North-Western Ethiopia. However, the productivity of the crop is markedly low due to low soil fertility and associated low soil nutrient availability, especially nitrogen and phosphorous. Reduced plant nitrogen use efficiency, erratic seasonal rainfalls, as well as inadequate fertilizer management practices have also contributed to the low productivity of wheat in the region. The present study designed pot experiment in which 100 plastic sleeves (depth 14 cm; diameter 10 cm) were filled with each of the field collected nitosol and vertisol. The experiments were conducted at Yemeka (Gozamin) in north western Ethiopia during October 28/2016 to March 5/2017 .The pots lay as a completely randomized design. Sow bread wheat seed, watering was performed every one day interval and growth performances of the plant were followed by measuring plant height, number of leaves, tiller, spike length, seed, grain yield (g) per plant, as well as biomass determination on randomly sampled plants. The results demonstrates that number of leaves, tillers, kernels, mass of grain yield, were highly significant ($P<0.05$) affected in vertisol and nitosol. For example mean height of plant in vertisol 32cm and in nitosol 25.4cm, mean number of leaves in vertisol 17 and in nitosol 11, effective tillers in vertisol 4 and in nitosol 1.5, kernel per plant in vertisol 152 and in nitosol 66.5. Based on this result vegetative growth and yield performances of bread wheat were higher in vertisol than nitosol. These results were analyzed and evaluated in light of providing the local farmers with requisite options and confidence for choice of soil type. Farmer sows bread wheat and use adequate fertilizer on vertisol to get more yield than nitosol. Based on the results, we conclude that sowing bread wheat in vertisol can provide more yield, compared to nitosol.

Key words:-Biomass, Grain yield, hexaploid wheat, pot experiments, vegetative growth, Gozamin wereda,

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List of Abbreviations

ANRS BoA	Amhara National Regional State Bureau of Agriculture
BY	Biomass yield
CEC	Cation Exchange Capacity
CSA	Central Statistical Authority
EAAPP	East African Agricultural Productivity Program
FAO	Food and Agricultural Organization of the United Nations
GY	Grain yield
KNO	kernel number
GWARDO.	Gozamin Wereda Agricultural and Rural Developmental Office.
KW	kernel Weight
masl	meters above sea level.
SNNPR	Southern National Nationality and People Region

1. INTRODUCTION

1.1 Back Ground of the Study

Bread wheat (*Triticum aestivum* L.) is one of the most important cereal crops globally and is a staple food for about one third of the world's population (Hussain and Shah, 2002). According to the FAO, 2005 report, about 620 million metric tons of wheat was produced from 217 million hectares in the year 2005/06 with an average yield of 2.85 metric tons per hectare. Wheat is grown on larger area than any other crop and its world trade is greater than for all other crops combined.

Wheat is one of the most important cereal crops in Ethiopia widely cultivated in wide range of altitudes. The crop is grown at an altitude ranging from 1500 to 3000 meters above sea level (masl), and between 6-16° N latitude and 35- 42 °E longitude. The most suitable agro- ecological zones, however, fall between 1900 and 2700 masl (Bekele Hunde, *et al.*, 2000). Rain fall distribution is bimodal and ranges between 600 and 2000 mm/annum. The rainy season is divided into the short rains (belg) falling from February to April and the main rains (meher) falling from June to September. At present, wheat is produced solely under rain fed conditions. Currently, about 60% of the wheat area is covered by durum and 40% by bread wheat (Hailu Gebre-mariam, 1991). The major wheat producing areas in Ethiopia are located in Arsi Bale, Shewa, Ilubabor, Western Hareghe, Sidamo, Tigray, Northern Gonder and Gojam zones (Bekele Hunde *et al.*, 2000).

Wheat is grown annually on 1.61 million hectare of land in Ethiopia with a total production of 3.92 million tons with on average productivity of 2.4 t ha⁻¹ which makes the country the largest wheat producers in sub Saharan Africa (CSA, 2014) Wheat provides more protein than any other cereal crops and it is a major source of energy and protein for population inhabiting most highlands in Ethiopia (Abera Bekele, 1991). Furthermore, wheat has been selected as one of the target crops in the strategic goal of attaining national food self-sufficiency, income generation, poverty alleviation and achieving socio- economic growth of the country.

Amhara National Regional State is one of the major wheat producing areas in Ethiopia. The total wheat area and production in the Amhara region was 529609.63 hectares and 1195823.25 tons respectively with the average productivity of 2.3 t/ha (CSA, 2015). Similarly, north- western Ethiopia in general and Gojjam .In particular are among the most

important wheat growing areas of the country (Yeshanew Ashagrie and Asgelil Dibaba,1999) and are considered as a high potential area for expansion of production of the crop.

Gozamin district is one of the areas in the North-western Amhara region, in Eastern Gojjam Zone, where wheat is widely cultivated as a dominant crop. However, the productivity of the crop has been consistently much lower than its potential production in the area is generally constrained by both biotic and abiotic factors such as low soil fertility, especially nitrogen and Phosphorus deficiency and low nitrogen use efficiency and use of inadequate fertilizer management practices. Low soil fertility is considered the most important constraints limiting wheat production in the Ethiopian highlands (Teklu Erkossa and Hailemariam Teklewold, 2009).Soil organic matter and nutrient depletion as a result of severe soil erosion, continuous cereal mono cropping, and absence of the practice of returning crop residues and manures into the soil have resulted in poor soil fertility status in north western Ethiopian highland (Tesfaye Zegeye *et.al* 2003).

Vertisols (Black soils) and nitosol (red soils) are important to Ethiopian agriculture especially in crop production. Vertisols account for 24% of all highland soils that are cropped, but their high yield potential has not been realized .production constraints are related to the physical properties of vertisol and their moisture regime. Rain fed crops such as teff, durum wheat, chickpea, lentils, linseed, Niger and bread wheat are generally grown on these soils. Wheat is the major crop producing in the study area. Hence, it is important to determine and compare the production potential of vertisol and nitosol on the growth and maximum yield performance of wheat plant. However, limited research has been done to evaluate and compare the effects of vertisol and nitosol on the growth, yield and yield components of wheat plant in the study area.

1.2 Statements of the Problem

The productivity of wheat studies on the topic effect of mineral fertilizer and organic fertilizers on the productivity and nitrogen use of efficiency of bread (*Triticum aestivum* L.) grown in nitosol. By Mulatu Kassaye in 2015, and the result was Increasing the rate of nitrogen application markedly increased the growth, yield, and yield components of the bread wheat in nitosol. However this study understood about only on nitosol increase bread wheat productivity but not indicate the productivity of bread wheat on vertisol as well as comparing of these soil types. Therefore this study was carried out to see the growth and yield performance of bread wheat on two soil types (nitosol and vertisol).

1.3. Research Questions

The questions to answer were:-

1. In which soil type (vertisol or nitosol) the bread wheat plant seedling growth first?
2. Are there significance differences on growth and yield performance of bread wheat in the two soil types (vertisol or nitosol)?
3. Is there a difference on the biomass of bread wheat which growth on vertisol and nitosol?
4. What is the bread wheat yield related to physio-chemical properties of the two soil types (vertisol or nitosol)?

2. RESEARCH OBJECTIVES

2.1. General Objective

The general objective of this study was to compare vegetative growth and yield performances of bread wheat (*Triticum aestivum* L.) plants grown in vertisol and nitosol.

2.2. Specific Objectives

The specific objectives of the study were:-

- To see in which soil type (vertisol or nitosol) first bread wheat plant seedling growth.
- To measure the vegetative growth and yield performance of bread wheat plant grown in vertisol and nitosol.
- To compare the biomass of bread wheat plants grown in vertisol and nitosol.
- To analyze contextual result of yield performance in bread wheat relation to the physico-chemical properties of vertisol and nitosol.

3. LITRATURE REVIEW

3.1. Taxonomy and Distribution of Bread Wheat.

3.1.1. Taxonomy of Bread Wheat

There are fifteen recognized species within the genus *Triticum*. About 90% of the world's wheat production consists of three species: *Triticum aestivum* L. (common wheat), *Triticum compactum* (club wheat) and *Triticum durum* (durum or macaroni wheat). Wheat belongs to the genus *Triticum* and the tribe *Triticeae* of the family Poaceae (Gramineae)(Abebe Tirunch, *et al*, 2015)).Bread wheat evolved from wild grasses found in the Eastern Mediterranean and Near East regions (MacKay, 1966). The species of the genus *Triticum* and their close relatives can be divided into diploid, tetraploid and hexaploid groups, with chromosome numbers of $2n = 14$, 28 and 42 respectively, in which the basic chromosome number is $x = 7$. The wild species are diploids ($2n = 2x = 14$). The most common cultivated wheat (bread wheat) now a day is hexaploid, *Triticum aestivum*, AABBDD, ($2n = 6X = 42$) (Zohary, 1970).

3.1.2 Distribution of Bread Wheat

Wheat belongs to the genus *Triticum* and the tribe *Triticeae* of the family Poaceae (Gramineae) (Mackay, 1966)) and it evolved from wild grasses found in the Eastern Mediterranean and Near East regions. Bread wheat is cultivated in every continent except Antarctica. It is grown at a wide elevation range from 260 m below sea level in the Jordan Valley up to 4,000 m on the Tibetan plateau. Although it is possible to grow bread wheat in a wide variety of soil types and climates, it is generally more successful in dry to sub-humid areas with a seasonal annual rainfall of 250–750 mm, (Oklahoma State University, 2013).

Bread wheat was probably domesticated around 10,000 to 15,000 B.C. in the bordered areas of the countries known as Iran, Iraq, Syria, and Turkey; a mountainous hilly region in the upper reaches of the Tigris and Euphrates drainage basin (Efrem,B ,*et.al*, 2000). Bread wheat includes the vast majority of genotypes, which show great diversity in agro-ecological adaptation and utilization (Gooding and Davies, 1997). Even though wheat is a crop of temperate regions, currently it is one of the most important cereals grown on a large scale in the tropical and sub-tropical regions of the world (Gooding and Davies, 1997). Algeria, Egypt, Ethiopia, Kenya, Morocco, South Africa and Tunisia are the major wheat producing countries in Africa (FAOSTAT, 2012).And Oromia, Amhara, Southern Nations Nationalities

and Peoples' Region (SNNPR) and Tigray regions are the major wheat producing areas in Ethiopia (CSA, 2013).

3.2. Agro Ecology of Bread Wheat

Wheat is a cool season temperate grain crop but widely adapted to varying climate conditions. Wheat production is concentrated between latitudes 30 °N and 60 °N and 27 °S and 40 °S (Nuttonson, 1955). The ideal daily temperature for different stage of wheat development varies from 20-25 °C for germination, 16-20 °C for good tillering, and 20-23 °C for proper plant development (Onwueme and Sinha, 1999). Subjecting a wheat plant to a high temperature (33- 40 °C) within a short day can markedly reduce the yield and quality of the crop (Randall and Moss, 1990). Wheat can be grown where annual precipitation is ranging from 250 to 1750 mm (Briggle and Curtis, 1987). About 75% of the wheat grown world-wide (receives an average rainfall between 375-875 mm annually. However, too much precipitation can lead to yield loss from diseases problems (Acevedo et al., 2002). Similarly, drought, environmental factors temperature, and water affects wheat growth, development and yield components, consequently, reduces grain yield (Moragues *et al.*, 2005). Wheat is produced across a wide range of soil conditions, although it is best adapted to the fertile well drained silt and clay loam soils (Onwueme and Sinha, 1999). Wheat grows under a wide range of soil pH, is considered medium acid tolerant with permissible ranges of 5.5-7.0 (Gooding and Davies, 1997). Wheat requires a good supply of nutrients especially nitrogen for its growth and yield. Nitrogen is one of the most important and expensive inputs in wheat production (Otteson *et al.*, 2008). Phosphorus was the second most essential element of crop production and it is deficient in most soils around the world to achieve maximum yields (Brady and Weil, 2002). Adequate phosphorus enhances many aspects of plant physiology like fundamental process of photosynthesis, flowering, seed formation and maturation (Salisbury and Ross, 1992).

3.3. Wheat Production in Ethiopia

Wheat is grown annually on 1.63 million ha of land in Ethiopia with a total production of 3.45 million tons which makes the country the largest wheat producer in sub-Saharan Africa (CSA, 2013). Wheat is identified as Ethiopia's strategic commodity and the East Africa. Agricultural Productivity Program (EAAPP) considered the country as a wheat centre of excellence (IDA, 2014). Most wheat producing areas in Ethiopia lie between 6° and 16° N latitude and 35° and 42° E longitudes at an altitude ranging from 1500 to 3000 meters

above sea level (masl). The most suitable areas, however, fall between 1900 and 2700 masl (Bekele Hunde, *et al.*, 2000). Wheat in Ethiopia is produced exclusively under rain-fed conditions with rain fall amount ranging from 600 mm to 2000 mm. Wheat is generally planted from June to September, and harvested from October to November. Currently, from the major wheat producing areas in Ethiopia Oromia region takes the lion's share accounting for 53.6% of the area coverage and 58.9% of the production, followed by Amhara region which accounts for 30.6% of the area coverage and 25.9% of the production, followed by SNNPR which accounts for 8.5% of the area coverage and 8.8% of the production and Tigray region which accounts for 6.9% of the area coverage and 5.9% of the production (CSA, 2013). It accounts for approximately 11 percent of the national calorie intake in the country (200kcal/day in urban areas /310kcal/day in rural areas). Despite the increased production, the demand for wheat exceeds the production. Consequently every year the country spends a huge amount of money for importing wheat to fill the gap. Wheat is the single most important staple crop imported from abroad and most of the humanitarian food aid and commercial import takes in the form of wheat (Demeke and Marcantonio, 2013).

3.4. Wheat Production in Gozamin Wereda

The average wheat productivity in Gozamin wereda (East Gojam zone) is estimated at 2.11 t ha⁻¹(CSA, 2013), which is much lower than the world average. In Gozamin wereda, wheat is a major crop produced by smallholder farmers. However, its productivity is far below the crop's potential mainly due to low soil fertility and other biotic and abiotic constraints. Soil erosion and the associated decline in soil fertility and organic matter depletion are major constraints to crop production in Gozamin (Mulatu Kassaye, 2015).). Low available soil nitrogen and low plant nitrogen use efficiency are some of the major constraints limiting wheat yield and protein content in Ethiopia (Haile et al., 2012). In addition, Lack of appropriate varieties and quality of seeds, rusts, mildew and other are major problems constraining the crop yield.

3.5. Importance of Bread Wheat

Wheat crop is one of the major cereals of choice in Ethiopia, dominating food habits and dietary practices, and is known to be a major source of energy and protein for the highland population of the country. Nutritionally, wheat provides an optimum amount of energy (339 kcal of energy), protein (10.3g), calcium (49 mg) and iron (1.5 mg)/100g of whole grain (Hoveland, 1980).Therefore wheat is an important source of both carbohydrate

and protein in human and livestock nutrition (Shewry, 2009). It has versatile uses in making various human foods, such as bread, biscuits, cakes, sandwich, etc. Wheat straw is an integral component of livestock feed and commonly used as a roof thatching material both in the rural and urban areas in Ethiopia (Gain, 2014).

3.6. Wheat Development

Organ differentiation defines the various stages of wheat development. Physiologically, the following stages are usually distinguished: germination, root development, leaf development, stem development, tillering, spike emergence, anthesis and, from anthesis to maturity. Physiological maturity is usually defined as the time when the flag leaf and spikes turn yellow (Hanft and Wych, 1982). The time-span of each development phase essentially depends on genotype, temperature, day-length and sowing date. Various environmental stresses, particularly heat but also water and salinity, may shorten the wheat growth phases.

3.6.1. Germination to Emergence

The water content required in the grain for wheat germination is 35 to 45 percent by weight (Evans *et al.*, 1975). Germination may occur between 4° and 37°C, optimal temperature being from 12° to 25°C. Seed size does not alter germination but affects growth, development and yield. Bigger seeds have several advantages when compared to smaller seeds, such as faster seedling growth, higher number of fertile tillers per plant and higher grain yield (Spilde, 1989).

When crop emergence occurs, the seed embryo has three to four leaf primordia and almost half of the leaf primordia are already initiated (Hay and Kirby, 1991). During germination, the seminal roots grow first, followed by the coleoptile, which protects the emergence of the first leaf. The length of the coleoptile limits sowing depth, and its length changes with genotype, increasing only slightly when seeds are sown deeper (Kirby, 1993).

3.6.2. Factors Affecting Wheat Seed Germination

Germination is the first and most critical process during propagation by means of seed. From a producer's perspective, successful seed germination and subsequent seedling establishment is seen as a first step towards economically feasible wheat production. Although initial input costs are linked to the acquisition of genetically sound seed, several other factors may also affect the process of germination. This process is complex and can be

affected at different stages by many interacting factors such as temperature, water availability, oxygen, light, substrate, maturity of the seed and physiological age of the seed.

3.6.2.1. Environmental Factors Affecting Seed in the Soil

The most important external factors include water, oxygen, suitable temperature, and sometimes light or darkness. Various plants require different variables for successful seed germination

Water

Water constitutes a basic requirement for germination. Mature seed are often extremely dry and need to absorb, through a process of imbibitions, a significant quantity of water, relative to the dry weight of the seed. Generally, the minimum water content required in the grain for wheat germination was 35% to 45% by weight.(Evans *et al.*, 1975).

However, seed may germinate in soil with low moisture content and the initial stages may even proceed, but such conditions are usually not conducive in allowing the seed to perform at its full genetic potential. Conversely, germination is generally impeded by excess moisture mainly due to a restriction of oxygen availability. When seed imbibes water, enzymes are activated which break down stored food reserves in the seed into metabolically useful chemicals

Gaseous Environment

Air is composed of around 20% oxygen, 0,03% carbon dioxide and 80% nitrogen, and the seed of most plant species germinate well in an environment providing this mixture of gases. Oxygen is required by the germinating seed for aerobic respiration, the main source of the seedling's energy until it grows leaves, which will enable photosynthesis (Acevedo, *et.al*, 2002).

Temperature

Soil temperature plays a significant role in the rate at which germination proceeds. Although germination may occur between 4°C and 37°C, optimal temperatures range from 12°C to 25°C. The rate of water absorption or imbibitions, the diffusion of respiratory gases and the rate of chemical reactions involved in the metabolism of the seed are all affected by temperature (Don, R. 2009).

3.6.3. Vegetative Growth

3.6.3.1 Root Development

One or more nodes may develop below the soil surface depending on the depth of sowing; each bearing roots (Hadjichristodoulou *et al.* 1977). Root axes are produced at predictable times in relation to shoot development, and the total number of roots formed is associated with the number of leaves on a tiller (flowering stem) and the degree of tillering (Klepper *et.al.* 1984). A mature wheat plant has two distinct root types. The seminal roots develop from the root primordia contained within the grain and are the first root type to emerge and the nodal roots emerge at the same time that tiller development starts (Kirby 2002). The relationship between root growth and plant height has been debated. Some have stated that root growth of a genotype is proportional to its top growth (Kirby, 2002) Crops obtain nutrients and water from the soil through their roots. Roots of plants normally continue to grow as long as soil conditions such as moisture, air, nutrients, temperature, and soluble salts are favorable.

3.6.3.2. Leaf Development

After germination the vegetative shoot apex initiates additional leaf primordia. Leaves are produced on alternate sides of the stem (Setter & Carlton 2000b). The final leaf before the ear is called the flag leaf. The number of leaf primordia can vary from 7 to 15 (Kirby & Appleyard, 1983) and is affected by genotype, temperature, light intensity, and nutritional status of the plant. Temperature has a major influence on leaf appearance and extension. The minimum temperature for leaf extension is approximately 0°C, the optimum 28°C and the maximum greater than 38°C (Kirby & Appleyard 1983).

3.6.3.3. Stem Development

Stem elongation coincides with the growth of leaves, tillers, roots and the inflorescence (Patrick 1972). Elongation of the stem begins when most florets on the developing spike have initiated stamen primordia, which corresponds closely to the formation of the terminal spikelet. The mature wheat plant consists of a central stem from which leaves emerge at opposite sides. It is made up of repeating segments, called phytomers, which contain a node, a hollow inter node, a leaf and a tiller bud found in the axils of the leaf (Kirby 2002). The leaf sheath wraps around the stem providing support to the shoot (Setter & Carlton 2000b). The stem terminates in the ear of the wheat plant. The height of the wheat plant ranges from 30-150 cm and is determined by the genotype and the growing conditions.

Differences in plant height are mostly attributable to variation in inter node length rather than inter node number (Austin & Jones 1975).

3.6.3.4. Tillers Development

The first tillers to emerge are those formed between the axils of the coleoptile and the first true leaf. In general, three phyllochrons (the interval between two successive leaves) separate the emergence of a leaf and its subtended tiller (phyllochron) is the interval between two successive leaves; (Kirby & Appleyard 1983). Tillers are lateral branches which are produced off the main stem of the wheat plant (Kirby 2002). They produce leaves on opposite sides of their central stem in the same manner as the leaves of the main stem are produced and are also able to produce an ear at their terminal (Setter & Carlton 2000b). Not all tillers will survive and produce an ear and this is thought to be due to competition for light and nutrients (Kirby 2002).

3.6.4. Reproductive Morphology

3.6.4.1. Spike Growth

Once the terminal spikelet is formed, stem elongation starts and the spike begins to grow. Spike growth occurs from the appearance of the leaf prior to the flag leaf up to ten days past anthesis (Kirby and Appleyard, 1984). Spike growth, slow in its early stages, increases greatly about the time the ligules of the flag leaf becomes visible (Krumm, *et. al.*, 1990)). In the wheat crop, there is a close relation between the number of kernels per unit area and the ratio between incoming radiations to the mean temperature above 4.5°C (Fischer, 1985a). Higher radiation increases the amount of photosynthesis available for spike growth, and lower temperatures prolong the period of spikelet growth and decrease competition for carbohydrates.

3.6.4.2. Anthesis to Physiological Maturity

The wheat spike contains only one spikelet per rachis node. Each spikelet has between three and six potentially fertile florets (Kirby and Appleyard, 1984), which are self-pollinated in 96 percent of the cases (Martinet *al.*, 1976). Anthesis begins in the central part of the spike and continues towards the basal and apical parts during a three to five day period (Peterson, 1965). The proximal florets of the central spikelet are fertilized two to four days earlier than the distal florets. After floret fertilization, cellular division is rapid, during which the endosperm cells and amyloplasts are formed. This period is known as the lag phase and lasts for about 20 to 30 percent of the grain filling period, there is a phase of cell growth, and

differentiation and starch deposition in the endosperm, which corresponds to linear grain growth and takes from 50 to 70 percent of the grain filling period. The embryo is formed at the time of endosperm growth (Jones, *et al.*, 1985).

3.6.4.3. Seed Development

The rate of endosperm cell division is influenced by light intensity, water stress, temperature and genotype (Brocklehurst *et al.* 1978). Starch deposition begins 1-2 weeks after anthesis and initiates a 2-4 week period of linear increase in kernel dry weight. This process is also influenced by water stress, temperature and genotype (The kernels formed in central spikelet and proximal florets within an individual spikelet are usually largest (Simmons & Crookston 1979). Each wheat ear can produce approximately 30 to 50 kernels while the number of ears a wheat plant produces depends on the number of tillers produced and the number of tillers that produce a mature ear (Setter & Carlton 2000b).

3.7. Potential Yield

Yield potential, defined as the yield of an adapted genotype grown under optimal management and in the absence of biotic and abiotic stresses, has been found to be a very useful concept since progress in yield potential usually leads to progress in wheat yield in farmers' fields, particularly if stresses are mild. The yield of a wheat crop can be expressed as the product of two components, such that:

$GY = KNO * KW$, Where: GY is grain yield (g/plant);

KNO is the kernel number (plant^{-1}); and KW is the kernel weight (g)/plant. It follows from equation that changes in wheat yield potential could be achieved through changes in KNO and/or KW. Strong associations with yield have been found with KNO for sets of wheat genotypes (Slafer, *et al.*, 1996). KNO is established in the period between 20 and 30 days before flowering and ten days after anthesis. This period coincides with tiller and floret mortality, along with the active growth of the stem (peduncle) and spike.

3.8. Soil Types

3.8.1. Nitosol (Red Soil)

Nitosol is a type of soil that develops in a warm, temperate, moist climate under deciduous or mixed forests and that have thin organic and organic mineral layers over laying a yellowish-brown leached layer resting on an alluvial red layer. Nitosol generally derived from

crystalline rock. They are usually poor growing soils, low in nutrients and humus and difficult to cultivate because of its low water holding capacity. Nitosol is red because of the presence of a particular chemical compound present in them. The mineral iron (chemically represented as Fe) can form two distinct oxides upon reaction with oxygen: ferrous oxide (FeO , one atom of Fe, one of oxygen) and ferric oxide (2 atoms of Fe and 3 of oxygen). Red soil is rich in the purple reddish ferric (Fe_2O_3) oxide. (https://en.wikipedia.org/wiki/Red_soil).

3.8.1.1. Characteristics of Nitosol

Physical Properties of Nitosol

The texture of red soils varies from sand to clay, the majority being loam. Their other characteristics include porous and friable structure, absence of lime and free carbonates, and small quantity of soluble salts. Nitosol has low-water holding capacity and difficult to cultivate because of its poor physical conditions. There for the productivity of red soil are low under natural conditions.

Chemical Property of Nitosol

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Nitosol are rich in iron, aluminum (hydr) oxide with strong fixation capacity of phosphate, poor nutrient availability are the main yield -limiting factors for the red soil. According to the results second national soil censuses data; the soil fertility of major red soil was moderate or poor. They are acidic (low PH) mainly due to the nature of the parent rocks. The alkali content is fair. They are poor in lime, magnesia, phosphates, nitrogen and humus. They are fairly rich in potash and potassium.

3.8.2. Vertisol (Black Soil)

Vertisol typically form from highly basic rocks, such as basalt, in climates that are seasonally humid or subject to erratic droughts and floods, or that impeded drainage. Depending on the parent material and the climate, they can range from grey or red to the more familiar deep black. Vertisol is a soil in which there is a high content of expansive clay

known as montmorillonite that forms deep cracks in drier seasons or years. Alternate shrinking and swelling causes self-mulching; where the soil material consistently mixes itself (<http://en.wikipedia.org/wiki/Black>)

The black color is attributed to the presence of titaniferous magnetite, compounds of iron and aluminum, accumulated humus and colloidal hydrated double iron and aluminum silicate. Vertisol are highly retentive of moisture, extremely compact and tenacious when wet, considerably contracted developing deep wide cracks on drying and self ploughing. Vertisol are credited with high fertility. The high clay content of the vertisol is responsible for their heavy water logging in highland areas with abundant rainfall and relatively low evaporation rates. This imposes severe restrictions on the traditional agricultural use of these soils and only 25 percent are currently cropped, mainly using residual moisture. Much of this land is left fallow and subject to erosion during the heavy rains. Evidence suggests there would be substantial increases in crop yields on vertisol if excess surface soil water were drained off and if appropriate cropping practices were used. It is found in Gojjam, Shewa, Arusi, Bale and Central Hararge.

3.8.2.1. Characteristics of Vertisol

Physical Properties of Vertisol

Texture of vertisol in Ethiopia generally contains more than 40% clay in the surface horizons and close to 75% in the middle part of the profiles. The sand fraction is low, often less than 20%, and is found in the bottom and the surface (plough layer) horizons. In the highland vertisol where soil burning is practiced, the sand fraction is normally high in the surface horizon because the clay bakes into sand-size particles

Bulk density of Ethiopian vertisol are available, it is not possible to characterize bulk densities of very widely distributed vertisol. Reports from elsewhere show that vertisol bulk density is usually high, 1.5-1.8 g cm⁻³, and may reach 2.05-2.1 g cm⁻³ (Murthy *et al*, 1982). These variations in bulk density are caused by swelling and shrinking with changes in soil moisture content. The soils have high bulk density when dry and low density when wet (Virmani *et al*, 1982).

Available water in vertisol has a relatively high water storage capacity in the root zone because of their depth and high clay content. The available water range has been reported as 110-250 mm for the top 1 m of the soil profile (Virmani *et al*, 1982). The high

water-storage capacity of vertisol is important in regions with uncertain rainfall. The growing season on deep vertisol is usually longer than on other soils; on the highland vertisol, wheat, lentil, chickpea and vetch grow to maturity entirely on residual soil moisture after establishment at the end of the rainy season.

Chemical Property of Vertisol

In the soil profile, the vertisol pH ranging is between 7.5 and 8.5. The dark color of vertisol was earlier suspected to be indicator of high organic matter contents. According to (Dudal, 1965), the content of organic matter varies from 0.5-2.0 in most of the African vertisol, Cation exchange capacity (CEC). Because of the usual dominance of 2:1 type clay minerals in the 2Nm particles size fraction vertisol are best with higher CEC.

3.9. Soil pH

pH: Soil pH is a measure of soil acidity or alkalinity. It is an important indicator of soil health. Soil pH has significant adverse effects on the availability of plant nutrients. Soil pH can be managed by measures such as applying the proper amount of nitrogen fertilizer, liming, and cropping practices that improve soil organic matter and overall soil health. Wheat grows best when the soil pH is between 6.0 and 7.0. Growing wheat at pH below 6.0 often results in magnesium (Mg) deficiency, slower mineralization of organic nitrogen (N), reduced availability of phosphorous (P), and increase the possibility of aluminum (Al) and manganese (Mn) toxicity. When wheat is grown on soil above a pH of 7.0, Mn deficiency may occur. Wheat land should be limited to a pH of 6.5-7. Soil pH levels that are too high or too low lead to deficiency of many nutrients, decline in microbial activity, decrease in crop yield, and deterioration of soil health (USDA).

3.10. Soil Nutrient

Nitrogen: Nitrogen is an essential element required for successful plant growth. It is one of the primary nutrients that plants need to produce proteins, DNA, RNA and chlorophyll. The most important role of N in the plant is its presence in the structure of protein, the most important building substances of living material or protoplasm of every cell is made. In addition, nitrogen is also found in chlorophyll, the green coloring matter of leaves. Chlorophyll enables the plant to transfer energy from sunlight by photosynthesis. Therefore, the nitrogen supply to the plant will influence the amount of protein, protoplasm and chlorophyll formed. In turn, this influences cell size and leaf area, and photosynthetic

activity. Plants need nitrogen to develop large, deep green leaves and strong stem growth and Plants grown with an adequate supply of nitrogen make rapid and thrifty growth of leaf and stem development is stimulated. Because plants require large amounts of nitrogen for healthy growth, it is called a macronutrient.

From all metabolic elements which plants use from soil, nitrogen needs in the largest amounts (Tucker, 2004). Nitrogen exists in organic and inorganic form and the greatest nitrogen content is in seeds, leaves, shoots and roots. Deficiency of nitrogen leads to loss green color in the leaves, decrease leaf area and intensity of photosynthesis. Leaves exhibit a structural and functional acclimation of the photosynthetic apparatus to the light intensity experienced during their growth (Prioul *et al.*, 1980). Nitrogen supply has large effect on leaf growth.. Nitrogen supply has large effect on leaf growth because it increases the leaf area of plants and, on that way, it influences on photosynthesis. Photosynthetic proteins represent a large proportion to total leaf N (Evans, 1989 ;). Chlorophyll content is approximately proportional to leaf nitrogen content, too (Evans, 1983). N caused enormous increase in the biomass and grain yield of wheat (Mojid, *et.al.*2010). The relationship between N and biomass accumulation in crops, relies on the reciprocal regulation of multiple crop physiological process. Therefore, N uptake and distribution in plant and crops involves many aspects of growth and development. The spike length of wheat became higher in response to the application of higher doses of nitrogen (Laghari, *et al.* 2010). However, the largest amounts are taken up during early stages of growth, held for later use and translocated within the plant where needed, for example, to the kernels from the leaves and stem during maturation. Nitrogen uptake significantly enhanced straw yield in wheat since N usually promotes the vegetative growth of the plant (Tarekegn Assefa *et al.* 2000).Nitrogen is usually the most limiting nutrient for wheat production. An inadequate N supply can greatly reduce yield and profit. Too much N can result in lodging, decreased yield and reduced profits. The bread wheat differed significantly in plant height across the nitrogen levels (Mulatu Kassaye).Determining the optimum rate of N fertilizer is the key to maximum economic yields.

Deficiency of nitrogen: The most easily observed symptom of nitrogen deficiency is the yellowing (chlorosis) of leaves due to a drop in chlorophyll content. This symptom is usually noticed first in the more mature leaves, and last in the upper actively growing leaves, because the N is translocated from older to new leaves to sustain growth. Thus, the older

leaves will wither and result in poor plant growth and yield reduction. Generally growth is slowed, stunted and firing of the leaf tips and margins is evident.

Phosphorus: Phosphorus is also macronutrient that plays a number of important roles in plants. It is a component of nucleic acids, so it plays a vital role in plant next to nitrogen, is often the most limiting nutrient for crop and forage production. Phosphorus' primary role in a plant is to store and transfer energy produced by photosynthesis for use in growth and reproductive processes, of which grain production is an important result. It is also critical in biological energy transfer processes that are vital for life and growth. Adequate phosphorus results in higher grain production, improved crop quality, greater stalk strength, increased root growth, and earlier crop maturity. Within a plant, it is present mainly as a structural component of the nucleic acids: deoxyribonucleic acid (DNA) and ribonucleic acid (RNA), as well as a constituent of fatty phospholipids that are important in membrane development and function. (<https://en.wikipedia.org/wiki/Phosphorus>)

Wheat takes up Phosphorous throughout the growing season. Phosphorus nutrition is critical to reaching the attainable yield potential of wheat. Early in the growing season, the wheat plant is dependent on sufficient phosphorus to establish tillers to build high yield. Maintaining adequate supplies throughout the soil ensures phosphorus is sufficient to meet plant needs during the entire season. Banding P_2O_5 near the seed at planting provides ready access to phosphorus supplies during early season growth, and is practiced in the hard wheat production regions. (<http://www.ppi-ppic.org/pwheat>) Adequate phosphorus enhances many aspects of plant physiology like fundamental process of photosynthesis, flowering, seed formation and maturation (Salisbury and Ross, 1992).) Reported that phosphorous availability influences the ability of wheat to differentiate and grow leaves and tillers thereby increasing spike population effective tillers (Valle and Calderini, 2010). Increased shoots dry matter yields of wheat in response to increased phosphorous application (Fageria and Baligar, 1999). Bread wheat differed significantly in phosphorus utilization efficiency and required different rates of phosphorus fertilizer for optimum growth and yields.

Deficiency symptoms of phosphorous: Because Phosphorus is needed in large quantities during the early stages of cell division, the initial overall symptom is slow, weak, and stunted plant growth. Phosphorus is relatively mobile in plants and can be transferred to sites of new growth, causing symptoms of dark to blue-green coloration to appear on older leaves of some plants. Under severe deficiency, purpling of leaves and stems may appear.

Potassium: Potassium is vital to many plant processes. A review of its role involves understanding the basic biochemical and physiological systems of plants. While K does not become a part of the chemical structure of plants, it plays many important regulatory roles in development. Its essentiality is proven in its multiple roles in assisting and facilitating plant processes. It mainly functions like a conveyor of electrical charge in the plant cell and acts as catalysts for many of the enzymatic processes in the plant that are necessary for plant processes. Potassium (K) increases crop yield and improves quality. It is required for numerous plant growth processes.

Potassium increase crop yields by: Increases root growth and improves drought resistance, Activates many enzyme systems, Maintains turgor; reduces water loss and wilting, Aids in photosynthesis and food formation, Reduces respiration to preventing energy losses, Enhances translocation of sugars and starch, Produces grain rich in starch, Increases protein content of plants, Builds cellulose and reduces lodging and Helps retard crop diseases. Potassium that is dissolved in soil water (water soluble) plus that held on the exchange sites on clay particles (exchangeable K) is considered readily available for plant growth. The exchange sites are found on the surface of clay particles. This is the form of K measured by the routine soil testing procedure. The K attached to the exchange sites on the clay minerals is more readily available for plant growth (Kalavati, *et. al.*2012).

Sodium: Sodium is found in all soils and crops. Sodium is present as a monovalent cation (Na^+) and is loosely held by the cation exchange complex in soil. Therefore, Na^+ is easily leached by water moving through the soil profile by rainfall or irrigation. Sodium (Na^+) can be beneficial to plants in many conditions, particularly when potassium (K^+) is deficient. Sodium transport in plant had largely been studied in the context of salinity stress. There is little biological relevance in the study of Na, as a limiting micronutrient because it is an abundant element in soils and soil-solutions.

Wheat being a glycophyte is sensitive to tolerant under saline and saline-sodic soil environmental conditions. Soil salinity is a global problem and results in reduction in plant growth, reduced yield and, in severe cases, total crop failure (Qadir, *et al.*, 2000). Of all the ions in a saline or saline-sodic medium Na^+ may produce detrimental effects on the availability of water in a root medium as a function of growth period and concentration in the root medium. Source of sodium ion also plays an important role in plant response to salinity. Sodium sulphate is less toxic than sodium chloride for the growth of wheat provided

potassium and calcium are available in the growth medium therefore the availability of macronutrients in saline or saline sodic medium is beneficial for the yield of crops. (Zaman, *et.al*, 2002a).

Soil organic matter: Organic matter is defined as a grouping of carbon containing compounds which have originated from living beings and deposited on or within the earth's structural components. Soil organic matter includes the remains of all plant and animal bodies which have fallen on the earth's surface. Soil organic matter and humus are terms which refer to the partially decomposed residue of plants, animals, and other organisms. Organic matter has long been recognized as having many beneficial effects on physical and chemical properties of the soil. Some of the more important effects of organic matter are: Improves Soil Structure promotes water movement and root penetration, Contributes to Cation Exchange Capacity (CEC) and Provides Plant nutrients.

Soil organic matter is approximately 5% N and 0.5% P or S. Organic matter is also the primary reservoir for available forms of most of the micronutrients. Good soil fertility and higher plant productivity result from organic matter in the soil. Increasing organic matter improves soil structure and increases biological activity, resulting in better plant yields. The new approaches to the use of organic amendments in farming have proven to be effective means of improving soil structure, enhancing soil fertility and increasing crop yields. Organic matter are excellent source of plant-available nutrients and their addition to soil could maintain high microbial populations and activities with increased values of biomass of C, basal respiration, total organic C ratio, and metabolic quotient(qCO_2). Crop yields have increased with the corresponding improvements in soil quality from additions of organic matter (Norman Q. *et.al*, 2005)

Cation exchange capacity (CEC): Cations are positively charged ions such as calcium (Ca^{2+}), magnesium (Mg^{2+}), and potassium (K^+), sodium (Na^+) hydrogen (H^+), aluminum (Al^{3+}), iron (Fe^{2+}), manganese (Mn^{2+}), zinc (Zn^{2+}) and copper (Cu^{2+}). The capacity of the soil to hold on to these cations called the cation exchange capacity (CEC). These cations are held by the negatively charged clay and organic matter particles in the soil through electrostatic forces (negative soil particles attract the positive cations). The cations on the CEC of the soil particles are easily exchangeable with other cations and as a result, they are plant available. Thus, the CEC of a soil represents the total amount of exchangeable cations that the soil can absorb. The cations used by plants in the largest

amounts are calcium, magnesium, and potassium. Soils with a low CEC are more likely to develop deficiencies in potassium (K^+), magnesium (Mg^{2+}) and other cations while high CEC soils are less susceptible to leaching of these cations (CUCE 2007). Several factors may restrict the release of nutrients to plants. Some groups promote the controversial idea of managing cation ratios, claiming ideal ratios for Ca: Mg or Ca: K. For plant nutrition, a more critical factor is whether the net amount of Ca or K in the soil is adequate for plant growth.

4. MATERIALS AND METHODS

4.1. Description of the Study Area

The pot experiment was conducted at Yemeka, Gozamin Wereda, East Gojjam Zone of Amhara National Regional State (Figure 1). The site is situated at 10° 21` N latitude and 37°43`E longitude and at a distance of 305 and 251 km from Addis Ababa and Bahir Dar, respectively. Debre Markos is the capital of the wereda. Gozamin is surrounded by Aneded and Debay Tilatgin in the East, Machakel and Debre Elias in West, Sinan wereda in North, Baso Liben wereda and Abay River in the South (GWARDO). Gozamin has an altitudinal difference of 1200-3510 meter above sea level. Based on these altitudinal differences, the district has three agro-climatic zones namely, Dega, Woina-dega and Kola meter above sea level (GWARDO). The average annual rainfall of the district is 1628 mm with the rainy season extended up to 6 months. However, the heavy rainfall is concentrated in the Meher season of June to September. The maximum and minimum average temperatures are 25°C and 11°C, respectively (Gozamin wereda Meteorology Station, 2016). The most dominant soil types are nitosol, vertisol and Cambisok while, Pheazomes, Acrisols and Leptosols are associate soil types in different parts of the district (Bekele Negussie, 2006). The most important crops grown in the wereda are cereals like wheat, teff, maize, barley and oats.

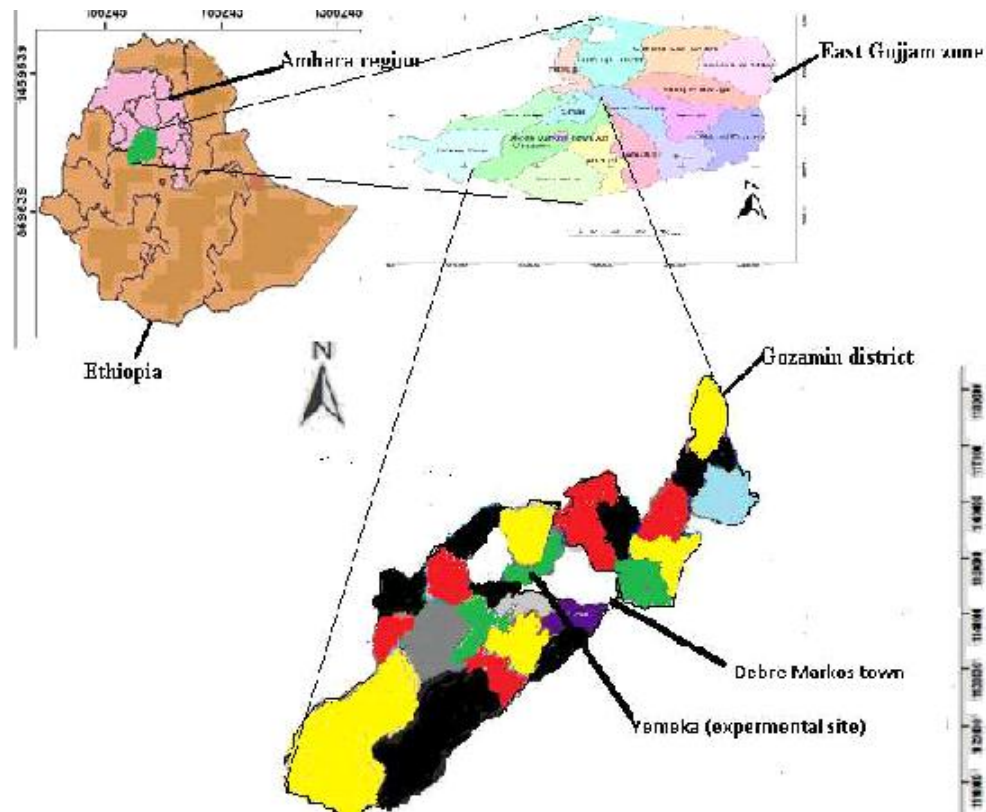


Figure 1: Map of the study area: Amhara National Regional State in Ethiopia, East Gojjam in Amhara region, Gozamin wereda in East Gojjam, and Yemeka in Gozamin wereda.

4.2. Soil Sampling and Analysis

Prior to planting, composite surface (0-20 cm) soil samples were collected from 6 across the farmer's field for each soil type by using hammer, core sample and oger (Appendix N). By using these apparatus the sample vertisol had been taken from teff farm and the nitosol had been taken from bean farm to analyze physico-chemical properties of the two soil types. The selected soil physico-chemical properties analysis was conducted at DebreMarkos soil chemistry laboratory. The soil samples were mixed, homogenized, air dried in shade, bulked, ground and passed through a 2 mm sieve, and analyzed for soil texture, pH, total N, available P, organic carbon, CEC and exchangeable cations (Ca_2^+ , Mg_2^+ , K^+ and Na^+). Soil particle size was determined using Hydrometer method. Soil pH was measured potentiometrically in the supernatant suspension of a 1:2.5 soil: water mixture using a pH meter according to method outlined by Sahlemedhin Sertus and Taye Bekele (2000). Total nitrogen was determined by the micro-Kjeldahl distillation and titration method as described by Jackson (1958). Organic carbon was determined following the wet digestion method as

described by Walkley and Black (1934). Available phosphorus was determined following the method of Olsen *et al.* (1954). Cation exchange capacity of the soil was determined from NH_4OAc saturated samples, which was measured through distillation using the micro Kjeldahl procedure as described by Bremner and Mulvaney (1982). Exchangeable Ca_2^+ and Mg_2^+ were measured using Atomic Absorption Spectrophotometry. Potassium and sodium contents of the soil were measured using flame photometry (Toth and Prince, 1949).

4.3. Preparation of Nursery Bed

A rectangular nursery bed of appropriate size 2.5m by 4.5m which was enough to accommodate the 100 pots was prepared. The nursery beds had 2 rows; each row had 25cm width; 300cm length and in each row contained 50 pots. The nursery bed was properly fenced by wood and thin wire.

4.4. Seed Collection

The seed were obtained from Debre Markos Seed Research Institution. A seed of bread wheat called Pica flora (kekeba in Amharic) were used as a test crop. Pica flora was released in 2005 by Kulmesa Agricultural research center (Asela). For Pica flora suitable altitude 1500-2700m and rain fall 500-800mm. It matures in 90-120 days, and has average plant height of 92 cm .Its grain yield range between 4-5.5 t ha⁻¹ on station and 3-4 t ha⁻¹ on farmers field (ANRS BoA, 2007)

4.5. Preparation of Soil

The soil used for this experiment was collected from Gozamin plain to the depth of 20 cm using pick hoe and shovel into sacks. Approximately 70kg of vertisol soil was dug out from the teff farm plot and other 70kg of nitosol also was dug out from other teff farm plot. The soil samples were mixed, homogenized, air dried in shade and sieved through a 2 mm sieve. So weighing and add one kg of soil to each pots.



Figure 2: Dried nitosol and vertisol by air



Figure 3: Weighing out soil samples collected from the farmers'

4.6. Preparation of Pots

Hundred (100) plastic pots with 10 cm diameter and 14 cm height were used for the experiment. Each fifty plastic pots were filled by one kg vertisol and other fifty pots were filled by one kg of nitosol. Each of the plastic bags which contained soil was pricked using a sharp nail of appropriate size at the bottoms (each pot with seven narrow holes) and at the side (each pots with seven narrow holes. Pots contained the two types of soil put in the nursery bed used random number or lottery method to randomize the placement of pots or the experiment was laid out as a completely randomized design (CRD) in a factorial arrangement.



Figure 4: the plastic pots with the two soil types were arranged on the surface bed in in randomized design (lottery method).

4.7. Fertilizer

Urea (46 % N) and NPS (19% N, 38 % P₂O₅ and 7% S) were used as a source of N, P, and S respectively. The amount of fertilizer required per pot was calculated from concentration of the nutrient in each established fertilizer rate on a hectare basis in to account (ANRS BoA, 2007) One hundred kg NPS ha⁻¹ and Urea 100Kg ha⁻¹. Then, the amount of fertilizer for 100 pots calculated for each established rate of the fertilizer, (NPS and urea) were weighted used a sensitive balance. The NPS and one-third of urea mixed with the soil and filled into the plastic pots. The remaining two-third of urea was applied at active tillering stage of growth or after the seed germinates 35-40 days.

4.8. Sowing and Follow Up

The each pot was thoroughly watered with half (1/2) litter or 500ml of water for the first day. Five healthy looking and big pica flora seeds were planted in each 100 pots. Each pot were watered with 100ml of water every 1 day interval, and seed germination days were recorded. Only one of the seedlings was kept and others had been removed after germination had occurred and the seedlings had grown to a height of 5 to 7cm.

Weeds were removed by hand at early tillering, maximum tillering, and booting stages of growth. No insecticide or fungicide was applied as there were no pest (insect and disease) incidences.

Harvesting was done twice. The first harvested was done on January 15/2017 to take measurements of biomass, weighted shoot and, root fresh weight, and shoot and root dry weight. The second harvested was done on March 5/2017 to take measurement of grain yield (g) per plant and straw yield (g) per plant across vertisol and nitosol.

4.9. Data Collection and Measurement

To compare the growth response of bread wheat in vertisol and nitosol, data on germination, heading, maturity response with respect to height, number of leaves, tillers and kernels, spike length, grain weight per plant, biomass of shoot and root, dry weight of shoot and root, 1000 kernel weight, and straw weight were recorded. Height increment for each seedling was measured by using a ruler (in cm) at 5 days interval for the first 30 days and at 7 days interval until anthesis. The number of leaves even the dead ones were counted every 10 days interval until anthesis. Total tillers, effective (fertile) tillers and non effective tillers, counted at a time after anthesis. 15 seedlings from vertisol and 15 seedlings from nitosol with

a total of 30 seedlings were randomly selected for biomass and dry mass determination. The roots of harvested seedlings were washed soil from roots. The shoot and root of the fresh seedlings were carefully separated by cutting with a dissecting knife and their weights were measured. The respective shoot and roots of each seedling were properly labeled and arranged to dry in oven. After dried the shoot and root of each were weighed separately to determine shoot and root weights by using sensitive balance. This Ovim and sensitive balance used in Debre Markos University. Finally for the remaining 70 plastic pots kernel number per plant counted and 1000kernel weight, grain and straw weight per plant were also measured.

4.10. Statistical Analysis

The growth and yield performance of bread wheat were analyzed by using ANOVA single factor using data analyzing excel for windows version10with treatments as factors. ($P \leq 0.05$) was used to determine the homogeneity subsets whenever significant differences existed among mean values of the treatments.

5. RESULTS

5.1 Soil Sample Analysis

Selected physico-chemical properties were analyzed using composite surface soil (0-20 cm) collected from each soil type before planting. Based the laboratory analysis result pH of vertisol and nitosol were 6.5 and 6.1 respectively. While the soil nutrients result also differ between the two types of soils as presented in Table 1 below.

Table1: Physico-chemical properties of the soil in the experimental site (Yemeka)

Description	Vertisol	Nitosol
pH	6.50	6.10
Organic matter	1.9%	1.3%
CEC (cmolckg-1)	37.0meq/100gmsoil	32.54meq/100gmsoil
Available P (ppm)	22.47PM	6.13PPM
Total Nitrogen	0.095	0.065
Exchangeable Na+	87mg/kg	73mg/kg
Exchangeable k+	185mg/kg	113mg/kg
Bulk density	0.97gm/cm ³	0.92gm/cm ³
Sand %	12%	8%
Silt %	20%	16%
Clay %	76%	68%
Texture class	Clay	Clay

Source; Deber Markose Soil Chemistry laboratory

5.2. Seed Germination

The bread wheat seed average days of germination in vertisol 7.0days, in nitosol 10.2 days. Bread wheat seeds can germinate in both types of soils but in vertisol germinates faster than nitosol. The growth pattern on seedling of bread wheat varies depending on the type (Table 2).

5.3. Phenological Parameters

Heading of plant in nitosol was faster than heading of plant in vertisol. The mean date of heading for bread wheat in nitosol was 64.6 days while in vertisol was 65.8 days.

physiological maturity of bread wheat grown in nitosol faster than in vertisol. The mean days of physiological maturity of bread wheat grown in nitosol was 115.0 days while in vertisol was 120.2 days (Table 2).

Table2: Effect of vertisol and nitosol on germination & phenological parameters of bread wheat

Soil type	Description		Date of 50% Germination	Date of 50% heading	Date of 90% maturity
Nitosol	N	Valid	50	49	49
		Missing	0	1	1
	Mean		10.2	64.6	114.7
	Std. Deviation		3.2	1.2	0.9
Vertisol	N	Valid	50	50	50
		Missing	0	0	0
	Mean		7.0	65.8	120.2
	Std. Deviation		1.5	2.5	1.4
Total	N	Valid	100	99	99
		Missing	0	1	1
	Mean		8.7	65.2	117.4
	Std. Deviation		3.3	2.1	3.0

5.4. Growth Parameters

5.4.1. Plant Height

Bread wheat plants grown in vertisol were taller than which grown in nitosol. Thus, the mean height of bread wheat plants 32.0 cm grown in vertisol significantly exceeded the mean height of bread wheat plants 25.4 cm in nitosol, on the other hand, the average final plant height grown in vertisol was 57.3 cm while in nitosol was 50.4cm (figure 5). But the difference was not significant. The bread wheat average height and increments (cm) measured in 5 days intervals, for 30 days; while it measured in 7 days interval until anthesis (Table 3).

Table 3: Bread wheat Average height (cm) Results

Soil Type	Days after planting											Mean	df ¹	p-value	f-critical
	10	15	20	25	30	35	42	49	56	63	Final				
VERTISOL	9.9	14.1	18.1	21.3	25.1	29.9	36.9	42.7	46.2	49.7	57.3	32.0	10	0.05	4.35
NITOSOL	5.7	9.4	12.8	15.9	19.2	24.1	29.1	34.3	36.7	41.9	50.4	25.4	10		

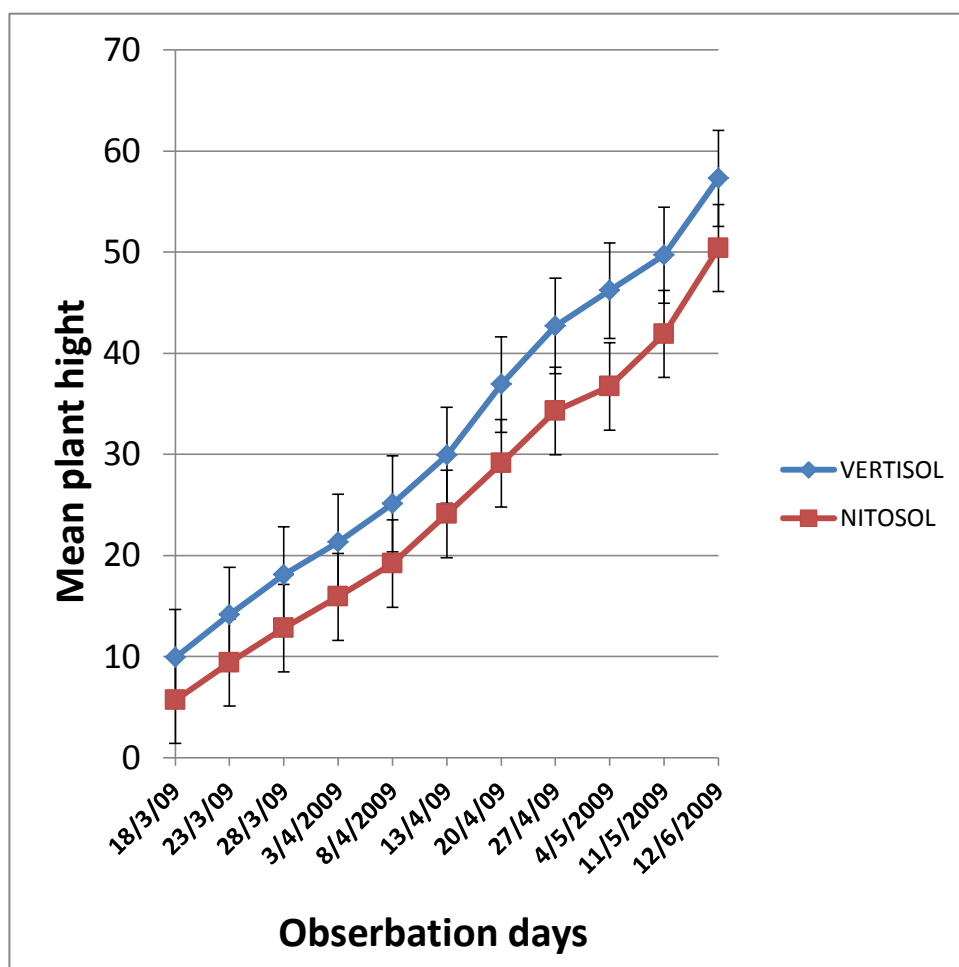


Figure 5: Growth performances of bread wheat plants maintained in nitosol and in vertisol, the plot provides mean height as a function of time.

¹Major test statistics are provided in the last four columns

5.4.2. Number of Leaves

Thus, the mean number of bread wheat leaves per plant was 17.0 those grown in vertisol 11.0 those grown in nitosol (Table-4), besides this the average final number of leaves grown in vertisol was 29.8 and in nitosol was 19.0 (figure 6).

Table 4; Number of leaf increment counted every 10 days interval.

Soil Type	Days After planting						Mean ²	Df	p-value	f-critical
	10	20	30	40	50	Final				
Vertisol	2.5	5.4	12.8	23.5	27.8	29.8	17	0.01	4.96	
Nitosol	2.9	3.9	8.4	14.3	16.9	19.0	11			

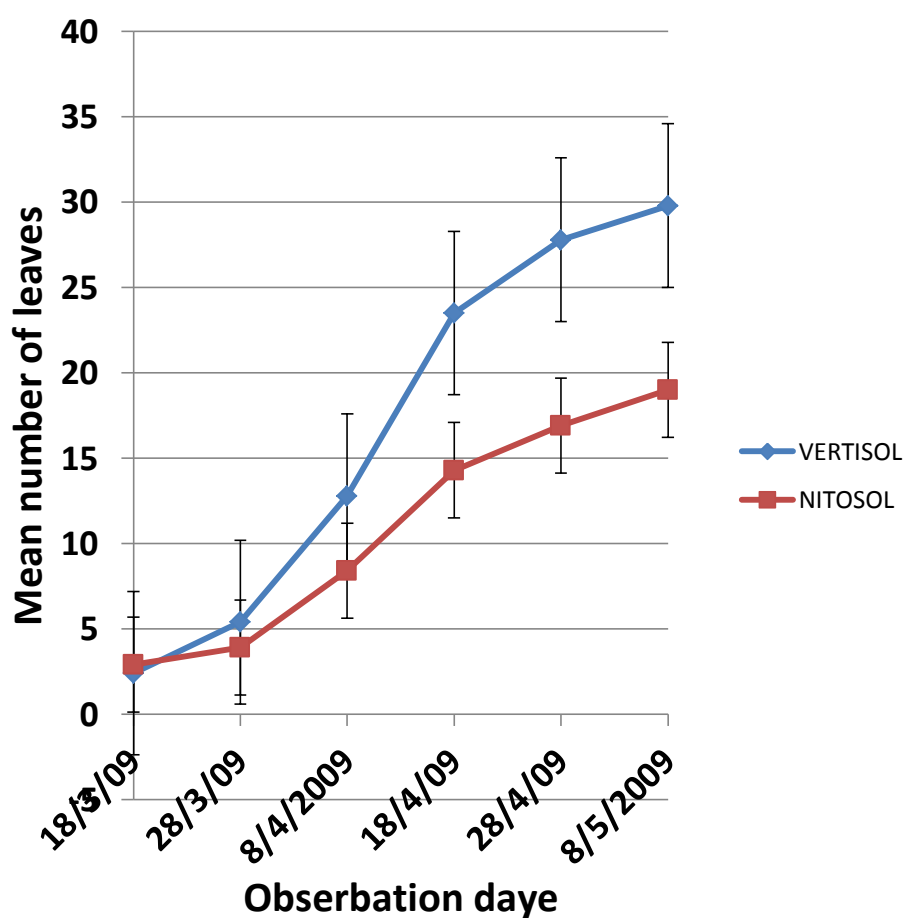


Figure.6: Growth performances of wheat plants grown in nitosol and vertisol increments in leaf number as a function of time.

²Major test statistics are provided in the last four columns

5.4.3. Spike Length

Bread wheat plants grown in vertisol were longer spike length per plant than bread wheat plants grown in nitosol. The mean spikes length per plants 7.4 cm grown in vertisol and 6.9 cm in nitosol (Figure-7).

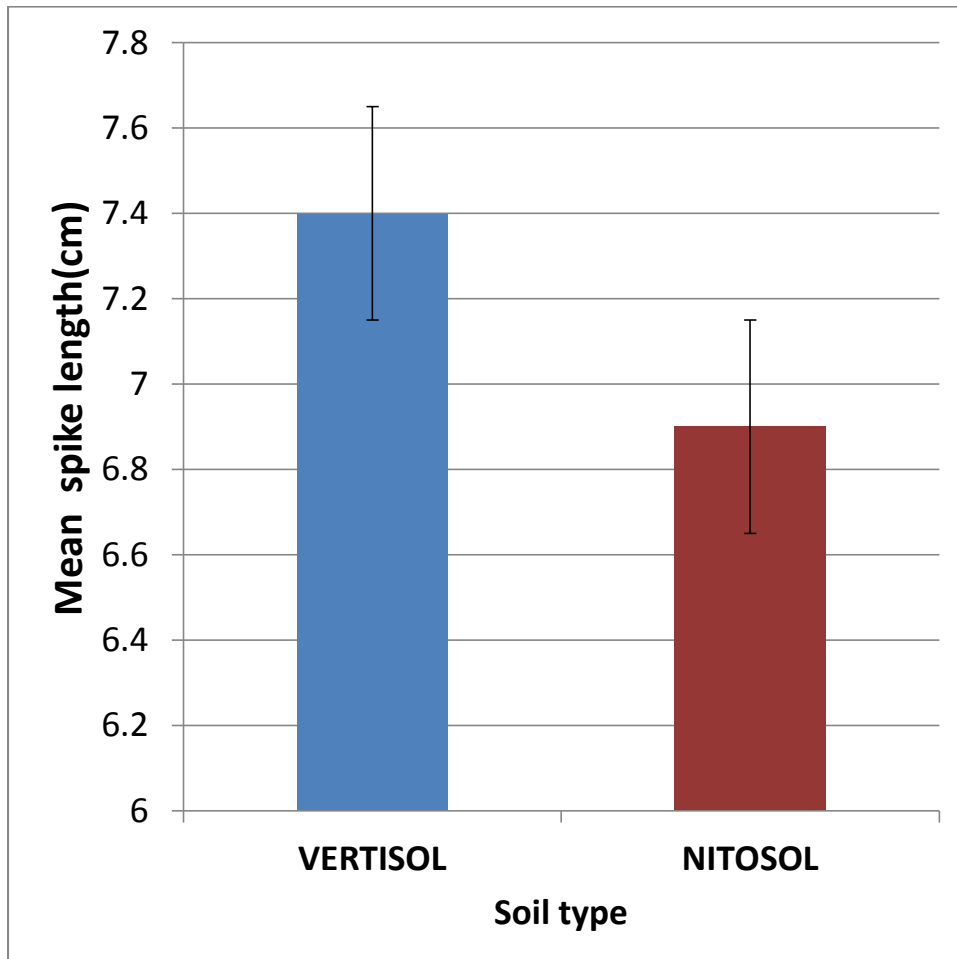


Figure 7: Growth performances of bread wheat plants maintained in nitosol and vertisol bread wheat spike length

5.5. Yield and Yield Components

5.5.1. Number of Tillers

The result showed that bread wheat was large number of tillers per plant in vertisol than nitosol. The mean number of tillers per plant in vertisol was 5.6 and in nitosol it was 2.6. The average number of effective tillers grown in vertisol was 4.0 whereas in nitosol it remains only 1.5. On the other hand, the average number of non-effective tillers grown in vertisol was 1.5 and in nitosol it resulted with 1.1 (Figure 8).

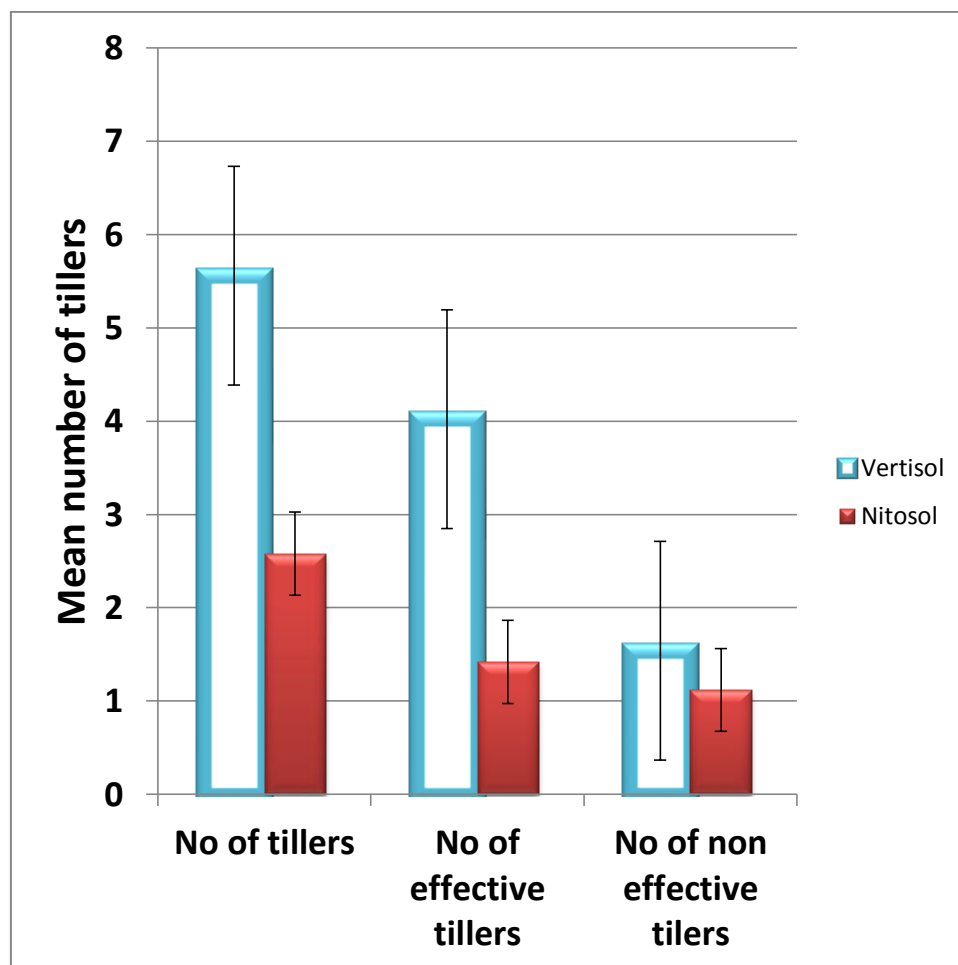


Figure 8: Yield performance of bread wheat plants grown in vertisol and nitosol.

NB: Performances were measured using tillers, effective tillers and non effective tillers.

5.5.2. Number of Kernel

The mean number of kernel per plant was recorded wheat grown in vertisol 152.4 and in nitosol 66.7 (Figure 9).The bread wheat grown in vertisol number of kernel per plant were statistically significantly different ($P \leq 0.01$) from the plant grown in nitosol.

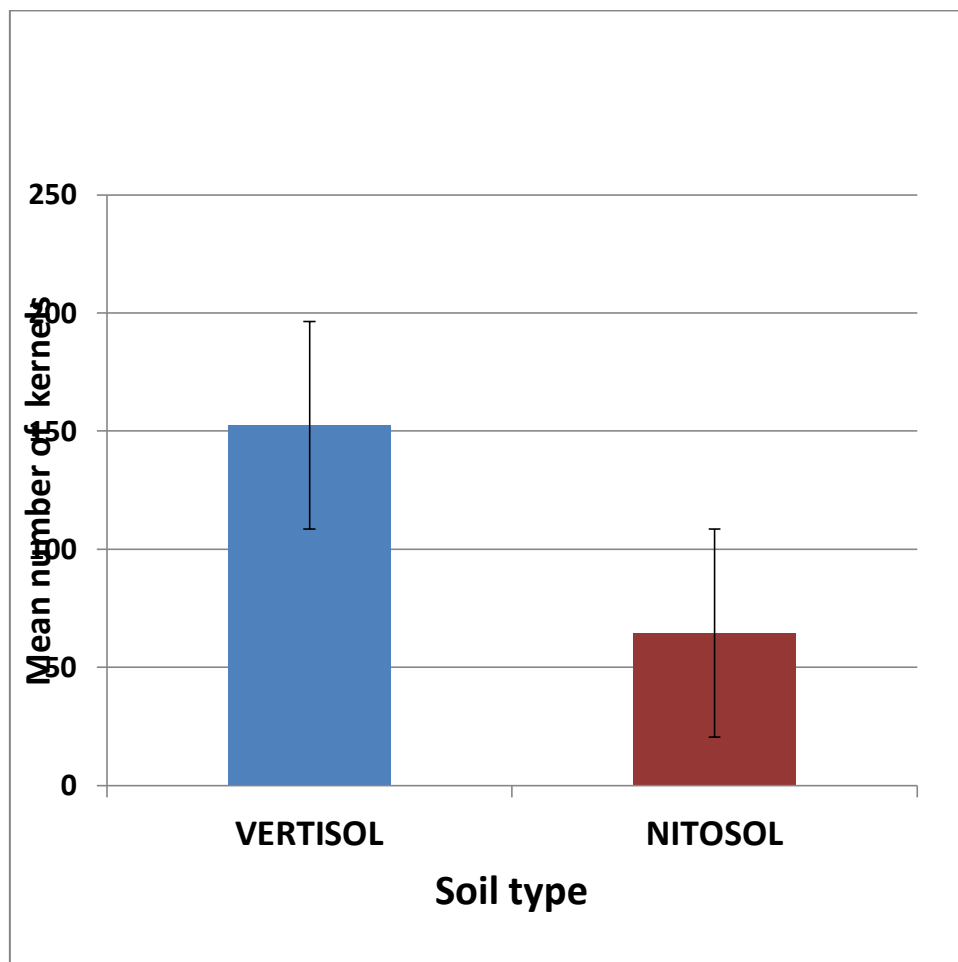


Figure 9: Yield Performance of bread wheat which grown in vertisol and nitosol produced kernel.

5.5.3. Grain Yield

The result showed that bread wheat grown in vertisol had high grain weight than nitosol. Mean weight of grain yield (g) per plant in vertisol was 5.8g and in nitosol it was 2.8g. (Figure10).

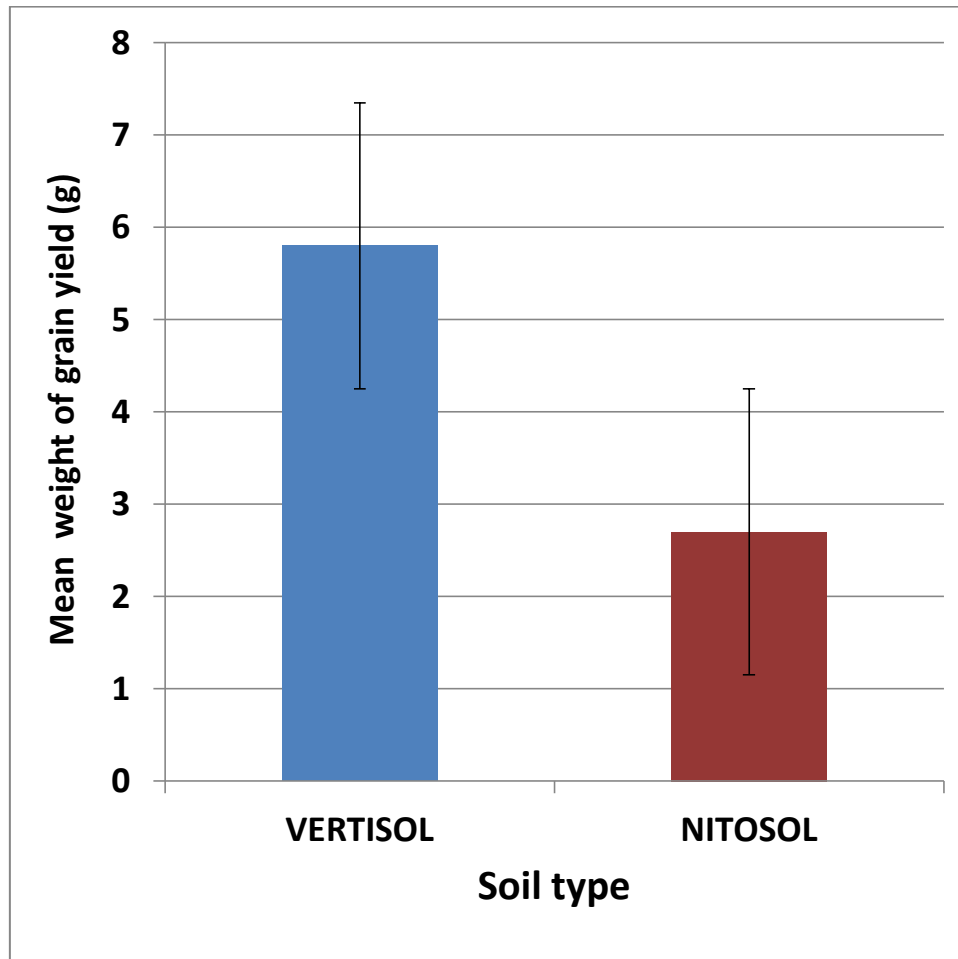


Figure 10: Yield Performance of bread wheat plant maintained in vertisol and nitosol weight of grain yield.

5.5.4. Straw Yield

The bread wheat grown in vertisol had a high straw yield per plant than nitosol. The mean straw yield per plant in vertisol was 4.3g and in nitosol was 2.5g see (Fig 11) below.

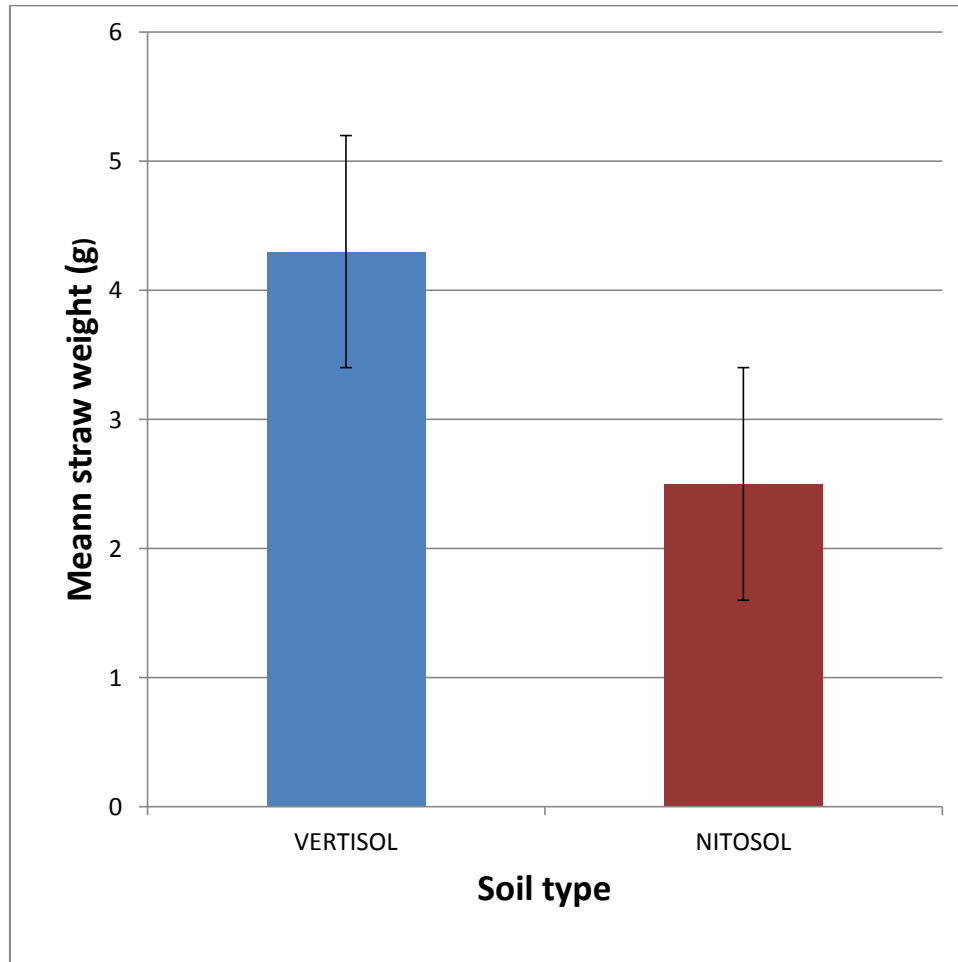


Figure 11: Bread wheat plant straw yield in vertisol and nitosol.

5.6. Biomass of Bread Wheat

The plant mean fresh shoot mass 19.3g in vertisol and 11.2g in nitosol per plant and fresh root mass 1.4g in vertisol and 1.0g in nitosol per plant. Therefore the maximum biomass of bread wheat per plant was 21.5g which was grown in vertisol whereas, the minimum biomass was 12.6g grown in nitosol see Table 5 below.

5.6.1 Dry Mass of Bread Wheat

Bread wheat plant after dry in oven mean dry weight per plant shoot mass was 14.1g, dry root mass was 0.9g in vertisol while in nitosol mean dry shoot mass was 8.6g and dry root mass was 0.5g. There for the larger dry mass of wheat grown in vertisol 15.0g than in nitosol 9.1g see Table 5 below.

Table 5. Effect of vertisol and nitosol on biomass and dry mass of bread wheat.

Soil type	Description		Fresh bio mass	Fresh shoot mass	Fresh root mass	Dry bio mass	Dry shoot mass	Dry root mass
Vertisol	N	Valid	15	15	15	15	15	15
		Missing	0	0	0	0	0	0
	Mean		21.5	19.3	1.4	15.0	14.1	0.9
	Median		17.0	15.0	1.3	12.5	11.6	0.9
	Std. Deviation		12.2	11.1	0.8	8.2	7.7	0.5
Nitosol Soil	N	Valid	15	15	15	15	15	15
		Missing	0	0	0	0	0	0
	Mean		12.6	11.2	1.0	8.6	8.1	0.5
	Median		11.6	10.4	0.8	8.2	8.0	0.3
	Std. Deviation		8.8	8.0	0.7	6.0	5.6	0.4

6. DISCUSSION

6.1. Soil Physicochemical Properties

The results of the laboratory soil analyses indicated that the relative amounts of sand, silt, and clay in vertisol of the experiment were sand (12%), silt (20%), and clay (68%) respectively. While for nitosol amounts of sand, silt, and clay of the experiment were sand (8%), silt (16%), and clay (76%) respectively. Therefore, according to description of the relative amount of a size fraction or particle in soil vertisol had high sand and silt than nitosol.

Based the laboratory analysis result pH of vertisol and Nitosol were 6.5 and 6.1 respectively. According to FAO (2008) suitable pH for most crops is between 6.5 and 7.5. So vertisol soil is more suitable pH than nitosol for bread wheat growth. The content of organic matter, total nitrogen, and available phosphors, CEC, exchangeable K^+ and Na^+ of vertisol was better than nitosol. That is why the former suitable for bread wheat growth and yield performance than the later type of soil.

6.2. Seed Germination

Bread wheat seeds can germinate in both types of soils but in vertisol germinates faster than nitosol. The difference was statistically significance at $p \leq 0.05$. Seed germination affected by temperature, oxygen and moisture. The observation that seeds germinate better in vertisol than nitosol could probably be due to the fact that the clay vertisol has moisture holding capacity which facilitate better germination. The present result confirms the results of Evans *et al.*, (1975).

6.3 Phenological Characteristics of Bread Wheat

Headings of bread wheat were successful in both vertisol and nitosol. However, plant heading was slightly faster in nitosol than vertisol, but the difference was not statistically significance at $P \leq 0.05$. The observation could be due to vertisol contain more nutrients might be extended vegetative growth instead of reproductive growth. Date of maturity is also another important Phenological characteristic of bread wheat. Days to maturity of bread wheat plants grown in vertisol were significantly different ($P < 0.05$) from plants grown in nitosol. The maturity of bread wheat plants were hastened in nitosol than in vertisol. Vertisol prolonged days

to physiological maturity by 5 days over that of nitosol. The highest numbers of days required for physiological maturity of this crop grown in vertisol may be due to the inherent abundant supply of essential plant nutrients especially nitrogen, phosphorus and other nutrients. Delayed physiological maturity promoted vigorous vegetative growth of wheat and extended vegetative growth instead of reproductive growth. The present result confirms the results of Birhanu Bayeh (2010).

6.4. Growth Characteristics of Bread Wheat

Characteristics such as plant height, plant leaves, tillers and spike length are the major bread wheat growth parameters that need justification further with this study. The study result showed growth pattern on seedlings of bread wheat height increment in vertisol was higher than in nitosol, but statically not significant This is due to the beneficial role of N and P in cell division and elongation as well as the shoot growth of wheat .As is true with all other plants, bread wheat growth performances are positively correlated with favorable levels of soil nitrogen, phosphorous, soil organic matter, soil moisture, as well as suitable soil physico-chemical properties, this conclusion is in agreement with the suggestion of Mulatu Kassaye,(2015),who state that the bread wheat differed significantly in plant height across the nitrogen levels.

The number of leaves of bread wheat plants grown in vertisol was larger than grow in nitosol. Number of leaves in bread wheat plants grown in vertisol were significantly different ($P<0.01$) from plants grown in nitosol. This difference may be the availability of nutrients in which enhanced the number of plant leaves. This could be due to high nitrogen availability in vertisol which results in high leaf production. This idea is in agreement with Evans, (1989); which suggested that. Nitrogen supply has large effect on leaf growth because it increases the leaf area of plants and, on that way, it influences on photosynthesis.

Number of total tillers is also another important character which ensures high yield in bread wheat seeds. In this investigation, vertisol produces high number of tillers (5.6) than nitosol (2.6). This could be due to high nitrogen and phosphorus availability in vertisol which results in high tiller production. Number of tillers per plan for bread wheat grown in vertisol showed a high significant difference ($P<0.01$) from plants grown in nitosol

Bread wheat plants grown in vertisol were longer spike length than it grown in nitosol. Thus, the mean spike length of bread wheat plants 7.43 cm grown in vertisol and 6.89 cm in nitosol. This difference may as the result of availability of nutrients in vertisol by promoting vigorous vegetative growth of the plant which enhanced spike length. This result is also in agreement with that of Laghari, *et al.* (2010) who reported that spike length of wheat became higher in response to the application of higher doses of nitrogen.

6.5. Yield Components

Effective tillers, kernels and grain yield were yield components of bread wheat. Crops yields are generally depended upon many yield contributing agents. Among these numbers of effective tillers the most important yield component of cereals is determined by the number of fertile tillers. In this investigation bread wheat grown in vertisol had large number of effective tillers than nitosol. Thus, the mean number of effective tillers grown in vertisol was better than grown in nitosol. Number of effective tillers of bread wheat plants grown in vertisol were significantly different ($P<0.05$) from plants grown in nitosol. This could be due to in vertisol had high level of phosphorus and that phosphorous enhances reproductive potential of plants through its effect in increasing growth, reproduction, tillering and carbon fixation and assimilation. This idea was in agreement with Valle and Calderini, (2010) reported that phosphorous availability influences the ability of wheat to differentiate and grow leaves and tillers thereby increasing spike population (effective tillers).

Number of kernels per plant was very high in vertisol than nitosol. The mean number of kernel per plant was recorded in vertisol 152.4 and in nitosol 66.7. The difference was statistically highly significant ($P<0.01$). This was due to in vertisol may be attributed to sufficient availability and uptake of the nitrogen by the plants at the seed formation growth stage, which might have enhanced the photosynthetic activities and partition of the carbohydrate produced in the kernels. This idea was agreed with Otteson *et al.*, (2008) who reported that wheat requires a good supply of nutrients especially nitrogen for its growth and yield. Nitrogen is one of the most important and expensive inputs in wheat production.

Furthermore the maximum grain weight per plant recorded in vertisol was high fold than grown in nitosol. In addition to this from per 1000 kernels counted and weighted bread wheat

grown in each soil type, the plant grown in vertisol weighs 44.1g while it was 39.1 g for plant grown in nitosol. This may be because vertisol and its nutrients were suitable for bread wheat plant growth.

Straw yield also influenced by the vertisol and nitosol. The bread wheat grown in vertisol has high straw yield per plant (4.26g) than which grown in nitosol (2.54g). This is due to response of N uptake and utilization in the shoot meristems may be attributed to increased plant height, leaves and tillers thereby overall plant growth and increase in above the ground biomass resulted. These results are in line with the finding of Tarekegn Assefa, *et al.*, (2000) who concluded that increased Nitrogen uptake significantly enhanced straw yield in wheat since Nitrogen usually promotes the vegetative growth of the plant.

6.6. Biomass of Bread Wheat

The biomass (Shoot biomass root biomass) of bread wheat per plant grown in vertisol was 21.5 g whereas, the biomass bread wheat per plant grown in nitosol was 12.6g. This was due to in vertisol had more nutrient than nitosol. Therefore, Nitrogen uptake and distribution in plant and crops involves many aspects of growth and development. This idea was agreed with Mojid, *et.al*, (2010), who reported that nitrogen caused enormous increase in the biomass and grain yield of wheat. The relationship between Nitrogen and biomass accumulation in crops, relies on the reciprocal regulation of multiple crop physiological process.

6.7. Dry Mass of Bread Wheat

After dried in oven the dry mass (shoot dry mass+ root dry mass) of bread wheat per plant grown in vertisol was 15.0g and while on nitosol it was 8.6g. The total dry matter of shoot and root of bread wheat was high with increased nitrogen level and requirement of available phosphorous. This result was agreed with the findings of Fageria and Baligar, (1999) who also reported increased shoot dry matter yields of wheat in response to increased phosphorous application.

7. CONCLUSIONS AND RECOMMENDATIONS

7.1. CONCLUSIONS

The yield of bread wheat is low in North Western Ethiopia due to low soil fertility particularly nitrogen deficiency, soil acidity, nutrient depletion in nitosol and poor fertilizer management practices. The results of the pot experiment on vertisol and nitosol demonstrated that the tested bread wheat significantly differed in growth, yield components, grain yield, straw yield, biomass and dry mass. This study result shows that among the tested bread wheat grown in vertisol was found to be the most productive than nitosol. For instance plant height, number of leave, spike length, number effective tiller, number of kernel, thousand kernel weights and biomass of the bread wheat grown in vertisol higher than it grown in nitosol. This implies that sowing bread wheat in nitosol as currently practiced by farmers in the study area would not lead to economical and sustainable production of the crop for enhancing food security.

Therefore, it can be concluded that producing significantly higher bread wheat grain yields than the current production in the study area is possible through cultivation of improved bread wheat sowing in vertisol having reach nutrients. Therefore, to get better benefit farmers need to sow bread wheat in vertisol. However, further research including in vertisol, nitosol and timing of fertilizer application should be conducted on the crop over seasons and locations to reach at conclusive recommendations.

7.2. RECOMMENDATIONS

Based on this study finding the following recommendations were forwarded:-:

- It is advisable to sow bread wheat(Kekeba in Amharic) which had high yield in vertisol than nitosol
- Bread wheat producers in Gozamin wereda use fertilizer application as the Amhara National Region Agricultural Bureau Package 2007.
- Stakeholders should work together for improvement of bread wheat production particularly, to encourage farmers to specialize on bread wheat production in vertisol than nitosol.

- Hence there is significance difference on growth and yield performance as well as biomass difference of bread wheat in the two soil types (vertisol or nitosol) growing on vertisol should be promoted.

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9. APPENDICES

Appendix 1: Mean squares of ANOVA for the effect of vertisol and nitosol on the Phenological Parameter of bread wheat in 2016/ 2017.

Phenologica Parameter	Source of variation	Sum of Squares	Df	Mean Square	F	Significance ($P \leq 0.05$)
Date of Germination	Between Groups	2580.3	9	286.7	4.4	.000
	Within Groups	5743.6	89	64.5		
	Total	8323.9	98			
Date of heading 50%	Between Groups	1279.9	8	160.0	2.0	.050
	Within Groups	7044.0	90	78.3		
	Total	8323.9	98			
Date of maturity 90%	Between Groups	2522.7	10	252.3	3.8	.000
	Within Groups	5801.2	88	65.9		
	Total	8323.9	98			

Appendix 2: Effect of vertisol and nitosol on growth performances of bread wheat

Soil Type	Description		Plant height (cm)	Number of leaves	Tiller number	Spike length (cm)
Nitosol	N	Valid	49	49	49	49
		Missing	1	1	1	1
	Mean		25.4	11.0	2.6	6.9
	Std. Deviation		5.2	4.9	1.8	1.0
Vertisol	N	Valid	50	50	50	50
		Missing	0	0	0	0
	Mean		32.0	17.0	5.6	7.4
	Std. Deviation		3.5	5.1	2.2	0.8
Total	N	Valid	99	99	99	99
		Missing	1	1	1	1
	Mean		29.0	14.0	4.1	7.2
	Std. Deviation		5.4	5.8	2.5	1.0

Appendix 3:-Mean squares of ANOVA for the effect of vertisol and nitosol on the growth performance of bread wheat in 2016/ 2017

Wheat plant Performance Indicators	Analysis type	Sum of Squares	Df	Mean Square	F	Significance (P \leq 0.05)
Plant height	Between Groups	7878.8	78	101.0	4.5	.000
	Within Groups	445.1	20	22.3		
	Total	8323.9	98			
Number of leaves per plant	Between Groups	7907.9	73	108.3	6.5	.000
	Within Groups	416.0	25	16.639		
	Total	8323.9	98			
Tiller number Per plant	Between Groups	5771.0	10	577.17	19.9	.000
	Within Groups	2552.907	88	29.010		
	Total	8323.879	98			
Spike length Per plant	Between Groups	6195.7	29	213.6	6.9	.000
	Within Groups	2128.2	69	30.8		
	Total	8323.9	98			

Appendix 4:-Effect of vertisol and nitosol on growth and yield performances of bread wheat

Soil type	Description		Effective tiller	Non effective tiller	Number of kernel per plant	Mass of grain (g) per plant	Straw yield (g)per plant
Nitosol	N	Valid	49	49	49	49	49
		Missing	1	1	1	1	1
	Mean		1.5	1.1	66.7	2.8	2.54
	Std. Deviation		1.7	1.0	47.7	2.2	2.1
Vertisol	N	Valid	50	50	50	50	50
		Missing	0	0	0	0	0
	Mean		4.0	1.5	152.4	5.8	4.26
	Std. Deviation		2.4	1.5	95.9	4.3	3.6
Total	N	Valid	99	99	99	99	99
		Missing	1	1	1	1	1
	Mean		2.8	1.3	110.0	4.3	3.4
	Std. Deviation		2.4	1.2	87.0	3.7	2.8

Appendix 5:-Table of ANOVA presenting sum squares, degrees of freedom, mean squares, computed F value and significance

Wheat plant Performance Indicators	Analysis type	Sum of Squares	Df	Mean Square	F	Significance (P _≤ 0.05)
Effective tiller Per plant	Between Groups	7339.0	9	815.4	73.7	.000
	Within Groups	984.9	89	11.1		
	Total	8323.9	98			
Non effective tiller Per plant	Between Groups	317.2	5	63.4	0.7	.598
	Within Groups	8006.7	93	86.1		
	Total	8323.9	98			
Number of seed per plant	Between Groups	8306.8	82	101.3	94.7	.000
	Within Groups	17.1	16	1.1		
	Total	8323.9	98			
Gram of seed per plant	Between Groups	8310.2	93	89.4	32.6	.000
	Within Groups	13.7	5	2.7		
	Total	8323.9	98			

Appendix 6:- Effect of vertisol and nitosol on fresh biomass and dry biomass of bread wheat one sample statistics

Soil Type		N	Mean	Std. Deviation	Std. Error Mean
Vertisol soil	Fresh bio mass	15	21.5133	12.18605	3.14642
	Fresh shoot mass	15	19.2733	11.14770	2.87832
	Fresh root mass	15	1.4440	.84304	.21767
	Dry bio mass	15	15.0133	8.15816	2.10643
	Dry shoot mass	15	14.1307	7.72417	1.99437
	Dry root mass	15	.8747	.51780	.13369
Nitosol soil	Fresh bio mass	15	12.5800	8.78491	2.26825
	Fresh shoot mass	15	11.1633	7.95317	2.05350
	Fresh root mass	15	1.0220	.72340	.18678
	Dry bio mass	15	8.5873	5.92815	1.53064
	Dry shoot mass	15	8.1313	5.64745	1.45817
	Dry root mass	15	.4753	.36841	.09512

Appendix 7:- Descriptive Statistics T-test for biomass of bread wheat.

Soil Type		Test Value = 0.05					
		T	df	Sig. (2tailed) (P<0.05)	Mean Difference	95% Confidence Interval of the Difference	
						Lower	Upper
Vertisol Soil	Fresh bio mass	6.821	14	.000	21.46333	14.7149	28.2117
	Fresh shoot mass	6.679	14	.000	19.22333	13.0499	25.3967
	Fresh root mass	6.404	14	.000	1.39400	.9271	1.8609
	Dry bio mass	7.104	14	.000	14.96333	10.4455	19.4812
	Dry shoot mass	7.060	14	.000	14.08067	9.8032	18.3582
	Dry root mass	6.168	14	.000	.82467	.5379	1.1114
Nitosol Soil	Fresh bio mass	5.524	14	.000	12.53000	7.6651	17.3949
	Fresh shoot mass	5.412	14	.000	11.11333	6.7090	15.5177
	Fresh root mass	5.204	14	.000	.97200	.5714	1.3726
	Dry bio mass	5.578	14	.000	8.53733	5.2544	11.8202
	Dry shoot mass	5.542	14	.000	8.08133	4.9539	11.2088
	Dry root mass	4.471	14	.001	.42533	.2213	.6294

Appendix 8: Seedling height increment of bread wheat (pica flora) in cm in five and seven day interval in vertisol.

No	Code	Days after planting										
		10	15	20	25	30	35	42	49	56	63	Final
1	97	10	15	17	23	27	31	40	41	44	47	58
2	93	16	20	22	26	30	31	36	42	43	44	50
3	20	10	14	15	18	20	24	27	33	37	48	62
4	56	13	17	19	25	27	29	36	42	43	43	43
5	48	11	13	18	22	23	28	35	42	43	50	60
6	59	9	15	19	23	27	30	38	44	46	48	58
7	11	10	19	22	23	28	35	41	43	46	50	54
8	75	11	18	22	25	29	30	39	44	47	51	53
9	89	8	10	15	16	20	23	30	33	37	45	60
10	55	8	14	20	22	25	29	32	33	40	46	58
11	63	10	14	18	22	24	28	35	40	42	43	48
12	21	7	10	12	14	20	24	26	28	33	39	50
13	77	9	11	16	19	21	25	31	37	42	48	52
14	45	8	11	15	20	24	28	34	39	43	47	60
15	91	12	16	18	23	26	28	34	42	47	50	61
16	74	13	18	20	24	29	33	46	49	51	56	60
17	08	8	12	17	20	23	30	37	43	47	51	61
18	67	5	8	15	19	21	27	35	43	47	53	59
19	42	10	13	18	22	24	31	40	47	48	51	55
20	44	8	10	17	19	24	31	37	44	47	51	65
21	98	10	13	18	20	24	30	32	38	42	47	60
22	09	7	10	16	19	23	28	30	37	39	46	61
23	19	11	13	19	23	25	34	44	47	50	51	66
24	18	9	13	17	22	26	31	40	47	49	53	59
25	81	10	12	19	22	25	31	35	46	49	52	63
26	03	15	20	27	28	32	38	48	51	54	61	67
27	35	13	18	22	25	28	37	45	52	56	62	65
28	100	10	14	18	24	27	34	44	50	54	55	58
29	85	15	20	22	26	31	34	43	50	52	57	66
30	62	12	21	23	26	29	35	40	50	51	55	57
31	68	11	15	21	24	25	29	35	41	44	48	56
32	54	13	22	23	26	31	36	44	50	55	58	65
33	60	10	15	21	22	27	33	37	43	47	51	65
34	05	13	17	20	23	30	34	47	52	55	60	65
35	23	5	8	12	17	21	28	32	42	46	49	52
36	04	11	19	21	25	29	34	48	50	56	60	64
37	37	7	9	12	15	19	27	38	44	48	50	50
38	39	9	13	18	23	25	30	39	44	50	50	50
39	83	7	11	17	20	22	27	32	38	42	49	57
40	64	5	6	9	12	18	27	34	42	45	50	52
41	38	13	19	22	24	28	31	36	40	45	48	52
42	87	10	14	17	21	25	30	35	42	42	44	48
43	92	7	8	13	16	20	26	32	35	45	47	58
44	99	10	19	21	24	28	32	38	43	44	45	47
45	51	13	18	19	20	24	25	34	43	47	50	50
46	14	12	14	19	22	25	27	33	39	44	47	58
47	41	8	10	17	20	22	27	33	39	44	47	58
48	34	13	18	22	27	31	34	44	48	52	53	59
49	94	6	8	12	14	21	28	34	41	43	48	54
50	73	5	8	11	14	23	27	34	40	41	44	50
	T.sum	496	703	905	1067	1256	1499	1849	2138	2284	2485	2851
	Average	9.9	14.1	18.1	21.3	25.1	29.9	36.9	42.7	46.2	49.7	57.3

Appendix 9: Seedling height increment of bread wheat (pica flora) in cm in five and seven day interval in nitosol

No	Code	Days after planting										
		10	15	20	25	30	35	42	49	56	63	Final
1	79	10	15	17	23	27	31	40	41	44	47	58
2	71	3	4	12	16	20	24	27	28	29	33	48
3	65	8	12	19	25	26	31	38	39	41	42	45
4	23	3	5	8	9	12	16	23	28	31	39	50
5	98	3	4	8	11	17	17	18	22	23	28	45
6	6	5	7	12	17	17	21	26	28	31	35	49
7	80	5	8	10	15	16	19	23	29	33	41	51
8	43	3	5	7	11	13	18	20	20	21	25	36
9	49	10	16	20	21	22	27	36	40	43	49	62
10	50	2	3	7	10	15	17	20	23	25	33	45
11	15	3	5	7	10	11	15	19	24	29	38	53
12	95	2	5	8	10	17	21	21	24	26	30	42
13	31	4	7	8	10	12	17	20	24	26	31	31
14	10	5	8	10	12	15	18	24	31	36	43	52
15	82	6	9	14	14	20	28	35	40	43	46	56
16	33	2	4	7	11	13	18	22	27	30	34	50
17	16	2	4	8	12	18	24	28	31	34	41	50
18	76	5	8	12	15	21	26	27	33	36	43	54
19	7	3	6	10	13	16	20	25	27	29	34	45
20	26	5	7	12	16	18	22	25	30	34	40	43
21	32	11	19	23	24	26	33	41	45	49	53	60
22	88	10	15	17	21	25	28	36	43	45	50	60
23	66	2	4	8	9	12	16	20	22	24	33	53
24	47	7	11	18	20	24	30	40	45	50	52	56
25	24	6	11	11	12	15	26	32	38	41	47	59
26	13	9	14	15	19	21	23	26	30	31	38	50
27	28	8	11	14	19	23	27	33	42	44	50	58
28	2	7	10	16	18	24	31	42	47	50	54	59
29	1	2	4	6	13	19	26	28	37	42	49	62
30	96	3	5	8	12	13	19	23	27	29	36	57
31	46	6	10	10	11	12	23	28	35	39	45	57
32	27	10	15	17	23	28	37	45	53	57	58	58
33	58	2	6	8	13	21	26	30	32	35	41	58
34	90	11	15	22	23	26	31	42	47	51	55	56
35	12	9	14	20	22	24	29	16	43	45	50	55
36	72	3	6	10	12	17	24	33	39	46	49	50
37	36	7	16	16	17	20	26	30	39	44	49	57
38	69	3	8	8	8	8	d	r	i	e	d	
39	29	6	11	18	19	23	29	35	41	43	44	44
40	17	8	12	16	20	21	28	33	37	40	43	43
41	57	5	7	10	16	18	21	26	33	40	44	44
42	52	11	16	17	19	24	27	35	41	45	50	59
43	40	6	9	15	17	20	27	37	41	45	46	46
44	53	9	13	17	20	21	24	31	36	38	42	48
45	84	11	17	20	23	28	32	37	43	43	47	54
46	78	6	9	13	18	21	27	34	39	43	46	48
47	61	3	7	10	15	18	23	27	36	40	43	59
48	25	4	8	11	12	16	22	31	37	38	38	38
49	30	12	19	22	27	29	33	39	45	47	50	56
50	22	2	4	10	12	19	27	30	33	37	41	53
	T.sum	288	468	642	795	962	1205	1457	1715	1835	2095	2522
	Average	5.7	9.4	12.8	15.9	19.2	24.1	29.1	34.3	36.7	41.9	50.4

Appendix 10: Number of leaves in bread wheat (pica flora) grown in vertisol for every 10 day interval until anthesis.

No	Code	Days after planting					
		10	20	30	40	50	Final
1	97	3	7	12	17	18	24
2	93	3	7	14	21	23	30
3	20	3	5	13	29	38	43
4	56	4	8	17	29	38	43
5	48	2	5	9	16	17	24
6	59	3	5	11	23	27	32
7	11	3	6	15	22	23	28
8	75	3	5	11	26	32	39
9	89	2	4	10	22	22	29
10	55	2	4	10	22	32	37
11	63	2	3	7	15	19	23
12	21	2	3	9	22	31	36
13	77	2	5	11	16	20	27
14	45	1	2	5	17	36	41
15	91	3	6	14	25	27	37
16	74	3	7	16	30	31	32
17	08	2	5	16	27	34	34
18	67	2	4	10	18	24	24
19	42	2	5	13	29	30	30
20	44	2	5	14	30	41	42
21	98	3	5	18	39	44	44
44	09	2	6	18	35	48	49
23	19	2	5	12	25	30	31
24	18	3	5	15	33	35	35
25	81	2	5	11	24	30	30
26	03	3	8	18	35	38	38
27	35	3	6	14	24	31	32
28	100	3	7	18	25	31	31
29	85	3	6	16	30	34	34
30	62	3	8	20	46	48	48
31	68	2	5	13	21	24	24
32	54	3	8	18	26	33	34
33	60	3	7	16	36	38	38
34	05	3	7	16	39	40	41
35	23	2	4	10	15	16	16
36	04	3	6	16	32	40	40
37	37	2	4	8	16	18	18
38	39	2	4	11	14	17	17
39	83	2	5	10	16	21	22
40	64	1	3	5	8	10	11
41	38	3	8	22	28	30	30
42	87	2	6	14	21	22	22
43	92	2	4	9	13	15	16
44	99	3	7	15	20	22	24
45	51	3	6	13	20	21	21
46	14	2	5	11	16	18	20
47	41	2	5	11	18	20	21
48	34	3	6	14	19	25	25
49	94	2	5	10	14	18	19
50	73	2	3	5	9	9	9
	T.sum	122	270	644	1177	1389	1494
	Average	2.4	5.4	12.8	23.5	27.8	29.8

Appendix 11: Number of leaves in bread wheat (*pica flora*) grown in nitosol for every 10 day interval until anthesis.

No	Code	Days after planting					
		10	20	30	40	50	Final
1	79	3	5	11	16	18	18
2	71	3	3	5	11	12	14
3	65	2	4	11	18	20	22
4	23	2	3	4	6	7	9
5	98	2	3	6	6	7	9
6	6	2	5	11	20	25	25
7	80	2	3	5	15	17	19
8	43	2	3	5	8	8	9
9	49	2	5	11	20	23	25
10	50	2	2	5	7	12	13
11	15	2	3	4	6	8	10
12	95	2	2	4	6	8	9
13	31	2	3	7	10	13	15
14	10	2	3	6	9	10	12
15	82	2	3	6	11	14	16
16	33	2	3	4	13	16	17
17	16	2	3	6	10	15	17
18	76	2	4	11	24	28	31
19	7	2	4	7	11	14	16
20	26	2	4	10	18	20	21
21	32	3	8	20	36	48	51
22	88	3	8	21	38	40	42
23	66	2	2	3	6	12	14
24	47	2	4	9	21	26	27
25	24	2	3	7	14	17	19
26	13	3	6	17	24	25	27
27	28	2	3	7	14	15	18
28	2	2	4	8	16	19	19
29	1	2	3	8	12	19	23
30	96	2	3	6	10	12	14
31	46	3	3	5	8	9	10
32	27	3	5	12	18	22	23
33	58	3	3	6	7	10	12
34	90	3	5	11	21	25	27
35	12	2	5	12	20	23	27
36	72	2	3	5	9	11	12
37	36	3	4	11	21	28	39
38	69	2	3	4	4	0	0
39	29	2	3	9	16	18	19
40	17	3	4	7	10	12	14
41	57	2	4	8	13	15	16
42	52	3	6	12	17	20	23
43	40	2	4	7	13	13	15
44	53	2	5	11	14	14	16
45	84	3	7	18	26	29	31
46	78	2	3	6	11	12	14
47	61	2	3	6	12	14	19
48	25	2	3	5	11	13	14
49	30	3	6	13	20	22	25
50	22	2	3	5	8	10	13
	T.sum	114	194	418	715	848	950
	Average	2.9	3.9	8.4	14.3	16.9	19.0

Appendix 12: Bread wheat grown in vertisol number of tillers, number of kernel and mass of grain (g) per plant

No	Code	No of Tillers	No of effective Tillers	No of none effective Tillers	No. of kernel	Weight Grain(g)
1	97	3	1	2	67	2.34
2	93	6	3	3	105	3.23
3	20	7	6	1	138	5.0
4	56	8	0	8	18	0.48
5	48	4	1	3	54	1.47
6	59	7	4	3	147	5.4
7	11	5	3	2	122	4.35
8	75	7	3	4	82	2.43
9	89	6	4	2	144	3.94
10	55	7	5	2	136	5.21
11	63	4	0	4	19	0.46
12	21	5	3	2	83	2.75
13	77	4	2	2	78	2.08
14	45	9	7	2	248	9.61
15	91	6	4	2	152	5.5
16	74	8	7	1	312	9.29
17	08	7	6	1	175	6.76
18	67	5	4	1	149	7.63
19	42	6	4	2	148	5.43
20	44	7	6	1	174	7.25
21	98	8	6	2	168	5.37
22	09	8	7	1	150	4.52
23	19	7	6	1	164	6.13
24	18	7	7	0	269	11.4
25	81	6	6	0	223	9.02
26	03	8	7	1	311	12.8
27	35	6	6	0	219	8.63
28	100	7	5	2	138	5.29
29	85	7	7	0	376	16.9
30	62	10	10	0	359	15.1
31	68	5	3	2	102	3.28
32	54	7	7	0	385	8.58
33	60	8	6	2	255	14.62
34	05	8	8	0	331	1.49
35	23	3	1	2	54	13.35
36	04	8	7	1	301	3.48
37	37	3	3	0	113	3.18
38	39	3	2	1	91	2.78
39	83	4	3	1	87	1.49
40	64	1	1	0	54	3.33
41	38	5	2	3	95	3.56
42	87	3	2	1	103	2.86
43	92	2	2	0	82	1.46
44	99	4	1	3	51	1.42
45	51	3	3	0	45	3.39
46	14	4	1	3	110	5.44
47	41	3	3	0	141	6.49
48	34	5	3	2	168	2.73
49	94	3	2	1	79	2.0
50	73	1	1		46	17.4
	T.sum	278	201	77	7621	288.07
	Average	5.56	4.02	1.54	152.5	5.8

Appendix 13: Bread wheat grown in nitosol number of tillers, number of kernel, and mass of grain (g) per plant.

No	Code	No. of Tillers	No of effective Tillers	No. of none effective Tillers	No. of seed	Weight of Grain(g)
1	79	3	1	2	71	2.71
2	71	2	0	2	26	1.08
3	65	4	1	3	94	2.11
4	23	1	0	1	11	0.52
5	98	0	0	0	20	0.82
6	6	5	3	2	65	2.72
7	80	3	1	2	54	2.75
8	43	0	0	0	6	0.13
9	49	4	3	1	138	5.16
10	50	1	1	0	37	1.54
11	15	0	0	0	30	1.26
12	95	0	0	0	18	0.5
13	31	2	0	2	12	0.4
14	10	1	1	0	51	2.21
15	82	2	1	1	50	2.46
16	33	2	1	1	52	2.59
17	16	2	1	1	55	2.78
18	76	5	3	2	101	3.54
19	7	2	1	1	38	1.36
20	26	2	0	2	32	1.18
21	32	8	7	1	141	8.1
22	88	7	5	2	140	7.9
23	66	2	2	0	88	3.41
24	47	4	4	0	131	6.32
25	24	3	2	1	81	3.35
26	13	3	0	3	28	1.1
27	28	3	2	1	126	4.89
28	2	3	3	0	145	6.22
29	1	4	4	0	135	6.51
30	96	2	0	2	29	1.13
31	46	1	0	1	25	0.74
32	27	4	3	1	170	7.29
33	58	1	1	0	46	1.96
34	90	5	2	3	115	4.3
35	12	4	2	2	120	4.49
36	72	1	0	1	35	1.12
37	36	6	6	0	153	5.0
38	69	0	0	0	-	-
39	29	3	0	3	25	0.5
40	17	2	0	2	8	0.3
41	57	2	1	1	27	1.04
42	52	2	1	1	69	2.49
43	40	2	0	2	30	0.77
44	53	2	0	2	31	1.0
45	84	5	3	2	111	3.83
46	78	1	1	0	62	2.1
47	61	3	3	0	138	6.31
48	25	1	0	1	8	0.2
49	30	3	2	1	94	3.51
50	22	1	1	0	26	1.16
	T.sum	129	71	56	3268	134.86
	Average	2.63	1.4	1.2	65.4	2.7

Appendix14: Selected pictures from the research work



a



b

Appendix A: Picture **a & b** were instruments used to collect soil sample from the farmers' field for soil laboratory



c



d

Appendix B: Picture **c & d** were digging out the soil sample types from the farmers' field for soil laboratory.



e



f

Appendix C: Picture e & f preparation of soil for planting seed.



g



h

Appendix D: Picture g & h weighting soil and take of 1kg soil in each plastic pots.



i



j

Appendix E: Picture i & j were the plastic bags (pots) with the two types of soils were arranged on the surface bed on randomized. Design (Lottery methods).



k



l

Appendix F: Picture k & l seedling different growth stage



m



n

Appendix G: Picture m & n Watering each pot every 1 day interval by measures 100ml of water and Count the number of leaves every 10 days interval respectively.



o



p

Appendix H: Picture o & p were heading of bread wheat.



q



r

Appendix I: Picture q& r were measured plant height by ruler (cm).and matured bread wheat respectively.



s



t

Appendix J: Picture s& t were dry bread wheat in vertisol and dry bread wheat in nitosol respectively.