ADDIS ABABA UNIVERSITY

COLLEGE OF NATURAL AND COMPUTATIONAL SCIENCE

DEPARTMENT OF ZOOLOGICAL SCIENCE

Title:- GROWTH AND YIELD RELATED PERFORMANCES OF FABA BEAN(*Vicia faba* L.) VARITES TOWARDS TO DROUGHT STRESS.

Tariku Gashabezaw

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Thesis Approval Sheet

This is to certify that the thesis prepared by Tariku Gashabezaw, entitled growth and yield performance of *Fava bean* towards to different soil moisture level at Sodo woreda, buei district. Accessions Evaluated for Drought Resistance under Greenhouse Condition and submitted in partial fulfillment of the requirement for the Degree of Masters of Science in Biology complies with the regulation of the University and meet the accepted standard with respect to originality and quality. Signed by the Examining Committee:

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As members of the board of Examiners of the MSc in Biology thesis open defense examination, we certify that we have read and evaluated the thesis prepared by Tariku Gashabezaw and examined the candidate. We recommend that the thesis be accepted as fulfilling the thesis requirements for the degree of Masters of science in Biology.

Name	Signature	Date
1, (Advisor) Dr. Awol Assefa	__________	___________
2, (Examiner) Dr. Habtamu Chekol	___________	____________
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Abstract

Fava bean is one of the best sources of protein grain used in human nutrition, as well as a feed. Ethiopia is the second-biggest producer of faba bean, following china. However the production of Fava bean has remained very low compared to the potential production due to living and non-living stresses combined with poor crop management methods. Thus, this research aimed at to examine the impacts of drought pressure on the development and yield performance in different fava bean collected from different agro-ecological zones of Ethiopia. The soil was prepared from soil, manure and sand with the proportion of 2:1:1 ratio. After the field capacity is determined with different moisture regimes of the field capacity level, such as 100%, 65% and 25% were determine morphological biometrics as well as grain yield were determined. Both shoot and root biomasses were dried in the drying over at 70 °C for 24 hrs. Growth measurements was started to collecting data from January 2023 up to April 2023 with across the different water regimes were significant. Analysis of variance result showed that, the measured parameters; number of node, number of tillers, productive tiller, leaf area at different time, number of pod per plant, yield per plant, rhizome dry biomass, steam dry biomass, total dry biomass, total fresh biomass, shoot fresh biological mass, root fresh biomass at different moisture levels were significant ($p<0.05$). Crop height, girth, number of nodule, number of node, rhizome dry biomass, steam dry biological mass, total dry biomass, total fresh biomass, steam fresh biomass, rhizome fresh biomass, number of tillers, productive tillers, green leaf number, leaf area at and yield related measurements evaluated in the shade house. There was no significant difference in plant height among the different fava bean accession at P Value .212. These findings emphasize the importance of effective moisture management strategies in maximizing fava bean productivity and underscore the need for further research to enhance drought resilience in this crop at 188ml (25%)moisture level.

Key words Accession, Biomass, Growth, yield, Moisture, Drought,

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Dedication

This Thesis is passionate to my dear mother Meselech Birbirsa and brothers Sisay and Tamen and sister Ehtalem for their devotion and unending love in inspiring my soul and insuring my future successful

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List of Acronyms

BVP ………………………………………………..Basic vegetable phase

CSA ………………………………………………..Central statistical agency

EIP………………………………………………...Ethiopian biodiversity institute

FAO ……………………………………………...Food and agricultural organization

FDP………………………………………………....Flower development phase

IPCC …………………………………………..Intergovernmental panel on climate change

PIP………………………………………………..photoperiod induced phase

RCBD…………………………………….......randomized complete block design

CHAPTER ONE

Introduction

1.1. Background

Ethiopia is one of the largest faba bean producers and center of secondary diversity. The world's top producers of faba bean (*Vicia faba L.)* are listed below. It ranks in faba bean exports, trailing only in France, Australia, and the United kingdom(FAO, 2016). Faba bean accounts for the majority of pulse acreage (443,966 hectares) and out put (848655 tones) in Ethiopia. Faba bean helps smallholder farmers improve their food and feed security, as well soil fertility. The crop is typically grown in Nitisol and Vertisol dominated areas of Ethiopia, together with grains and field peas. The average national out put of faba bean is approximately 2.1 t ha-1 (CSA, 2018). This is significantly lower than the average yield of 3.7 t ha-1 in major producer nations (FAOSTAT, 2017). Climate, edaphic, biotic (diseases, pests and weeds) and inadequate agronomic techniques are the most commonly cited reasons for low faba bean output in Ethiopia. On the other hand, the on- farm average yield of released faba bean types is up to 3.5 t ha-1 (National Planning Commission, 2016), demonstrating a significant production disparity between farmer managed and researcher managed plots. Furthermore, there is a need to quantify the potential yield of faba bean under different situations in order to assess the amount of the exploitable gap and establish strategies that can boost productivity and achieve yield closure (Cassman et al., 2003).

Fava bean is primarily grown in high altitude areas of Ethiopia with elevations ranging from 1800 to 3000 meters above sea level, Amhara region has the largest pulse area coverage (43.7%) and contributes to the highest production (47.0%) in the country followed by the Oromiya region, with 38.0% of the area and contributing 39.0% of national production (Mussa and Gemechu, 2006). Agriculture particularly in Ethiopia is highly dependent on variable and unpredictable rainfall. Owing to the reduction of the rainfall compared with the long term average, national food production is reduced by 4.4% (Abdelmula A and Abuanja IK (2007)). As a results, small-scale farmers must come up with strategies to overcome these obstacles in order to guarantee food security and sustainable livelihoods. Over coming this environmental challenge through suitable intervention methods is essential for fostering resilience and enhanceing food and nutritional security(Ashenafi M, Mekuria W (2015).).

Poverty was getting higher in rural areas by 39% compared with the urban areas. *Fava beans* has multiple advantages, it is consumed as diary seeds, green vegetables, or as processed food. Its products are a rich source of high quality protein in the human diet that ranges from 24-33% and used as animal feed (Sainte, 2011). In spite of its numerous advantage and the existence of high-yielding varieties, the productivity of fava bean has remained significantly lower than its potential. The average national yield of fava bean under small –scale farmers farmer is very low and according to the production–ecological approach (Talal AB, Munqez JY (2013)), there are three yield levels of crop yield, namely, potential (Yp), water limited (Yw) and actual yields (Ya) that explains potential, water limited and actual production levels as function of yield defining, yield limiting and yield reducing factors, respectively. This article is examined with the aim of identifying the effects of drought on the development and yields of fava bean and to choose drought tolerant fava bean in the study area

1.2. Statement of the problem

Faba bean (Vicia faba L.)is one the most significant legume as the source of protein. Different growth performance and yield variability are the most major problems in growing *fava beans*. Shortage of water is more prominent in tropical countries including Ethiopia and subtropical semiarid and arid climates, in which water losses through evaporation and evapotranspiration are high (Mavi and Tupper2004)). Drought, which can occur at any stage during plant growth, reduces pod yield and pod quality of common bean. Drought reduces the number of flowers, pod setting and leaf area and at the end reduction of yields in bean by 51, 63 and 60%, respectively (Manzoor,Q. ,2013).

In this research, the effect of moisture stress on growth, biomass partitioning and yield related variation among the different fava bean was under controlled conditions and the research was showed the effects of drought stress or water logging on the general plant growth performance and yield .

1.3. Significance of the study

Drought stress affecting the growth and yield potential of faba beans (*vicia faba. L).* Increased production can be achieved by maintaining an optimum plant population across diverse planting patterns. The optimum plant density is the smallest number of plants required to provide maximum yields.. Faba bean is cultivated in most parts of Ethiopia with a wide range of variation in altitude, rainfall, temperature, cropping system, and socioeconomic factors. It is essential to assess the pattern of character variations among and between the different to screen the best drought stress tolerant type where rainfall is the most difficult challenge in many areas of Ethiopian where the crop is grown.

1.4. Research questions

1. How do drought stress affect growth of fava bean?
2. Is there a difference among the different fava bean interims of growth when subjected to drought stress?
3. What are the response mechanisms of fava bean to drought stress?
4. Is there any different among the different fava bean in response to drought stress among the different fava bean collected from different agro ecological zone of Ethiopia

1.5. Objectives

1.5.1. General Objective

- The general objective of this research is to evaluate the effect of drought on growth and yield related performance of faba bean collected from different agro ecological zone of Ethiopia low water moisture levels.

1.5.2. Specific Objectives

- To evaluate growth performance of different *faba bean* accessions towards to different moisture levels
- To determine yield and yield related performances different faba bean accession.
- To evaluate the effect of drought stress among faba bean accessions.

UNIT TWO

2. LITERATURE REVIEW

2.1. Faba Bean Origin and World Distribution

The Faba bean plant, also known as the broad bean or fava bean,is believed to have originated in the ancient civilization of the Middle East, dating back around 6,000 years (Multari et al., 2015). The faba bean plant, also cultivated as globally and occupies the third- place spot as the most importan grain legume (Gu et al., 2020). According to FAO (FAOSTAT 2012), global faba bean production reached 4.3 million originating from a total cultivated area of 2.55 million hectares. The faba bean has an average yearly 1,960 kg/ha and a global production area of 2,511,813 ha, which translates to a crop output yield of 4,923,154 tone/year with 36.7% of the world's output, China is the leading faba bean producer with 36.7% of the global output, china is the top producer of faba beans, followed by Ethiopia (20.1%), the UK (8.2%), and Australia (7.7%) (FAO, 2018).

Fava beans are popular breakfast foods in the Middle East, Mediterranean region, China and Ethiopia. The most fava bean meals include Medamis (stewed beans), Falafel (deep fried cotyledon paste with vegetables and spices), Bissara (cotyledon paste poured onto plates) and Nabet soup (boiled germinated beans) (Hawtin and Hebblethpiait, 1983). Fava bean was occasionally cultivated for green manure, but mostly for stock feed (Prabhu, S and Rajeswari, D. 2018). Large-seeded varieties are utilized as vegetable. In india, roasted seeds are consumed as if they were peanuts. In Egypt and Sudan, fava bean Straw is considered a cash crop and is sold at premium. In Sudan and Ethiopia, straw is also used to make bricks and as afuel (Hulse, 1994). Cultivated fava beans are utilized as human food in underdeveloped nations and as animal feed industrialised countries, primarily for pigs, horses, poultry and pigeons(Singh and Bhatt, 2012). It can be consumed as a vegetable, green or dried, fresh or tinned(Gasim and Link, 2007).

Vicia fava L is found in the Central Asian, Mediterranean, and South American centers of diversity and is thought to be a native to North Africa and southwest Asia, as well as widely grown abroad(Zohary and Hopf, 2000). Afghanistan and Ethiopia are thought to be secondary diversity hot spots. Nowadays, fava bean is widely farmed in temperate and subtropical countries as well as greater altitudes in the tropics. It is primarily widespread in east Africa, particularly Sudan and Ethiopia (Musa and Gemechu, 2006). The primary producing countries of fava beans in the world are China, Ethiopia, Egypt and Australia in the decreasing order of their production potential (Hawtin and Hebblethwaite , 1983). Fava bean is one of the oldest food legumes and has been cultivated since antiquity, mainly for human consumption (Musa and Gemechu, 2006). Faba bean serve as primary source for human consumption and multiple purposes, including as a food source and as green manure for improving soil fertility in poor soil condition. The Chinese used them for food since 5,000 years ago, and they were cultivated by the Egyptians 3,000 years ago (Chafi and Bensoltane 2009). Wild progenitor and the exact origin of faba bean are unknown. However, certain wild species (Vicia narbonensis L. and V. galilaea Plitmann and Zohary) are taxonomically similar to the cultivated crop, but they have 2n = 14 chromosomes, whereas farmed faba bean has 2n = 12 chromosomes. Although vicia is commonly classified in the same genus as the vetches, some botanists consider vicia to be a different monotypic genus known as fava sativa Moench (Zohary and Hopf, 2000).

2.2. Biology, taxonomy and ecology of Vicia faba. L

Vicia fava is an annual herb with coarse and upright stems that grow unbranched 0.3 to 2 m tall and have one or more hollowed stems from the base. The leaves are alternating,, pinnate and consist of 2 to 6 leaflets each up to 8 cm long. Unlike most other members of the Genus, it lacks or has rudimentary tendrils. The plant blooms lavishly, but only a small percentage of the blooms develop pods. Flowers are big, white with dark purple markings, and are borne on short pedicels in clusters of 1-5 on each axillary raceme usually between the 5th and 10th node. Each flower cluster produces 1-4 pods, and growth is indeterminate, though determinate mutants are available (Hanelt and Mettin, 1989). Bumblebees are the primary insect pollinators, and around 30% of a population's crops are cross fertilized. There is a strong tap root with several branched secondary roots. Based on seed size, two subspecies were identified:, paucijuga and faba. Vicia faba has a diploid (2n) chromosomal number of 12, which means that each plant cell contains 12 chromosomes (6 homologous pairs). Five pairs of acrocentric chromosomes and one pair is metacentric (Alghamdi, 2009).

The current available statistics show that faba bean is ranking fourth among cool season food legumes with global dry grain production of 4.84 million tons in 2017 (FAOSTAT 2020), though this probably grossly underestimates the nutritional and societal importance of the species as a majority of faba bean worldwide is cultivated and consumed locally by local farmers in India, china, south America and many Mediterranean countries for vegetable purposes. Furthermore, FAOSTAT figures related to faba bean do not have specific data for large-seeded types consumed as green grains and pods.

The faba bean (*Vicia faba* L.) is grown widely under a range of climatic conditions from temperate to subtropical and it hosts a wide variety of regional, native and exotic cosmopolitan insect pests, fungal pathogens and viruses as well as parasitic weeds. The three broad types of faba bean, Mediterranean-adapted, cool-temperate winter, and spring, are exposed to different pests and diseases at different times of their growth cycles. Mediterranean and winter-type faba beans are sown in autumn in conditions of abundant but declining pest activity, that then remains relatively low until temperatures increase in early spring.

In the event that each flower on each fava bean plant generated a pod and each of those pods produced three seeds, the yield of the crop would be approximately ~38–43 t/ha (Patrick and Stoddard 2010). The explanation lies in the amount of sunlight reaching the leaves near open flowers over the subsequent three days. Those foliage leaves undergo photosynthesis and produce sugars that nourish the blossoms. If there little to no photosynthesis, then there are insufficient sugars produced to support pod development. It is not uncommon for less than 20% of the flowers set by fava beans to mature into pods (Hawtin,G and Hebblethwaite, 2008).

Fava beans are both self and cross-pollinated, so poor pod set cannot always be attributed to the absence of bees. In certain situations, a lack of bee or pollinator activity, resulting from either the absence of bees or environmental factors might decrease yield. A significant portion of the flowers that a bean crop sheds have been pollinated. In the early stages of planting, Fewer seeds are placed on each node for crops that are sown earlier. During a low seeding yields results in more seeds being set per node at lower nodes, however at higher sowing rates, seeds more evenly distributed along the stem. This implies that aligning the variety in conjugation with the time of sowing and sowing rate is particularly crucial with fava beans. Utilizing a high sowing rate with early sown produces and densely growing crops early in the period that shade the flowers, decreasing pod set and thus the maximum yield(Huang, et al, 2016).

2.3. Faba bean production in Ethiopia

Fava bean is one of the most popular legumes, planted during the main season on both red and black soils especially in Oromia, Amhara, Tigray, and SNNP regional states (IFPRI, 2010). It is grown atelivations ranging from 1300 to 3800 meters, with the majority of it occurring between 2000 and 2500 meters(Musa and Gemechu, 2006). Rust is the greatest production constraint below 1800 meters, and frost above 3000 meters. Fava bean requires 700–1000mm rainfall per year, with more 60% of that coming during the growth season. Fava bean has four key purposes in agro-ecosystems: providing protein rich food and feed; giving Nitrogen to agro ecosystems through symbiotic N2 fixation with Rhizobium bacteria to boost soil fertility; diversifying the crop system to minimize constraints on the growth and productivity of other crops in the rotation; as well as minimizing fossil energy usage for agricultural production. Furthermore, fava beans are planted for green manure, which can greatly boost cereal and other crops (Wani et al., 1994).

Fava beans indeterminate growth patterns allows for lengthier nitrogen assimilation, reaching around 315 kg N ha^{-1}after 110 days. The nitrogen concentration in the fava bean crop biomass was around 5% a few days before flowering; during the initial stages (30 days) of reproductive growth; the nitrogen concentration rapidly decreased to c. 2.5–3%, due to the biomass accumulation rate being faster than the N assimilation rate, and the N concentration remained at this level until maturity (Knaak et al., 1993). Fava bean accumulates nitro from nitrogen fixation at an increasing rate until the commencement of the maturity phase, unless other factors such as water availability hinder the N2 fixation process early in growth (Anetoun and Prevost, 2005).

2.4. Nutritive value of faba bean (Vicia faba L.)

Fava Bean (Vicia faba) is important and affordable source of plant protein for human and cattle diets, cool-season annual grain legume crop (Gu et al., 2020). While Fava beans can be grown in any climate (Singh et al., 2013), soybeans do not grow well in cool climates and perennial forage legumes do not do well in high altitude environments with short growing seasons (less than 100 days) According to Duc et al. (2015), the ideal growing environment for the faba bean plant is thought to be cool and damp.

Furthermore, fava beans can be grown in a variety of soil environments, particularly in regions with the worst soil types in whereby wheat and barley yield subpar results (Castanon et al., 1990). Furthermore, fava bean plants are unique in that they have the highest N fixation efficiency of any cool-season legume. This means that fava beans can help reduce the use of commercial N fertilizers by offering ecosystem services that support sustainable agriculture (Khazaei et al., 2019).

2.4.1. Nutritional Composition of the faba bean

In human diets, Fava beans are a significant source of nourishment. In order to reduce feed prices and provide a steady supply of feed for animals, it offers the livestock sector an alternative source of protein and energy(Etemadi et al., 2018).

The main components of the approximate nutritional content of faba bean seeds, which ranges from 210–341 g/kg dry matter, are globulins 61.35% crude protein and albumin 20.02% crude protein. The main carbohydrate components of faba bean seeds are starch, total sugars, and fibre. The total carbohydrate content of the seeds ranges from 457 to 701 g/kg dry matter. Further more, fava bean seeds are an excellent source of dietary minerals, specifically potassium, phosphorus, iron, and zinc(Gasim, S et al, 2015).

Iron and zinc are necessary for human and animal nutrition as well as appropriate physiological function. The faba bean seeds have gross energy contents ranging from 14.69 to 19.70 MJ/kg dry matter and from 11.30 to 13.80 MJ/kg DM, respectively and metabolizable energy(ME) values. The particular genetic composition of cultivar, the planting environment, and agricultural management techniques all have major impact on the germination of faba bean seeds and Faba beans seeds have higher levels of crud protein, dietary, potassium, iron,and folic acid than common grains including rice, corn, and wheat (Howard et al., 2018).

2.5. Impact of drought on growth and yield of *Fava Bean*

Global warming has a negative impact on water supplies and agricultural yields worldwide (IPCC, 2019). Fava bean may be particularly susceptible to climate change because it is a cool-season legume produced as a short-season crop in many cropping systems. Fava bean is a classic Middle Eastern crop that provides a significant amount of protein for both humans and animals(Multari, et al, 2015). To analyze the possible impact of climate change on fava bean, it is required characterize the plant processes sensitive to temperature and rainfall variation. In other crop species, sensitivity to air temperature and rainfall has been critical in developing of crop models that take in to account crop phenology, leaf area growth, plant gas exchange, and symbiotic nitrogen fixation. Drought can alter plant leaf area by influencing the rate of leaf appearance, as defined by the phyllochron, as well as the rate and duration of individual leaf expansion (Craufurd et al., 1997).

In fava bean, a linear rise in main stem node number versus cumulative drought units has been observed (Dennett et al, 1979). These interactions follow a curvilinear pattern, with low increases in leaf area at low leaf numbers and growing to bigger leaf area when larger leaves are generated at successive nodes. However, no allometric connection to estimating leaf area in fava beans has been recorded. Soil drying can have a significant impacts on plant water use. A popular way to express transpiration sensitivity to soil dryness is using volumetric soil water content. Plant responses to soil drying are typically represented by two linear segments with an initial plateau of little sensitivity to soil drying followed by a linear drop. The threshold for decreased transpiration rate varies by genotypes. A high threshold enables the crop should be water conservative so that there is enough water in the soil to sustain crop physiological activity during late-season droughts. Fava bean is often grown in low rainfall areas, nonetheless, a lack of such information is a significant barrier to defining possibility for enhancing fava bean productivity, especially if climate change causes higher variability(Bailey et al., 2015).

In comparison to leaf gas exchange, symbiotic nitrogen fixation in grain legumes might be particularly sensitive to soil dryness. Nitrogen fixation rates have been reported to decrease at high soil water concentrations, resulting in losses of the crucial nitrogen input for these species generating high protein seeds. The only published data on fava bean nitrogen fixation response to soil water content came from a single cultivar experiment. In that research, fava bean nitrogen fixation was found to be significantly more resistant to soil dryness than transpiration rate(Elsheikh, E.A.E et al 1999).

2.6. Major *Fava Bean* Production Constraints in Ethiopia

The majority of Ethiopian farmers cultivate local Fava bean Varieties. However, most local fava bean land races are highly susceptible to biotic and abiotic factors end up with reduction of yield (Rajian, K et al. 2012). The development and productivity of faba bean plants are influenced by various abiotic factors including soil acidity, waterlogging, forestation, and deficiencies in essential soil nutrients, limited external inputs, poor agronomic practices employed by farmers, and moisture stress. Factors like climatic, edaphic practices that are not independent of each other and interact to affect the chemical characteristics of the soil (Jensen et al., 2010).

Environmental factors (light, temperature, water and soil) greatly affect plant growth and geographic distribution. Thus, determine the suitability of a crop for a particular location, cropping pattern, management practice, in order to maximize the production of any crop, it is important to understand environmental factors that affect plant growth and development the impact of different abiotic stresses needs to be assessed in order to design appropriate breeding strategies (Mihailovic, V. et al., 2016).

Production bottlenecks for fava bean in Ethiopia are numerous and can be categorized as cultural, biotic and abiotic factors. Diseases such as chocolate spot (Hotrytis Hbae), black root rot (Fusariwn solani), Rust (Urotnyces fabae) and insect pests: African bollworm (Helicoverpa annigera) and aphids (Acyrthosiphon pisum) and abiotic factors: waterlogging, frost, hail damage, and poor soil fertility are the major faba bean production constraints in Ethiopia (Yohannes, 1997). Despite the immense economic and ecologic merits, the productivity of fava bean in Ethiopia is far below the potential due to a number of biotic and abiotic constraints, socioeconomic constraints in smallholder farms and inadequate technological interventions (Basha and Dembi, 2017). Productivity of fava bean is far below expected potential due to low input usage, natural disasters like snow storm, depletion of macronutrient from cultivable land and unavailability of essential nutrients such as phosphorus. The productivity of fava bean is also constrained by low soil pH associated with low P availability. Acid soils occur widely in the highlands of Ethiopia where the rainfall intensity is high and the land has been under cultivation for many years. The with pH values of less than 5.5, resulted in low fava bean yields compared to other fava bean growing areas of the country (Tadele et al., 2016). The reduced yield in faba bean cultivation is influenced by lack of essential nutrients, including phosphorus(P), calcium(Ca), and magnesium(Mg), or toxicity of Al, Fe and Mn. As a result, P deficiency is one of the most widespread soil constraints in these soils(Caddish, G. 1990).

2.7. Breeding *fava bean* for drought tolerance

Drought is a significant biotic stress that poses a threat to crop production globally, and it negatively impacts the growth and yield of plants. It can be caused by various nonliving stress factors, as well as by global warming. Dray lands cover over 40% of the world and more than 50% of the average yield of most major crops is lost due to drought stress (Asefaw and Tesfaye, 1994). Faba bean is relatively sensitive to water deficit among legume. Drought stress cause inhibition of photosynthesis by altering pathway stomata closure and decreasing flow of CO_2 in to mesophyll tissue and also by impairing the activity of ribulose-1,5-bisphosphate carboxylase/oxygenase (Anil,K.S et al, 2004). Also, respiration, translocation, ion uptake, carbohydrates, nutrient assimilation and growth promoters are disturbed under stress. A range of molecular, biochemical, and physiological processes are involved in faba bean plant's complex tolerance to abiotic stress (Razamijoo et al., 2008).

In Ethiopian, several significant production areas for fava beans are situated in regions prone to drought, such as the northern part of the country. The issue is not only the scarcity of rainfall but also the irregular distribution, which often does not follow a predictable pattern of occurrence. According to Razmjoo et al. (2008), the ability of faba beans to with stand biotic stress is a multifaceted trait that involves several molecular, biochemical and physiological pathway.

The distribution of rainfall during the growing season has more significant impact on crop productivity than the total amount of rainfall received. To enhance crop performance, it is crucial to comprehend how different crop species react and adapt to drought condition. The fundamental aspects of drought adaptation for plant breeders and crop physiologists lies in altering the morphology and physiology of crops to match their environment, thereby managing water economy through stomata and regulating water uptake by roots (Attila, Y et al, 2014).

2.8. Fava bean growth and physiology

In warm temperatures and subtropical regions, Fava bean is cultivated as a winter annual. In the Mediterranean region, more resilient cultivars can withstand winter temperatures as low as -10^{o}C with out sustaining significant damage. On the other hand, the hardest European cultivars can tolerate temperatures as low as -15^{o}C(Robertson et al. 1996). Although typically grouped together in the same genus, vicia, with the vetches, some botanists categorize it in a distinct monotypic genus, faba. In many English speaking regions, the term “broad bean” is employed to describe the large-seeded cultivars cultivated for human consumption, whereas “horse bean” and “field bean” refer to cultivars with smaller seeds, which are either used for animal feed or human food. The broad bean, also known as the faba bean, is a legume originating from the Mediterranean region. It has a robust flavor and is used in various human dishes, such as falafel. The term “faba bean” is commonly used in united kingdom(Krogman k.k 1980). The classification of faba beas can vary based on seed size, with recognized subspecies: paucijuga and faba. Faba has been further divided in to three varieties: Vicia faba var. minor, vicia faba var. equine, and vicia faba var. Major, based on seed size. Taxonomically, the crop falls under section faba of the Genus vicia. Cubero initially proposed four species: Vicia faba ssp. minor, Vicia faba ssp. equina, Vicia faba ssp. major, and Vicia faba ssp. paucijuga (McEwen, J., 2011).

2.8.1 Growth stages of *fava bean*

The reproductive phase of a faba bean plant begin when it starts to flower at any node. The standard description of the development of a faba bean plant aids research planning and communication and assists extension recommendations for the timing of cultural practices. Germination is hypogeal, with the cotyledons remaining below the soil surface (Ivarsson, E. 2018). This enabeles it to emerge from sowings as deep as 25cm. In drier regions, faba beans are sown deep because surface moisture is often inadequate to enable crop germination and establishment node at which the first leaflet arises from the main stem above the soil is counted as node one. Anode is considered developed when leaves are unfolded and flattened out. Scale leaves at the base of plant and close to the ground are not counted as true nodes. In faba beans alternate primary branch(tillers) usually originate frome the base just above ground level(Keating, J.D.G and C.P Shaykevion, 1997).

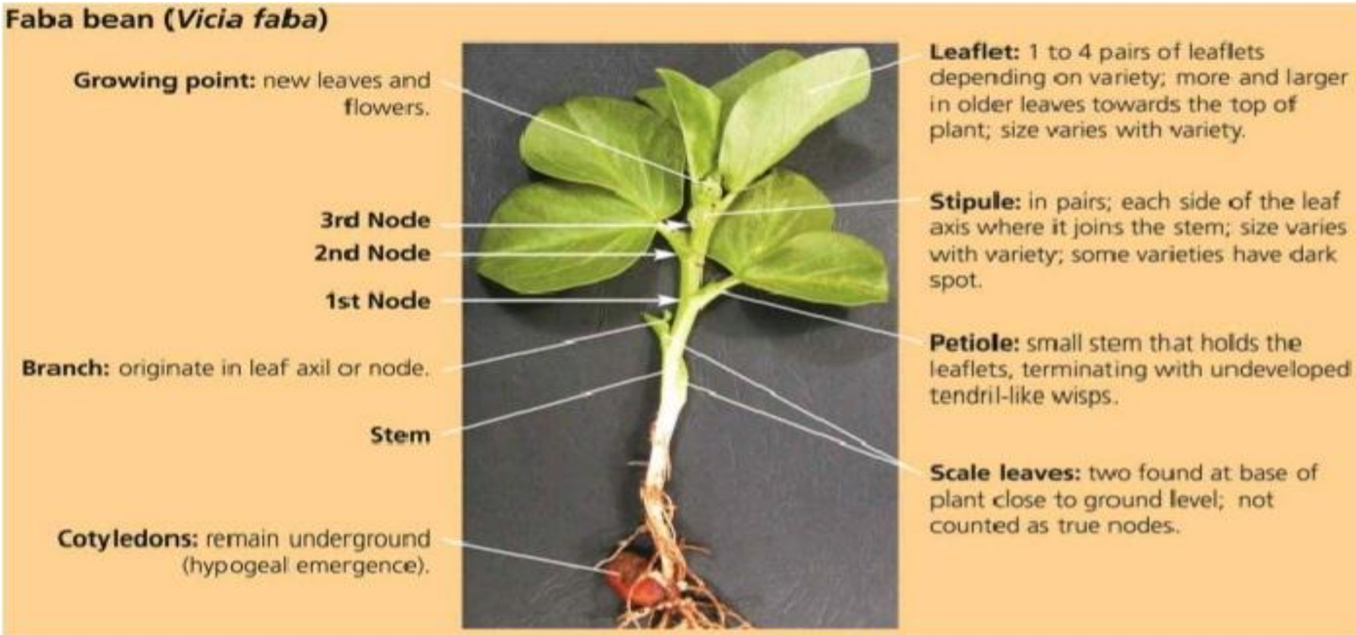

Figure 1 early developmental phase (Bowcher and Holding (2004)

The different varieties of faba bean typically exhibit either indeterminate or semi-determinate growth habits. Indeterminate plants continue to grow vegetative even after they begin to flower and produce seeds, while semi-determinate plants will continue to grow vegetative for a period after flowering begins but will eventually terminate before moisture becomes limiting(Ritchie, 1981). Flowers of faba bean are white with some purple or black markings and are borne on a peduncle that arises from nodes. The flowers are bothself pollinated and cross pollinated, which means that they can be pollinated by either wind or insects. Globally faba beans are popular, particularly in the Mediterranean region, where they have been cultivated for thousands of years. They are a valuable source of protein ,fiber, and other essential nurtients, making them a popular choice for vegetarians and vegans. Faba bean can be eaten fresh, cooked,or dried, and they can be used in a variety of dishes, from salads to stews(Shiferaw et al. 2013).

2.8.2. Plant improvement

Plant longevity is significantly influenced by Drought, resulting in varying times from planting to harvest under divers temperature condition. The idea of heat units is the method employed to represent a crop’s need to accumulate a minimum time for development throughout each crucial growth phase (e.g., vegetative or reproductive growth). Therefore, plants cultivated in cooler air temperatures typically need more time to mature compared to those grown in warmer temperatures. The progression to flowering in fava beans is substantially affected by temperature and the accumulation of heat units ((max T° – min T°)/2, assuming a base temperature of 0°C) (McDonald et al., 1994).

Thermal time, also known as heat units, degree-days or growing degree-days is a measure used to track the the accumulation of heat in growing season. It is commonly used in agriculture to predict the timing of various stages in plant development, such as flowering and maturity. The base temperature for calculating thermal time for faba bean is 0°C. Once aspecific number of certain degree-days have been accumulated, flowering begins, but the exact number of thermal units required varies depending on the location, photo period, and variety. The flowering of plant is regulated by the accumulation of thermal units. Once a sufficient number of heat units have been accumulated, the plant enters its reproductive phase and begins to flower(CSA, 2013).

At this stage, the stress tolerance of faba bean is notably diminished. Suboptimal average daily temperatures, typically around 30^{o}C, can lead to flower loss and water stress. Faba beans are particularly susceptible to waterlogging during flowering, exhibiting similar responses to low light or low temperatures resulting in flower and pod abortion, leaf senescence, and reduced pod set and yield. Sowing date and canopy closure are additional factors that can influence pod set and yield. The life cycle of most crops can be divided in to nine stages: i. seeding to sprouting. ii. emergence. iii. vegetative stage (VS), which is unresponsive to day length. iv. A day length-induced phase (DIP), which ends at floral initiation. v. A flower development phase (FDP), which ends at 50% flowering. vi. A brief pause before the start of grain filling. This period is relatively brief in faba beans(Gasim,S., and Link, W. 2007).

The flowering response of faba beans to varying environmental conditions can be represented by the equation: $1/f = a + bt + cp$, where f is the number of days from sowing to first flower, t is the mean temperature and p is the photoperiod. From constant values of a, b and c differ among gene serve as the foundation for responsiveness to temperature and photoperiod(McDonald et al., 1994),

3. Materials and Methods

3.1. Description of the Research Area

The research was conducted at Sodo wereda, and it is located in east Gurage zone in central Ethiopia (CE). It is one of the fourth woredas of east Gurage zone. It is located at 8˚26 5.6"76'N and 38˚36"43.56'E and at an elevation ranging from 1740 to 2900 meters above sea level. The district is bordered on the south by Meskanena and Mareko district and on the west, north and east by the Oromia Region. The administrative center of the district is Buee Town. The annual rainfall varies from 900 - 2000 mm and the annual average minimum and maximum temperature varies from 15˚C to 25˚C.

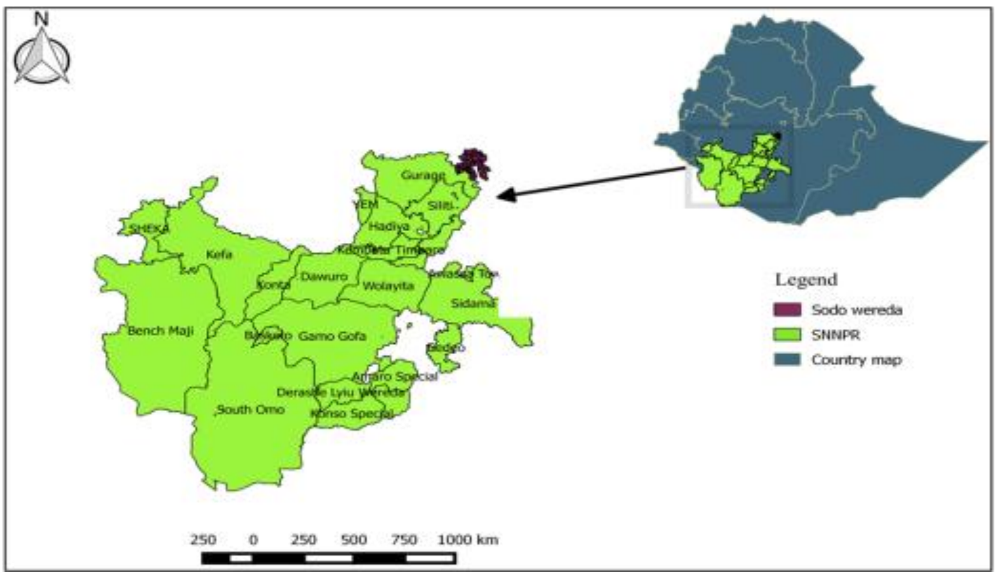

Figure 2 map and position of study area **Source http:/doi.org/10.1371/journal.**

3.2. Experimental Materials and preparations

3.2.1. *Faba Bean* Variety description and seed preparation

A released three Faba bean variety was collected from different areas and kept in seed bank, sterilized area by Ethiopian biodiversity institute. Variety one MST (142) was collected in 2014 for high altitude 2504m of faba bean growing area of Amhara region, Gojam, Variety two WAM (734) was collected in 2017 for mid altitude 1625m of faba bean growing area of SNNP, Gedeo and Variety three DAM (0010) was collected in 2011 for high altitude 2613m of faba bean growing area of Oromia regional state, Arssi and stored in serialized seed bank by Ethiopian Biodiversity Institute (EBI).

3.2.2. Pot preparation

Before sowing the seed their was prepared gallon or plastics with required size were ordered with specific width of 52cm by 32cm height and the required quantity (Kg) at one of painting plastic gallon. There were 27 total white painting plastic gallons are required and they were prepared.

3.2.3. Soil, sand and compost (animal dung) preparation

Soil was collected from the surface of cultivable land at 0-20 cm depth, dried and crushed by pestle and mortar and sieved because it is the most fertile layer of the soil. Their was different components that were prepared like soil ,sand and animal dung. The ratio of soil, sand and animal compost were, 2:1:1 respectively.

3.2.4. Experimental design

The experimental treatment was arranged in Randomized complete block design (RCBD) with three replications to provide estimate treatment effects or measure the effects of water on growth performance of faba beans variety. There are three variety of common beans that are obtained from EBI and I was prepared 9 pots at each three accession and totally 27 pots were prepared. The experiment was controlled by treating each pot by adding different amounts of water which means that the weight one was measured before adding water in to the pot as W1=.4000gm , and weight two was measured after adding in to water containing container ,as W2= 5700gm , and weight three was measured after putting the pot on open area for tow days as W3= 4950gm. In order to determine the water field capacity there was calculated as W2-W3 = (5700-4950gm) =0.75gm. In mathematical calculation 1g/ml= 1000g=1L=1000ml. The 100%, 65% and 25% of water field capacity was calculated as 750ml, 488ml and 188 ml respectively in volume , water holding capacity of each pots was determined and forming holes at the bottom of the pots and sowing the seed on the prepared pots. Recording was started after germination up to growth till grain yields was harvested. Depending on different growth parameters like, height, number of pods and number of seed per pod, the researcher were measured and compared the growth, yield and identifying the best drought tolerant beans variety from the experiment. The plots was prepared before planting and the field trials laid out in a randomized complete block design (RCBD) with three replications. There were 9 pots prepared at each 3 block and the whole design has 27 pots. These treatments are 100% =750ml, 65%=4.88ml and 25%=1.88ml

Table 1 Experimental design and treatment

Treatment		Varity	Acc. No	No of pot	Seed collected from different Region and zone
%	Water amount in ml				
100%	750ml	Varity one MST 142	24682	3	Amhara,Gojam
		Varity two WAM 734	26861	3	SNNP,Gedeo
		Varity three DAM 0010	16511	3	Oromia, Assela
65%	488ml	Varity one MST 142	24682	3	Amhara,Gojam
		Varity two WAM 734	26861	3	SNNP,Gedeo
		Varity three DAM 0010	16511	3	Oromia, Assela
25%	188ml	Varity one MST 142	24682	3	Amhara,Gojam
		Varity two WAM 734	26861	3	SNNP,Gedeo

		Varity three DAM 0010	16511	3	Oromia, Assela

3.3. Experimental procedure and management practice

The research was started collected data after germination and emerging pairs of scale leaves visible. Their was collected the plant growth performance data at every 15 days at each four months and the data was recorded 8 times from January 21/2023 up to April 21/2023.

3.4. Plant growth monitoring and data collection

The faba bean growth performance was monitored by treating by different moisture level, 750ml, 488ml, and 188ml. Plant growth was evaluated based on non-destructive plant growth parameter such as height (cm), stem girth (cm) number of true leaf counted, leaf width (cm), number of node counted, inter node length and estimated leaf area (cm^2) using three faba bean seedling which were selected randomly per plot because the pot was arranged randomly in their accession and different moisture level. Destructive plant growth parameter was used to separate the shoot from root parts and dry weight (g).

3.5. Data analysis

All the collected data were subjected to the analysis of variance (ANOVA), using SPSS Software (Version 16, SPSS Inc. Chicago USA). Means of each measured data were separated using Tukey's range test at the 95% level of probability to test the significance of the treatments.

CHAPTER FOUR

4. RESULTS

The measured parameters at all the three accessions and three different treatment (moisture level) for the measured parameters for different morphological biometrics are tabulated as follows (Table 2).

Table 2 list of parameters based on accession and their p- value

List of parameters	**N**	**Minimum**	**Maximum**	**Mean**	**St. deviation ±**	P-value
plant height at different time	36	14.0	110.0	53.14	31.89	.212
plant Girth at different time	36	1.7	4.8	3.3	.8704	.167
no of nodule	36	10.0	108.0	47.78	30.965	.013
no of node	36	4.0	39.0	14.53	9.266	.000
no of tillers	36	1.0	4.0	1.58	.649	.011
productive tiller	9	.0	3.0	1.1	1.05	.011
green leaf no	36	2.0	56.0	17.64	14.29	.109
leaf length	27	3.5	9.0	5.99	1.7	.013
leaf area at different time	36	24.0	45.0	32.916	5.25	.000
no of pod per plant	36	1.0	5.0	2.1	1.17	.008
no of seed per pod	36	1.0	3.0	2.19	.749	.719
yield per plant	9	4.0	20.0	14.2	5.91	.000
root dry weight	9	.013	.250	.12	.07	.015
shoot dry weight	9	.04	.4	.22	.138	.011

total dry weight mass	9	.09	.65	.35	.199	.004
total fresh weight mass	9	.19	.98	.678	.308	.000
shoot fresh weight	9	.10	.52	.379	.16	.000
root fresh weight	9	.09	.46	.2989	.15	.000

The overall mean standard deviation with minimum and maximum of the parameters across the different soil moisture levels and accession types were indicated (Table 2). The highest and the lowest plant height were 14 cm and 110cm, respectively and the mean is 53.139 with a minimum of 14.0 and maximum 110.0 and the variation with in plant height at different time is 31.89. The mean plant Girth at different time is 3.31 with minimum 1.7 and maximum 4.8 and the variability with in plant girth at different time is .87. The average number of number of nodule, quantity of node, quantity of pod per plant, quantity of seed per pod and green leaf number is 47.7, 14.5, 2.1, 2.2 and 17.6 with variation within number of nodule, no of node, quantity of pod per plant, number of grain per pod and number of vegetative part is 30.9, 9.3, 1.2, 0.7, 14.3, respectively. The mean number of tillers (from which treatment and productive tillers were 1.6 and 1.1, respectively., the average number of productive tiller and no of tillers is 1.1 and 1.58 of variation within productive tiller and no of tillers is 1.054 and .649 respectively.

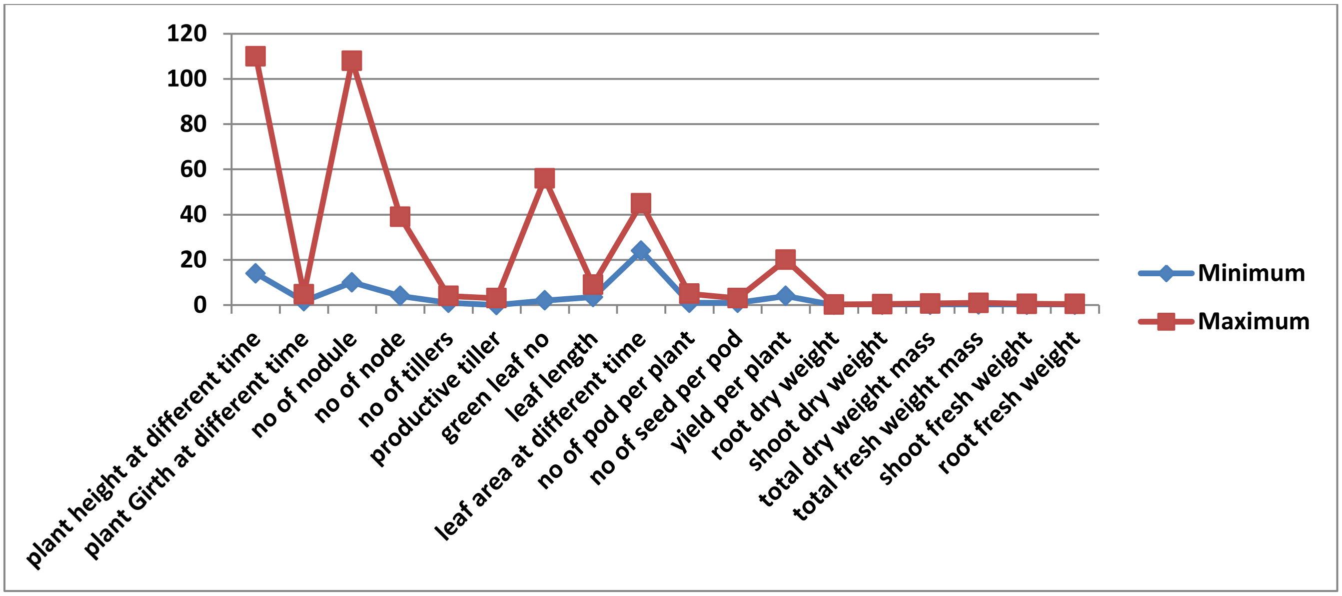

Figure 3 The three accession growth performance

Regarding to leaf length and leaf area at different time the average number is 5.9963 and 32.9 respectively. The variations among accessions have been observed in leaf length and leaf area at different time, which is 1.702 and 5.245, respectively. The yield per plant is 14.2 with variation among accessions is 5.91138. The mean rhizome dried mass, stem dry mass, entire dry mass, total fresh weight mass, shoot fresh weight, root fresh weight also .12, .224, .3456, .6778, .3789 and .2989 respectively.

Table 3 Descriptive statics for mean

List of parameters	**Different accession no**											
	24682				26861				16511			
	Mean	**St. d**	**Min**	**Max**	**Mean**	**St. d ±**	**Min**	**Max**	**Mean**	**St. d ±**	**Min**	**Max**
plant height at different	54.8	32.5	15	104	53.0	33.7	15	110	51.58	32.2	14	108

time												
plant girth at different time	3.41	1.01	1.8	4.8	3.29	.85	1.9	4.3	3.23	.81	1.7	4.2
no of nodule	47.8	34.4	10	108	48.9	31.9	14	105	46.58	29.1	12	98
no of node	15.3	10.9	4	39	15.3	9.87	5	35	12.92	7.27	4	27
no of tillers	1.50	.90	1	4	1.92	.29	1	2	1.33	.49	1	2
productive tiller	1.67	1.15	1	3	.67	1.15	0	2	1.00	1.0	0	2
green leaf no	17.8	14.6	2	43	17.4	13.3	3	45	17.75	16.1	2	56
leaf length	6.43	1.74	4	9	5.86	1.65	3.8	8.5	5.70	1.8	3.5	8.9
leaf area at d/t time	33.3	4.25	27	40	33.8	6.44	25	45	31.67	5.0	24	42
no of pod per plant	2.42	1.38	1	5	2.00	1.21	1	5	1.92	.90	1	4
no of seed per pod	2.50	.67	1	3	2.25	.62	1	3	1.83	.83	1	3
yield per plant	14.33	6.35	7	18	16.00	6.08	9	20	12.33	7.2	4	17
root dry weight	.147	.100	.05	.25	.104	.079	.013	.15	.113	.06	.05	.17
shoot dry	.29	.17	.09	.4	.20	.12	.09	.35	.17	.12	.04	.3

weight	0	3			9	9	7		3			1
total dry weight mass	.44	.27	.14	.6 5	.31	.20	.11	.5	.29	.18	.09	.4 3
total fresh weight mass	.71	.34	.33	.9 8	.69	.33	.31	.92	.63	.38	.19	.8 9
shoot fresh weight	.42	.16	.23	.5 2	.37	.17	.17	.48	.35	.22	.10	.5 1
root fresh weight	.29	.18	.1	.4 6	.33	.16	.14	.44	.28	.18	.09	.4 4

As we have seen from the table 3, the average plant height across the different soil moisture levels in each accession no. The highest and the lowest plant height were 15 cm and 104cm, respectively recorded from accession 24682 and accessions type is 54.8 with a minimum of 15 and maximum 104 and the variation with in plant height at different time is 32.5. The highest and the lowest plant girth were 1.8 cm and 4.8 cm, respectively recorded from accession 24682 and average is 3.41 with a minimum 1.8 and a maximum of 4.8 and the variation with in plant height at different time is 1.01.

The highest average number of nodule, number of node, number of tiller, leaf area at different time, yield per plant and root fresh weight across different soil moisture is 48.9, 15.3, 1.92, 33.8, 16.0 and .33 and the variations among accessions have been observed in number of nodule, number of node, number of tiller, leaf area at different time, yield per plant and root fresh weight, which is 31.9, 9.87, .29, 6.44, 6.08 and .16 respectively recorded from accession 26861. The highest and the lowest number of nodule, number of node, number of tiller, leaf area at different time, yield per plant and root fresh weight were (14,105), (5,35), (1,2), (25,45) and (.14,.44) respectively.

4.1. Comparison of the measured parameters in each different moisture levels

In the table 4 below, the mean comparisons of measured parameters at each different moisture level across the different accession were presented as follow. As we have seen the ANOVA value (Table 4), the mean score of plant height at different time and plant girth at different time are higher at 100% moisture level (where 750ml was applied) compared to other two moisture levels. However, the mean difference of plant height at different time of the three different moisture levels was not significant

Table 4 ANOVA table for measured parameter based on accession and different moisture level

List of parameters	Accession and Different moisture level						P-value
	24682,26861,16511		24682,26861,16511		24682,26861,16511		
	750 ml =100%		488ml=65%		188ml=25%		
	Mean	St. d	Mean	St. d	Mean	St. d	
plant height at different time	62.75	37.9	56.33	31.17	40.33	23.04	.212
plant girth at different time	3.62	.99	3.37	.82	2.95	.72	.167
no of nodule	53.25	37.7	48.58	32.85	41.50	22.67	.658
no of node	19.92	11.0	14.50	7.70	9.17	3.71	.013
no of tillers	2.17	.58	1.33	.49	1.25	.45	.000
productive tiller	2.33	.58	.67	.58	.33	.58	.011
green leaf no	23.33	17.9	18.42	15.34	11.17	6.41	.109
leaf length	6.56	1.5	6.73	1.89	4.70	.85	.013

		1					
leaf area at different time	37.17	4.71	33.67	3.68	27.92	2.07	.000
no of pod per plant	2.83	1.47	2.08	.90	1.42	.51	.008
no of seed per pod	2.33	.89	2.17	.58	2.08	.79	.719
yield per plant	18.33	1.53	17.67	1.53	6.67	2.52	.000
root dry weight	.173	.068	.153	.015	.038	.021	.015
shoot dry weight	.353	.045	.243	.118	.076	.031	.011
total dry weight mass	.53	.11	.40	.11	.11	.03	.004
total fresh weight mass	.93	.05	.83	.02	.28	.08	.000
shoot fresh weight	.48	.04	.49	.03	.17	.07	.000
root fresh weight	.45	.01	.34	.05	.11	.03	.000

The mean differences in number of nodule at different moisture level was not significance with p-value = 0.658, but the average number of nodule at 750 ml =100% moisture level is higher with mean score 53.25 followed by average number of nodule at 488ml=65% and 188ml=25% moisture level orderly. The mean score of green leaf number and number of seed per pod at different moisture level were higher at 750 ml =100% moisture level as compared to other two moisture levels, but not significant in green leaf number and number of seed per pod at different moisture level (Table 4). Thus, the different measured parameters; plant height at different time, plant girth at different time, number of nodule, green leaf number, and number of seed per pod at different moisture levels were not significant at 0.05 significance level.

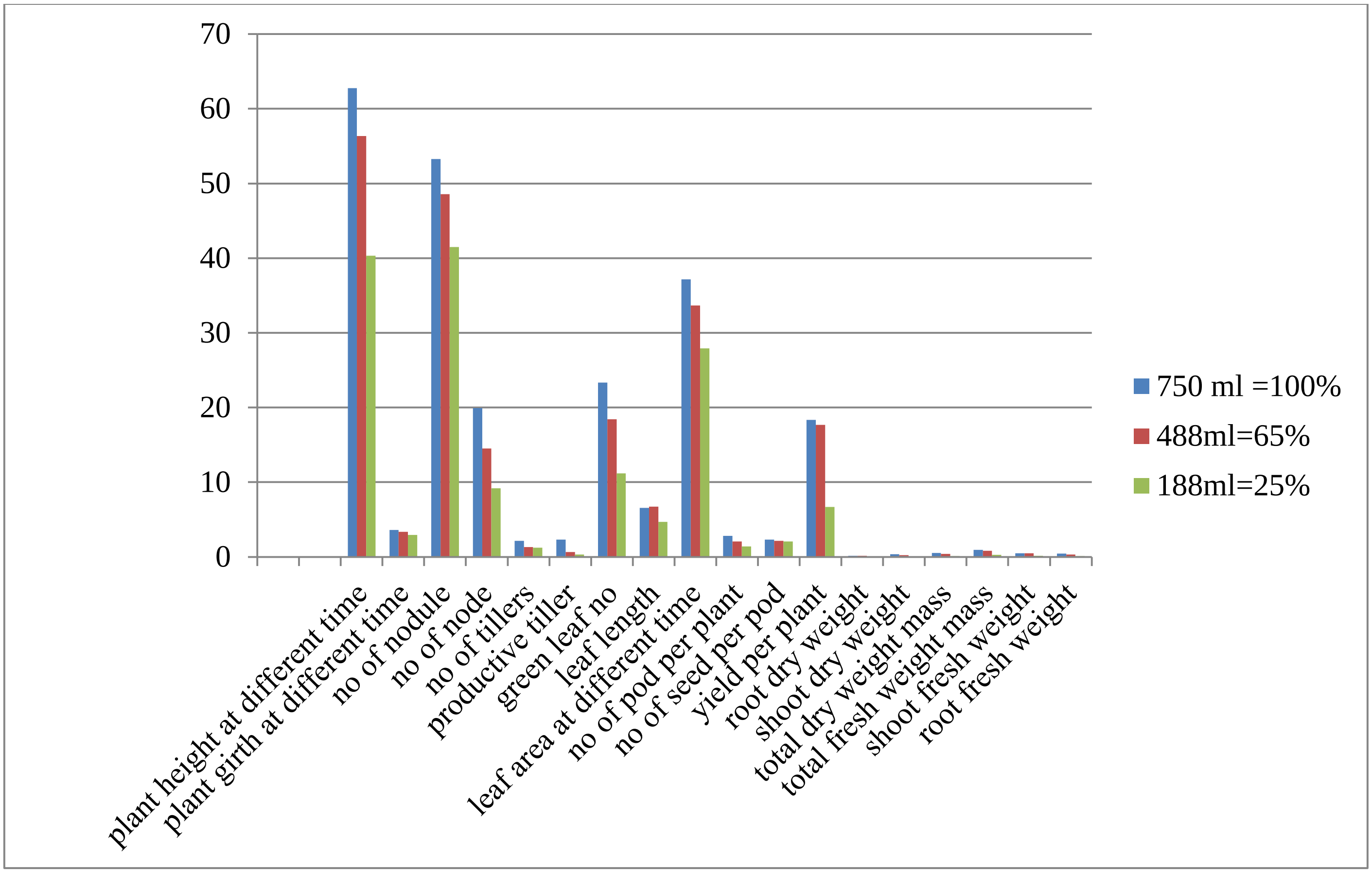

Figure 4 The three accession based on their treatments

Analysis of variance showed that there was significant mean difference of measured parameters; number of node, number of tillers, productive tiller, leaf length, leaf area at different time, number of pod per plant, yield per plant, root dry weight, shoot dry weight, total dry weight mass, total fresh weight mass, shoot fresh weight, root fresh weight in different rate of moisture. As we have seen from the result on Table 4, the mean number of tillers at 750 ml =100% moisture level was 2.17; which is higher than the mean number of tillers at 488ml=65% and 188 ml =25% moisture level. Similarly, the mean number of tillers, productive tiller, leaf length, leaf area at different time, number of pod per plant, yield per plant, root dry weight, shoot dry weight, total dry weight mass, total fresh weight mass, shoot fresh weight, root fresh weight were significantly ($P<0.05$) higher at 750 ml =100% moisture level compared to other moisture regime 488ml=65% and 188 ml =25%. In generally, the growth performance of different faba bean landraces at750 ml =100% moisture level was significantly higher compared to on other moisture regime 488ml=65% and 188 ml =25% moisture level.

4.1.1 Multiple comparisons

Using different morphological biometrics we can apply pair wise comparison to find out which one is different. That is comparing the difference between 100%, and 65% or 100% and 25% or between 65 and 25% water regime levels of the variables which is significance or not. Analysis of variance result above showed that, the measured parameters; number of node, number of tillers, productive tiller, leaf length, leaf area at different time, number of pod per plant, yield per plant, root dry weight, shoot dry weight, total dry weight mass, total fresh weight mass, shoot fresh weight, root fresh weight in different rate of moisture at 0.05 level of significance. The multiple comparisons of those variables are listed below.

Table 5 The multiple comparison for the parameter in all three accession

Dependent Variable and accession	(I) Different treatments	(J) Different treatments	Mean Difference (I-J)	Std. Error	Sig.
no of node **24682,26861,16511**	750 ml =100%	488ml=65%	5.41667	3.41682	.367
		188ml=25%	10.7500*	3.41682	.010
	488ml=65%	750 ml =100%	-5.41667	3.41682	.367
		188ml=25%	5.33333	3.41682	.384
no of tillers **24682,26861,16511**	750 ml =100%	488ml=65%	.83333*	.20821	.001
		188ml=25%	.91667*	.20821	.000
	488ml=65%	750 ml =100%	-.83333*	.20821	.001
		188ml=25%	.08333	.20821	1.000
productive tiller **24682,26861,16511**	750 ml =100%	488ml=65%	1.66667*	.47140	.037
		188ml=25%	2.00000*	.47140	.016
	488ml=65%	750 ml =100%	-1.66667*	.47140	.037
		188ml=25%	.33333	.47140	1.000
leaf length **24682,26861,16511**	750 ml =100%	488ml=65%	-.17778	.69723	1.000
		188ml=25%	1.85556*	.69723	.041
	488ml=65%	750 ml =100%	.17778	.69723	1.000

		188ml=25%	2.03333*	.69723	.023
leaf area at different time **24682,268 61,16511**	750 ml =100%	488ml=65%	3.50000	1.48944	.025
		188ml=25%	9.25000*	1.48944	.000
	488ml=65%	750 ml =100%	-3.50000	1.48944	.025
		188ml=25%	5.75000*	1.48944	.001
no of pod per plant **24682,268 61,16511**	750 ml =100%	488ml=65%	.75000	.42343	.257
		188ml=25%	1.41667*	.42343	.006
	488ml=65%	750 ml =100%	-.75000	.42343	.257
		188ml=25%	.66667	.42343	.375
yield per plant **24682,268 61,16511**	750 ml =100%	488ml=65%	.66667	1.56347	1.000
		188ml=25%	11.6667*	1.56347	.001
	488ml=65%	750 ml =100%	-.66667	1.56347	1.000
		188ml=25%	11.000*	1.56347	.001
root dry weight **24682,268 61,16511**	750 ml =100%	488ml=65%	.020000	.034393	1.000
		188ml=25%	.135667*	.034393	.023
	488ml=65%	750 ml =100%	-.020000	.034393	1.000
		188ml=25%	.115667*	.034393	.046
shoot dry weight **24682,268 61,16511**	750 ml =100%	488ml=65%	.110000	.061523	.372
		188ml=25%	.277667*	.061523	.012
	488ml=65%	750 ml =100%	-.110000	.061523	.372
		188ml=25%	.167667	.061523	.103
total dry weight mass **24682,268 61,16511**	750 ml =100%	488ml=65%	.13000	.07409	.390
		188ml=25%	.41333*	.07409	.004
	488ml=65%	750 ml =100%	-.13000	.07409	.390
		188ml=25%	.28333*	.07409	.026
total fresh weight mass	750 ml =100%	488ml=65%	.10333	.04286	.158
		188ml=25%	.65333*	.04286	.000
	488ml=65%	750 ml =100%	-.10333	.04286	.158

24682,268 61,16511		188ml=25%	.55000*	.04286	.000
shoot fresh weight **24682,268 61,16511**	750 ml =100%	488ml=65%	-.00333	.03801	1.000
		188ml=25%	.31667*	.03801	.000
	488ml=65%	750 ml =100%	.00333	.03801	1.000
		188ml=25%	.32000*	.03801	.000
root fresh weight **24682,268 61,16511**	750 ml =100%	488ml=65%	.10667*	.02841	.028
		188ml=25%	.33667*	.02841	.000
	488ml=65%	750 ml =100%	-.10667*	.02841	.028
		188ml=25%	.23000*	.02841	.001

As we have seen from the result of multiple comparisons on Table 5, from multiple comparisons reported findings reveal significant differences in various plant growth parameters under different soil moisture levels. Specifically, in a 0.05 stage of significance, important differences were observed on root fresh weight and leaf area between 100% and 65%, 100% and 25%, as well as 65% and 25% soil moisture levels. Additionally, the average number of nodes, number of pods per plant, and shoot dry weight differed significant difference between 100% and 25% soil moisture levels. Moreover, the mean differences in number of tillers and productive tillers were significant between 100% and 65%, as well as 100% and 25% soil moisture levels. Furthermore, significant differences were noted in leaf length, yield per plant, root dry mass, entire dry mass, entire fresh weight mass, and steam fresh mass between 100% and 25%, 65% and 25% soil moisture levels. These results underscore the influence of soil moisture levels on various aspects of plant development and productivity, emphasizing the importance of water management practices in agricultural contexts.

4.2. Mean comparison of the measured parameters in each accession number

From table 6, the ANOVA clearly shows that measured parameters; plant height at different time, plant girth at different time, number of nodule, number of node, number of tillers, productive tiller, green leaf number, leaf length, leaf area at different time, number of pod per plant, number of seed per pod, yield per plant, root dry weight, shoot dry weight, total dry weight mass, total fresh weight mass, shoot fresh weight, root fresh weight were not significantly related accession (between groups p-value>.05), we conclude that at least average measured parameters of one accession were not significantly different from the other at 0.05 level of significance. The average plant height at different time and plant girth at different time were higher at 24682 accessions as compared to other two accessions. But, the mean difference of plant height at different time at three different accessions was not significant with p-value = 0.971 and 0.888 respectively. The different accessions have not significant impact on the growth performance of different faba bean landraces in this study.

Table 6 ANOVA table for both accession and treatment

Accession number	List of parameters	Different moisture level					
		750 ml =100%		488ml=65%		188ml=25%	
		Mean	St. Dev.	Mean	St. Dev.	Mean	St. Dev.
24682	plant height at different time	60.00	39.66	61.25	36.80	43.25	26.16
	plant Girth at different time	3.83	1.26	3.38	.99	3.03	.85
	no of nodule	53.75	43.79	46.25	38.37	43.50	29.51
	no of node	21.25	15.11	15.50	9.40	9.25	4.79
	no of tillers	2.50	1.00	1.00	.00	1.00	.00
	productive tiller	3.00	.	1.00	.	1.00	.
	green leaf no	22.00	16.57	19.00	18.89	12.25	9.00
	leaf length	7.00	2.00	7.17	1.76	5.13	1.10
	leaf area at d/t time	34.75	3.77	35.75	4.35	29.50	1.73

	no of pod per plant	3.25	1.71	2.50	1.29	1.50	.58
	no of seed per pod	2.50	1.00	2.25	.50	2.75	.50
	yield per plant	18.00	.	18.00	.	7.00	.
	root dry weight	.250	.	.140	.	.050	.
	shoot dry weight	.400	.	.380	.	.090	.
	total dry weight mass	.65	.	.52	.	.14	.
	total fresh weight mass	.98	.	.82	.	.33	.
	shoot fresh weight	.52	.	.50	.	.23	.
	root fresh weight	.46	.	.32	.	.10	.
26861	plant height at different time	65.25	44.13	54.50	33.77	39.25	24.74
	plant Girth at different time	3.50	1.03	3.38	.93	3.00	.74
	no of nodule	54.50	41.39	49.75	37.01	42.50	23.76
	no of node	22.00	12.78	15.25	8.02	8.75	3.50
	no of tillers	2.00	.00	2.00	.00	1.75	.50
	productive	2.00	.	.00	.	.00	.

	tiller						
	green leaf no	23.25	16.32	18.00	15.41	11.00	6.78
	leaf length	6.33	1.53	6.57	2.18	4.67	.78
	leaf area at d/t time	40.50	4.20	33.25	4.27	27.50	1.73
	no of pod per plant	2.75	1.71	1.75	.96	1.50	.58
	no of seed per pod	2.25	.96	2.25	.50	2.25	.50
	yield per plant	20.00	.	19.00	.	9.00	.
	root dry weight	.150	.	.150	.	.013	.
	shoot dry weight	.350	.	.180	.	.097	.
	total dry weight mass	.50	.	.33	.	.11	.
	total fresh weight mass	.92	.	.85	.	.31	.
	shoot fresh weight	.48	.	.45	.	.17	.
	root fresh weight	.44	.	.40	.	.14	.
16511	plant height at different time	63.00	41.86	53.25	31.90	38.50	25.16
	plant girth at different time	3.53	.91	3.35	.79	2.83	.77
	no of nodule	51.50	37.81	49.7	33.21	38.50	20.73

				5			
	no of node	16.50	9.33	12.75	7.68	9.50	3.87
	no of tillers	2.00	.00	1.00	.00	1.00	.00
	productive tiller	2.00	.	1.00	.	.00	.
	green leaf no	24.75	22.91	18.25	16.36	10.25	4.57
	leaf length	6.33	1.53	6.47	2.45	4.30	.72
	leaf area at d/t time	36.25	5.06	32.00	1.63	26.75	2.06
	no of pod per plant	2.50	1.29	2.00	.00	1.25	.50
	no of seed per pod	2.25	.96	2.00	.82	1.25	.50
	yield per plant	17.00	.	16.00	.	4.00	.
	root dry weight	.120	.	.170	.	.050	.
	shoot dry weight	.310	.	.170	.	.040	.
	total dry weight mass	.43	.	.34	.	.09	.
	total fresh weight mass	.89	.	.81	.	.19	.
	shoot fresh weight	.45	.	.51	.	.10	.
	root fresh weight	.44	.	.30	.	.09	.

5. DISCUSSION

Finding the most drought-tolerant faba bean landraces for low soil moisture levels was the aim of this study. In order to choose and develop accessions tolerant to moisture stress conditions, different morphological and psychological screening protocols have to implement. In my study, different parameters were measured at three different accessions (24682, 26861, and 16511) and moisture levels (188ml=25%, 488ml=65%, 750ml=100%).

The plant height at different time, plant girth at different time, number of nodule, number of node, , root dry weight, shoot dry weight, total dry weight mass, total fresh weight mass, shoot fresh weight, root fresh weight, number of tillers, productive tillers, green leaf number, leaf length, leaf area at different time and yield related measurements (number of pod per plant, number of seed per pod, yield per plant) evaluated in the field were variable for most of the traits considered. For this case, the three accessions were not observed to show significant variation in growth performance of different faba bean landraces. According to Vurayai et al. (2001), accessions have significant relationship between plant height during the vegetative and flowering stages, which is attributed to reduction of stem and leaf expansion contradicts with this study. Earlier studies have also reported that drought had insignificant effect on grain weight but reduced the number of pods per plant or grain per m^2 (Barker and Dennett, 2013; Nachi and Guen, 1996).

Plant height is a vital indicator of overall plant health and vigor. In drought conditions, reduced water availability typically limits cell expansion and elongation, leading to shorter plants. Plant girth, or stem thickness, can reflect the plant's structural integrity and its ability to transport water and nutrients. A consistent girth across accessions under varying moisture levels indicates a shared adaptation mechanism, possibly related to maintaining vascular function during drought.

Nodules are crucial for nitrogen fixation, a process significantly affected by water availability. The lack of significant variation in nodule number among the accessions suggests a uniform response in their symbiotic relationship with nitrogen-fixing bacteria under drought stress. Similar node counts among the accessions across different moisture levels might indicate that their growth patterns are not significantly disrupted by drought, or they have similar strategies for node development under stress conditions.

Root and shoot dry weights are direct measures of biomass accumulation, reflecting the plant's ability to capture and utilize resources. The uniformity in root and shoot dry weights among accessions under different moisture levels suggest that these accessions manage biomass allocation similarly during drought, potentially prioritizing critical functions over growth. The total dry and fresh weight mass combines the effects of both above and below-ground growth. Similar results among the accessions indicate that overall biomass production is not significantly differentiated by genotype under the given moisture conditions. This point to a shared strategy for coping with water stress, possibly through efficient resource use or growth reduction.

The number of tillers and productive tillers are important for yield as they directly influence the number of pods produced. The consistency in these traits among the accessions suggests a similar reproductive strategy under drought stress, potentially focusing on maintaining a stable number of reproductive structures.

The measurement of plant height is crucial for assessing overall growth and development in faba bean plants. Previous studies have demonstrated that plant height can be influenced by various factors, including genetic background and environmental conditions (Salem et al., 2017). In our study, we observed significant variations in plant height across different moisture levels and accessions, indicating the influence of moisture stress on vertical growth (Barker and Dennett, 2013).

Overall, the study contributes to our understanding of faba bean resilience to moisture stress and provides a foundation for further research and breeding efforts aimed at developing drought-tolerant varieties. By identifying promising landraces and elucidating the underlying mechanisms governing moisture stress responses, this research has implications for sustainable agriculture and food security, particularly in regions prone to water scarcity and climate variability.

6. Conclusion and Recommendation

6.1 Conclusion

This research intended to select the best drought tolerant fava bean landraces to low soil moisture levels. Three accessions were observed to show moderate to high levels of tolerance against three soil moisture level. There were also accessions observed at three different moisture rates to be very susceptible to drought stress that wilted before heading. The following accessions and moisture level are selected due to their drought stress resistance such as; 24682, 26861, 16511 and 188ml=25%, 488ml=65%, 750ml=100% respectively, based on the combined measured parameters such as plant height at different time, plant girth at different time, number of nodule, number of node , root dry weight, shoot dry weight, total dry weight mass, total fresh weight mass, shoot fresh weight, root fresh weight, morphological (number of tillers, productive tillers, green leaf number, leaf length, leaf area at different time) and yield related measurements (number of pod per plant, number of seed per pod, yield per plant).

The analysis of variance conducted on the accessions and moisture levels in relation to the measured parameters showed that none of the selected accessions exhibited significant correlations with the growth performance or drought tolerance of fava bean landraces in this study. However, the various moisture levels tested did show significant associations with both growth performance and the drought tolerance of faba bean landraces. The mean score of the measured parameters number of node, number of tillers, productive tiller, leaf length, leaf area at different time, number of pod per plant, yield per plant, root dry weight, shoot dry weight, total dry weight mass, total fresh weight mass, shoot fresh weight, root fresh weight were significantly different towards each moisture levels, which mean the average score of the measured parameters higher at 750ml=100% moisture level. The rate of moisture 750ml=100% has significant influence on yield and yield related performances of fava bean landraces and different moisture levels have significant impact on the growth performance of different fava bean landraces.

6.2 Recommendation

Based on the results and conclusion, the subsequent suggestions are presented;

- a comprehensive assessment of fava bean performance using various morphological and yield-related parameters proved valuable in this study. Future research efforts should continue to employ multi-parameter evaluations to capture the nuanced responses of fava beans to moisture stress accurately.

- Investigating the genetic basis of drought tolerance in fava beans could provide valuable insights into the underlying physiological mechanisms.
- Understanding the impact of different moisture levels on fava bean growth and yield performance is crucial for implementing effective moisture management strategies.
- Conducting field validation experiments and on-farm trials is essential to confirm the performance of selected faba bean landraces under real-world conditions. Collaborative efforts involving farmers, extension services, and research institutions can facilitate the adoption of drought-tolerant varieties and promote sustainable agricultural practices.
- By addressing these recommendations, further studies should be conducted in the growth performance of fava bean landraces and identify other accessions and moisture level on the best drought tolerant fava bean landraces to low soil moisture levels that are not considered in this study.

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Appendices

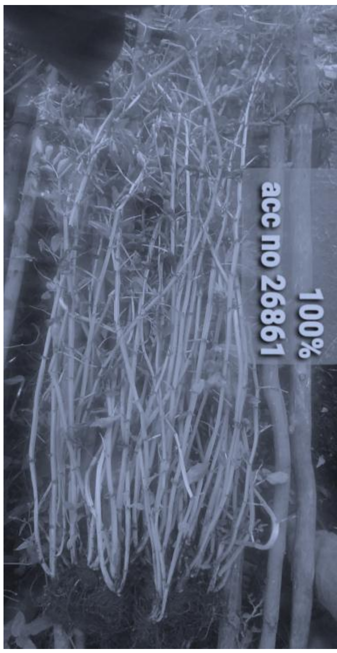
Table 7:- appendix , faba bean accession and passport data

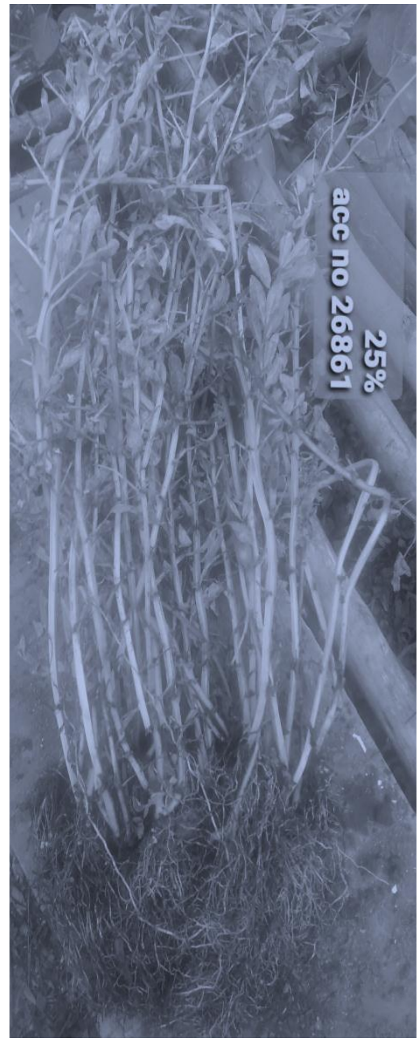
Accession No	Genus	Species	Region	Zone	Woreda	Latitude	Longitude	Altitude	Remark
16511	Vicia	faba	Oromiya	Arssi	Gedeb Asasa	07-12-07 N	39-09-26-E	2613	
24682	Vicia	Faba	Amara	Misrak Gojam	Enese	10-57-57-N	38-02-19-E	2504	
26861	Vicia	Faba	SNNP	Gedio	Wanago	05-33-07-N	37-54-17-E	1615	

Appendix 1 recording the growth

Appendix 2 recording the growth

Appendix 3 the growth of faba beans





Appendix 4 total dry and fresh biomass