ADDIS ABABA UNIVERSITY
COLLEGE OF NATURAL AND COMPUTATIONAL SCIENCES
DEPARTMENT OF ZOOLOGICAL SCIENCE

The effects of compost application on growth and yield performances of Lupin (*Lupinus albus*L.)

By

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August, 2021
Addis Ababa, Ethiopia

ADDIS ABABA UNIVERSITY

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GRADUATE PROGRAMMES

DECLARATION

This is to certify that the thesis prepared by Agegnehu Melese Bogale, entitled “The effects of compost application on growth and yield performances of white Lupin (*Lupinus albusL.*) Grown in potted vertisol at Addis Ababa town, central Ethiopia”, submitted in partial 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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The effects of compost application on growth and yield performances of *White Lupin (Lupinus albus*L.*)*

By: Agegnehu Melese Bogale
Addis Ababa University, 2021

ABSTRACT

Lupinus is a diverse genus in the legume family *(Fabaceae).*Its common name used in Europe and Australia *lupin* for both native and domesticated species, while the common name for native *Lupinus* in North America is *lupine.*Taxonomically,*lupins* are classified within the order *fabales,family Fabaceae,trible Geniseae and genus lupinus and* the number of species in this genus is expected to be over 1000.However ,the commonly agreed number of the existing *lupin* species is around 280.

The present study was undertaken to evaluate the effects of compost on growth and yield of *L. albus* in pot experiment. A total of 100 plastic bags (depth 20cm, diameter 10 cm) were filled using, 50 bags contained 1kg of vertisol, and 50 contained soils mixed with compost. The study found out that vertisol mixed with compost at rates of 120 quintal/ha improved the vegetative growth of *L.albus* by 51% and yield increased by68%. In contrast, no significant difference in seed germination ($p \leq 0.05$) was observed between the two treatments for all the germination parameters measured. In particular, differences in mean germination time and germination vigor were not significant between seeds germinated in vertisol mixed with compost (VR+Comp) or in vertisol only. Maximum mean plant height (cm), internodes length (cm), branches/plant, leaf number, leaf area (mm^2), root collar diameter (RCD) (cm), number of capitulae/plant, number of seeds, 1000 seeds weight (gm) and total dry weight (gm) were41.5, 11.9, 7, 26, 43.2, 1.3, 8, 164, 0.5, 2.2, and 1.9, respectively, for plants grown in VR+comp.The corresponding measurements for the control plants were25, 5.3, 3.0, 19.2, 26.2, 1.2, 4, 90, 0.3, 1.8, and 1.2, respectively. Based on the results obtained it is concluded that application of compost significantly ($p < 0.01$) improved almost all the growth and yield components of *L. albus*.

Keywords/phrases;Capitulae, compost,montmorillonite,*Lupinus albus*,seed germination,pods,vertisol.

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LIST OF ACRONYMS and ABBREVIATIONS

ANRSBA = Amhara National Regional State Bureau of Agriculture
ARC = American research center
BYMV = Bean yellow mosaic virus
CEC =Cation exchange capacity
CMV = Cucumber mosaic virus
DAG = Days after germination
EBI = Ethiopian Biodiversity institute
FAO =food and agriculture organization
GP = Germination percentage
GV = Germination vigor
MGT = Mean germination time
NVZS = Nitrate vulnerable zones
Q tl/ha = quintal per hectare
RCD = Root collar diameter
T/ha= Tone per hectare
RCD = Root collar diameter
VR + Comp = Vertisols plus compost
VR = Vertisols

1. INTRODUCTION

1.1 Background

Food is an essential requirement of mankind and plants provide up to 95% of world's food supply, directly or indirectly. But global population projections indicated that food production must continue to increase and must be doubled in next 35 years (Johnson, 1975). The research output jointly conducted by the Ethiopian Biodiversity Institute (EBI) and the International Biodiversity Institute (IBI) proved that the local varieties have a better yields and productivity. However, little attention is given to indigenous crop varieties in favor of improved seed varieties, as the result, indigenous crops are facing a serious of threat of extinction in Ethiopia (Yonas Abiye, 2015).Although humans rely on a diverse range of cultivated plant species for various purposes, only a few staple crops produce the majority of the food supply and many species such as lupins are underestimated and underutilized.

Lupins are highly valued as animal feed but have been underutilized as human food yet the seeds are reported to be a rich source of protein (33 - 47%) and oil (6 - 13%). There are also claims that the seeds are rich in dietary fiber and beneficial photochemical. Lupins are now receiving national and international interest as a future source of food ingredients that could be used to enhance the nutritional profile of existing food products. Lupin flour can be used in production of different products. It can be added to pasta, crisps, bread and emulsified meat products to increase nutritional value, aroma as well as modify the texture of the end products. Moreover, protein isolate produced from lupin seeds can be utilized for milk and meat imitation products. In the Middle East, lupin seeds are consumed as a snack after they are soaked in water, scalded and dehulled. Additionally, in some European counties, pickle is produced from lupin seeds.

Lupinus albus (white lupin) seeds grown in Ethiopia and locally known as '*Gibto*', is used as roasted bean '*kolo'* and to prepare local alcoholic drink '*katikala*' and other food products especially in the northwestern part of the country, after debittering by roasting and soaking the seeds in a river/spring water for 3-7 days (Personal communication with the local people). The high-lysine, low-methionine content of lupin complements than the wheat flour proteins, which are poor in lysine and relatively high in the sulphur-containing amino acids. In addition to their utilization in bakery products, value added products such as pasta, crisps, milk and yogurt analogues, meat analogues, lupin protein isolate for the enrichment of vegetable and fruit based foods can be produced from the lupin flour after removal of the anti-nutritional factors present in the lupin seeds. Little is known about the nutritional value, physicochemical and functional properties of locally grown lupins in Ethiopia. This information gap does not allow intensive and extensive utilization of lupin as a value added product (food/feed) in the country.

Farmers, processors and end-users have a little information in utilization of the lupin seeds in Ethiopian context. The growth and yield of lupin seed are greatly influenced by a number of physical and chemical factors (Get net and Sharma, 1996). Research has indicated that Ethiopian soils are generally low in available nitrogen and phosphorus and cannot produce high crop yields unless these nutrients are supply. When crops are planted in the same soil year after year, the nitrate supply becomes depleted and the mineral removed from the soil by crops unless it is replaced by addition of fertilizers (Hall and Lesser, 1966).Lupin is a nitrogen fixing crops has a potential to improve soil fertility and used as fodder. It can be grown on less fertile, acidic and sandy soils where other crops produce lower yield (Jensen *et al.*, 2004, Doxastakis 2007). It is also very important for crop rotation, especially in organic agricultural production, due to its positive impact on yield of subsequent crops, mainly cereals (Jensen *et al*., 2004). This is due to the inclusion of lupin in crop rotation positively influences biodiversity and soil fertility as the bacteria at the root of lupin symbiotically absorb nitrogen (N) from air. Farmers don't use fertilizers for Lupin production. That was the question why farmers don't use fertilizers as well as why extension institutions don't advice farmers to use fertilizers for lupin production under the present serious fertility declining conditions. Therefore, the present study was to evaluate the effect of compost on growth and yield components of lupin in pot experiment under nursery bed conditions.

1.2 Statement of the problem

Ethiopia's long history of agriculture has contributed to the diversification of the general agro biodiversity, biodiversity for food and agriculture of the indigenous crops long time ago (Zemede Asfaw and Abebe Getahun, 2001). Ethiopia is one the richest biodiversity country including domesticated species. The various genetic constitutions of the cultivated plants are remarkable.

Many researchers state that the use of lupin seeds for consumption and medicinal purposes has been the subject of interest for more than 3000 years around the Mediterranean Sea. White lupin is the longest known crop species in the history of the genus *Lupinus*.The importance of lupin was known among Aegean farmers at least 400 years B.C. Until the beginning of the 19th century in Europe in the Mediterranean Sea region, lupin was the most frequently cultivated plant for green manure and for feeds, which were used in animal and human nutrition. However, because of high alkaloid content, the seeds could not be considered as a safe food component (Prusinski, 2015).

A traditional way to avoid bitter taste caused by the presence of alkaloids of the lupin seeds was by fine grinding, and followed by multiple rinsing with water commonly used by Mediterranean Europe and Andean countries , however, this practice caused decreases a nutritional value as a result of removing soluble proteins, free amino acids, carbohydrates, and minerals (Petterson, 1998). As I have interviewed the agricultural extension workers of Banja Wereda from 47,312 hectare agricultural land only 210 hectare was planted by lupin seed (*Lupinus albus)*. Therefore, this study was conducted to evaluate the effect of compost on growth and yield of *Lupinus albus* and in an effort to draw attention to this neglected and underutilized species so it can contribute to food security and income of subsistence farmers.

2. OBJECTIVES OF THE STUDY

2.1 General objective

The general objective of this study was to evaluate the effect of compost on growth and yield performances of Lupin (*Lupinus albus*).

2.2 Specific objectives

- To compare germination performance of lupin seeds in vertisols and in vertisols and compost mixture.
- To evaluate the effect of compost on growth parameters of lupin grown in vertisols and in vertisols and compost mixture.
- To compare the effect of compost application on lupin biomass compared with lupin grown on vertisol only.
- To compare the yields performances of lupin grown in vertisol and vertisol and compost mixture.

3. LITERATURE REVIEW

3.1 Taxonomy and morphological features *L.albus*

Lupins belong to the genus Lupinus and family of Genisteae, which is also called Fabaceae or Leguminosae (Uzun, *et al*., 2006). This is a large and diverse genus which includes more than 500species (Kurzbaum, *et al*., 2008 and ARC center of excellence for integrative legume research, 2009). Lupinus is a genus of self or cross-pollinating, consisting of mostly indefinite plant species native to diverse geographic locations (Phan, *et al.,* 2007). Second to cereal crops,lupin is the common name for members of the genus Lupinus of the legume family (Kurzbaum, *et al*., 2008). The name lupin is derived from the Latin word Lupus, meaning 'wolf'. The Romans believed that lupins robbed the soil nutrients in the same way that wolf would steal domestic animal. It is known as lupines in the United States, as turmus in the Middle East and Tawari in Latin America. The plant is characterized by having various flowering spikes in large range of colors (Fig. 1).

L. angustifolius *L. albus* *L. luteus* *L. mutabilis*

Fig.1. Flowers of different lupin species, source (Kurzbaum *et al*., 2008).

Commonly, four lupin species are reported as cultigens in the world (Fig.1). These include*L.albus L, L.angustifolius L., L.leutus L*and *L.mutabilis L*. (Uzun, *et al*., 2006, Kurzbaum, *et al*., 2008). Trivially, these species are called white lupin, narrow-leafed (blue) lupin, yellow lupin and pearl lupin respectively (ARC center of excellence for integrative legume research, 2009).Out of these four species the focus area of this research is on *Lupinus albus .L*. This species is also called white lupine in most part of the world. In this document we will use its scientific name *Lupinus albus.L* consistently to refer the crop. The lupin seed is produced in pods which develop on the main stem of the lupin plant. Pods contain between three and seven seeds and these seeds vary in size, color, appearance and composition depending on the species of lupin. Among them the seeds of *Lupinus albus* are the largest. They have a circular flattened shape and are cream in color.

Lupinus albus is a relatively tall, branching plant, with broad leaves and large, fleshy pods. However, it will take longer time to mature than other lupin species. Furthermore, harvesting and conserving the plant as whole-crop silage removes the seed for further processing, storage, and associated equipment and facilities (Fraser. *et al.*, 2004). *L. albus* is an important grain legume crop that is able to recover from severe water deficit conditions. During the progression of water deficit, the several tissues behave quite distinctly in the amount and rate of water loss. In contrast to the stem stele, which loses only a small amount of water during the stress period, the water content of mature leaves is rapidly and strongly affected by the water shortage (Pinheiro. *et al*., 2004).This crop is susceptible to chlorosis in calcareous soils. The severity of iron chlorosis correlates poorly with shoot growth and seed yield in the field, especially for plants showing iron chlorosis at early growth stages (Raza.*et al*., 2000). Cultivation is possible on acid to neutral soils with moderate calcium content. This has been a major constraint to the development of the lupin crop in Europe and Australia. The reduction in growth caused by several factors such as high pH, bicarbonate content, iron deficiency and calcium toxicity. Thus both shoot and root growth were reduced in *Lupinus albus* at pH= 7.5 compared to 6.0 (Raza. *et al*., 2000).

Lupinus albus and other agronomic Lupinus species are relatively undomesticated when compared with most crops (Noffsinger and Santenin, 2005). Cultivation of lupins is also limited worldwide (Jimenez-Martinez. *et al*., 2003). However in 2005, the total cultivated area was increased to 1,007,018ha with a yield of 1,086,006 tones which indicates an increase in production of the crop from year to year (Uzun. *et al*., 2006). The two types of lupins that are mainly cultivated today are white and blue lupin mainly produced in Europe and Australia respectively (Yoshie-Stark and Wasche, 2003). Depending on the species, lupins may be either annual or perennial. Most of them are herbaceous, but a few are shrubs or small tree. Western Australia leads the world lupin exports in recent times.

L.albus has a strong capability for nitrogen fixation and organic phosphorus release from soil. This let the crop agriculturally to be used in crop rotation during intensive crop production. Especially this feature of *Lupinus albus* is feasible within nitrate vulnerable zones (NVZs) (Sujak. *et al*., 1992, Fraser. *et al*., 2004). For example; in Western Australia, sustained wheat yields are directly dependent on the rotational benefits of *Lupinus albus*. They are also used for weed management and between fields of cereal crops to keep diseases from spreading .Nitrogen is an indispensable element in protein and other nitrogen compounds. It can be taken by plants in NH_4^+ or NO_3^- and under specific conditions in amine form NH_2 (urea). All legumes, including lupins, use the atmospheric nitrogen (N^2) for biological fixation, protein biosynthesis, and synthesis of other nitrogen containing compounds e.g. amino acids, nucleic acids, vitamins, polyamines, alkaloids, etc. In nitrogen fixation, atmospheric nitrogen is converted into ammonia, which is subsequently available for biosynthesis of nitrogen containing molecules (Ciesiolka. *et al.*, 2007).

The other advantageous agricultural feature of *Lupinus albus* is becoming a model for the study of plant adaptation to extreme phosphorus (p) deficient condition. Adaptation to low p is linked to modifications of root development and biochemistry resulting in roots cluster (Phan.*et al.*, 2007).Interest in *Lupinus albus* production is increasing, due to its potential as a source of protein, for pharmaceutical purposes, a green manure and due to the high alkaloid content, as a natural component of plant pesticides (Sujak. *et al.*, 2005). For example; *Lupinus albus* is cultivated in the Mediterranean and Egypt for its edible seeds (Mahamoud. *et al.*, 1994).

Although *Lupinus albus* has been widely grown and utilized by people in Mediterranean area and Andean highlands, in Europe its cultivation remains behind that of the other leguminous plants (Sujak. *et al.*, 2005). According to FAO the main lupin cultivating countries in Europe are France (24,000 t/ a), Italy (5,000 t/ a) and Spain (9,800 t/ a). In France, the lupin cultivation increased from 6,321 t/ha in 1996 to 24,000 t/ ha in 2003, which demonstrates the growing interest for lupin as food and feed source. In Germany the cultivation area of lupins used for food and feed use in 2002 reached 40,000 t/ a (El-Adawy. *et al.*, 2000). The amount of lupins used for food applications is estimated to be around 5 to 10% of the total lupin production worldwide (Australian health info center, 2009).In Ethiopia the information regarding the crop's agricultural feature is few. Based on the information gathered from the focus group discussion at the beginning of this research the sowing season for *Lupinus albus* is May and June and the crop mature five to six months. Usually the farmers use it for intercropping along with teff, wheat, and sometimes with eucalyptus tree. The crop doesn't need any fertilizer, pesticides, etc for its growth. The crop does not any soil preferences (i.e. it can grow on marginal lands too). Regarding the yield there is no information both from the farmers and agricultural centers. In agricultural centers the crop is known by the name “black lupine”, due to the very dark green nature of the whole crop.

3.2 Origin and geographical distribution

Four different centers of origin have been proposed for the genus lupinus. These include the Mediterranean region (including northern Africa), North America, South America, and East Asia. Today, approximately 90% of the recognized species are found in alpine, temperate and subtropical zones of North and South America, which ranges from Alaska to Southern Argentina and Chile. The remaining species are native to the Mediterranean region and Africa. But due to their larger seeds, most of the economically important species come from the Mediterranean region (ARC center of excellence for integrative legume research, 2009).In places where no other crops can be grown profitably, Lupins could be considered as a model for low input plants. Among the common species *Lupinus albus, Lupinus luteus* and *Lupinus angustifolius* are Old World species whereas; *Lupinus mutabilis* is a new worlds species originating from South America (Cowling. *et al.,*1998).In Ethiopia apart from one native and one cultivated, at least four species of lupines have been introduced (Demisseie , 1983). This is attributed for both trials as forage crops or green manure, as well as use for soil and water conservation programs, and as ornamentals. These include *Lupinus luteus*, *Lupinus. mutabilis*, *Lupinus mexicanus* and *Lupinus albus* (locally known as Gibto) (Demissie , 1983) . According to the plant database from forest gene bank, the currently available species in the country include *Lupinus mutabilis* and *Lupinus albus* (Forest Gene Bank, 2008). But *Lupinus mutabilis* is found in small areas of Oromiya (Shewa), Tigray (Adwa), and SNNP (Gurage) regions. The widely spread species in the country is *Lupinus albus*. This bitter species is widely found in Amhara and SNNP regions. In Amhara region, especially in west Gojam and Gondar areas, it has the highest yield (Table 1) (Forest Gene Bank, 2000 and CSA, 2007). As it has been observed in the table the largest production is recorded in Amhara regional state. In the region south Gondar and west Gojam have equal annual yield of 7.17 Qtl/ ha (CSA, 2007).

Table 1: Report on Area production of crops (private peasant holdings in Mehir season) of pulses and Gibto (*Lupinus albus*) (2007/2008).

Areas	**Pulses**			**Gibto (*Lupinus albus***			
	No of Holders	**Area in ha**	**Production in Qt**	**No of Holders**	**Area in ha**	**Production in Qt**	**Yield Qt/ ha**
South Gondar	310,364	107,295.76	1,084,606.14	50,813	9,104.75	65,251.33	7.17
East Gojam	291,299	91,096.2	1,227,433	17,391	*	*	*
West Gojam	265,995	74,235.99	970,886.71	39,623	7,283.16	52,222.93	7.17
Awi	69,248	16,287.93	159,377.99	25,536	6,429.58	29,645.95	4.61
Amhara Region	2,285,014	703,526.94	8,175,493.73	134,033	26,052.58	162,539.64	6.24
SNNP region	1,364,816	157,092.94	1,627,170.81	2,796	*	-	-
Ethiopia	6,778,640	1,517,661.93	17,827,387.94	138,722	26,398	165,541.58	6.27

Source: - Ethiopian central statistical agency (2007)

N.B:- The area and production designated by (*) indicates the not reported data because of highcoefficient of variation, (i.e. they are less reliable). However, they are consolidated in the totalestimates.

: - (-) Indicates not reported (Federal democratic Republic of Ethiopia Central statistical agency, 2007).

In Ethiopia *Lupinus albus* is traditionally called ‘Gibto’. The local community gives this name;because they thought the origin of the seed is Egypt (Gibtse in Amharic). So they name the cropafter Gibtse (Gibt) (Sileshi , 1985). This species has very useful agronomic characteristics. It is non-shattering, disease resistant, high yield giving, growing on marginal soil and so on. This makes the crop better species than the sweet variety growing in Australia.

3.3 Ecological and economic importance

In Ethiopia, white lupin is cultivated on less fertile soils where most crops and all other seeds fail to grow and contributes a great deal to increase soil fertility and land rehabilitation because of its mycorrhizal relationship and its potential as a bio-fertilizer. The dried stalks may be used to mulch fruit trees or merely spread out to decompose over the soil surface, serving as a source of organic matter.

Leguminous crops that are studied are strategically needed high protein crops of modern crop production, and economic and bio-energetic valuation of their breeding efficiency is long-range and important issue nowadays. In present-day socioeconomic conditions one of the main problems of agriculture economic sector of Ukraine remains essential increasing and stabilization leguminous crops production, that are the main source of balanced in amino acid composition and content of eco-friendly protein. In the article studied ecological features of the white lupine varieties. The present state of the trends of economic use of lupine has been analyzed and its perspectives have been determined. Established varietal assortment of lupine species listed in the State retests and analyzed dynamics by years of their creation. Investigated the properties of high-quality varieties of white lupin Veresnevii and Makarovskii. As a research argued that Veresnevii and Makarovskii provides -high-yield 3.61 t/ha and 3.23 t/ha respectively. Both varieties are resistant to the disease of spring frost. Comparison of the obtained results with the characteristics of varieties presented by the originator showed the coincidence of varietal characteristics by all indicators. It has less diseases and pests infestation than other seed crops. Lupin seed is a valued source of edible crop in Ethiopia, where it is called ‘gibto’. The crop is the source of producing local beer called ‘katicala’ and supplier of edible crop in some regions.

Today, under the difficult economic and environmental conditions, the role of crops with significant biological and economic potential is increasing. Crops such as lupin play an important role in reducing feed and food protein deficiency, improves soil fertility and structure, with the ability to form symbiotic system nodule bacteria of lupine plants accumulate in the biomass to 400 kg/ha of nitrogen, 70% of which is accounted for symbiotic. But the nitrogen-fixing activity and productivity of white lupine depends on the varietal characteristics of plants and adaptability to environmental conditions.

One of the most important means of improving the productivity of crops is the variety. It is through the creation of new varieties that it is possible to increase productivity, quality of grain, resistance of plants to diseases, which will improve the state of the environment and lead to colorization of agriculture, by 30-70%.

In the countries of the East, lupine is very important as a food culture, and in other countries of the world, for example, in the USA, lupins were first grown for feed or green fertilizer and only much later began to dominate the grain trend. At the same time, growing lupine for grain in some countries reaches almost 100%. In Ukraine, lupine has not yet acquired such a strategic and important value, and it is grown mainly in certain regions only on grain. However, at the expense of lupin, the problem of supplying feed protein in the livestock sector in Ukraine is still not possible. At the same time, in Australia, the USA, China, Brazil, Italy and other countries, the production of lupin grain and its efficient use in livestock production are growing at a high pace.

Therefore, the problems of lupine production in our country, the preservation of the varietal resources of this culture and the conquest of one of the main protein regions of the world-must are solved on the basis of scientifically substantiated formation of the varietal resources of this extremely valuable culture.

3.4 Production and utilization

The white lupin in Ethiopia is locally known as Gibto. It is produced by small holder subsistent farmers in two regional states of Ethiopia; Amhara and Benishangulgumuz, the former being the largest producer. It is grown in elevations ranging between 1500-3000 m.a.s.l. In the main production season (Meher season, June-December) of the year 2008, a total of 17, 241 tons of lupin, with a mean productivity of 0.84 t/ha, was produced in these two major lupin producing regional states (ECSA, 2009). According to Francis (1999), the white lupin variety grown in North-western Ethiopia is bitter variety due to its high alkaloid content. However, the same author reported that though the variety is bitter, it is relatively non-shattering, high yielding and most importantly is resistant to lupin anthracnose disease which currently is a problem for the cultivation of white lupin in some parts of Western Australia and Europe.

Lupin production by small holder farmers in the area is targeted for its grain and soil fertility maintenance values. Its grain is used as snack and for the preparation of local alcoholic drink, Areke. However, lupin grain and forage is hardly used as livestock feed, though it is a very important livestock feed in Australia, Europe and America. According to Erbas et al., (2005) in the year 2001 a total of 1, 387,660 t lupin was produced in the world. The report of van Barneveld (1999) indicated that the vast majority of lupin produced in the world is used for livestock feeding. In Australia a total of 550,000 t of lupin grain is used annually for sheep feeding as protein supplement (van Barneveld, 1999). Although shortage of protein sources limit livestock production in Ethiopia, nevertheless, the contribution of lupin as livestock feed has remained negligible.

Lupin, as legume, can fix atmospheric nitrogen into nitrate (NO3), usable form of nitrogen by the companion or succeeding crop. Potentially lupin can fix and accumulate a total of 150 to 400 kg/ha per year nitrogen (Takunov and Yagovenko, 1999; Reeves *et al.*, 1990; Jansen, 2006). In the North-western part of Ethiopia where mixed crop-livestock production is the typical farming system, crop rotation and/or fallowing is a common practice. Although lupin has immense potential from feed, food and soil fertility maintenance perspective, the Ethiopian local lupin cultivation, genetic improvement and utilization remains far behind as compared to the other pulse crops. In addition to these, there is no available detailed information about the production system, current uses, potentials and limitations of the Ethiopian local white lupin.

According to my information from local people, there are gender related aspects of lupin production and utilization. Although both male and female family members participate in farm activities during peak seasons, there is division of labor in lupin production and utilization. In land preparation for lupin planting is done only by male family members. Threshing requires two steps; separating of the pod from the stem by hand using long stick and threshing by animals to separate the seed from the pod cover. In this activity, both male and female family members participate. In addition to this, both male and female family members participate in lupin crop residue handling, lupin marketing and consumption of lupin products. Processing of lupin for food is totally the responsibility of female family members in with few exceptions in which male family members assist females during soaking and washing. There is also share of responsibility in decision making. The decision about the plot of land to be allocated for lupin production in a given production season is the responsibility of the husband. Whereas, decision about the amount of lupin product to be sold and the amount for home consumption is the responsibility of the wife.

3.5 Seed harvest and storage

As lupin seed ripens over a period of several weeks it is harvested when the pods become yellow to reduce shattering, which reduce the yield up to 25%. The optimum stage to harvest is when the top leaves starts turning from green to yellow, the fruits are white-yellow and when the moisture content is 45-50% (Hiruy Belayneh, 1987). Harvesting is done manually; the lupin stalks are cut below the branches and laid out to dry in the fields for 4 to 7 days and taken to the threshing ground in an upright position for further drying and threshing. As lupin seeds are loosely held in the head, threshing is easy. In India for instance, is harvested when the leaves dry up and the pod turns white yellow (ICAR, 1992). Following drying, farmers thresh the seeds by grasping the pods and beating the seed pods on a wooden platform placed over a canvas in the field. Afterward, white yellow seeds are cleaned and stored. Lupin seed has stored, when properly dried, can be stored for many years without losing its viability (Hong *et al*., 1996).

3.6 Mode of reproduction

Lupins can reproduce both sexually and asexually. Under natural conditions, most annual lupin species reproduce by self- pollination. Perennial lupin species reproduce mainly through cross pollination due to self-incompatibility (Kittelson and Maron 2000; Kurlovich 2002).Asexual reproduction is only common through vegetative regeneration in perennial lupin species .There is no evidence to show that lupin can reproduce through apomixes (Richards, 1986). For the annual lupin species commonly used in agricultural practice, no vegetative reproduction has been reported. However, under natural conditions, some perennial lupin species reproduce vegetative.

All lupin species reproduce sexually by producing seeds. They produce an inflorescence in the form of a spike (raceme) of the apical truss type .Flowering on the main inflorescence (primary flower set) in old world lupins starts 59-136 days from planting depending on the type of, and the growth conditions (Buirchell and Cowling 1998). The most basal flower on the inflorescence is the first to reach anthesis. The secondary flower set on branches. Typically around 30 flowers may open on main shoot inflorescence, lasting about 20 days, and branches bear fewer flowers and the flowering duration is shorter (Dracup and Kirby 1996a).

Different genotypes within one species may have varied response to vernalisation. With L.albus , there are three types (also called morphotypes);winter, semi-winter, and spring. Winter types have an obligate requirement to be vernalised (cold treatment) to complete their life cycle; semi-winter types flower without cold treatment, but only after prolonged vegetative growth. Spring types are similar to semi-winter types and flower without cold treatment, but cold treatment can shorten the time from vegetative growth to floral differentiation (Clapham and Willcott 1995).

3.7 Factors affecting seed germination

Seeds are central to crop production, human nutrition, and food security. They carry the full genetic complement of the crop and are therefore the delivery system for agricultural biotechnology and crop improvement. The vast majority of crops produced in world agriculture begin with the sowing of a seed to establish a new plant in the field. Successful seedling establishment is the first critical step for crop production, and determines the success or failure of the future harvest. Seed is composed of three generation of plant tissues including the sporophyte that produces an immature seed known as ovule and the gametophyte that develop inside the ovule to produce ova. The third plant tissue of the seed is the new sporophyte embryo. Endosperm is the nutritive substance of the seed up on which the seed embryo feeds as its development (Konging, 1994). Despite these anatomical structures of seed in higher plants, seed morphology differs from one plant species to another, there are small and big seeds, thin, flat, light, papery, dehiscent and indehiscent, smooth and hard seed coat.

Germination is the process by which the embryo wakes up from the state of dormancy and takes to active life. This process, in fact, covers all the changes from the earliest sprouting of the seed till it established itself as an independent plant. The signs of seed germination are redemption essential process, including transcription, translation, and DNA repair followed by cell elongation, and eventually at the time of radicle protrusion, resumption of cell division (Barroco *et al*., 2005). Germination is a two process, where testa rupture is followed by endosperm rupture. Following rupture of micropylar endosperm by emerging radicle, germination is complete (Krock *et al*., 2002; Liu *et al*., 2005).During seed germination various stored substrate are reactivated, repaired if damaged and transformed into new building materials necessary for initial growth of the embryo, its subsequence growth, and seedling establishment in its natural habitat (Koller and Hadas, 1982). External and internal factors are declared to affect seed germination (Raven *et al.*, 2005). But according to Legesse Negash (1995-2010a), propagation of many indigenous tree species from seed had been difficult due to lack of precise knowledge on their seed biology and germination physiology, because many native plant species have developed survival strategies through evolutionary process for million years, understanding these strategies in the context of seed physiology for successful plant propagation.

3.7.1 External factors

Environmental factors such as temperature, light, pH, and soil moisture are known to affect seed germination (Chachalis and Reddy, 2000). Burial depth of seed also affects seed germination and seedling emergence. Some of the most important external factors are water, oxygen and suitable temperature. (I) **Water or moisture**: A dormant seed is generally dehydrated and contains hardly10 to 15% of water in its living cells. The active cells, however, require about 75-95% of water for carrying out their metabolism. Therefore, the dormant seeds must absorb external water to be active and show germination. Besides providing the necessary hydration for the vital activities of protoplasm, water softens the seed coats, causes their rupturing, increases permeability of seeds, and converts the insoluble food into soluble form for its translocation to the embryo (Raven *et al.,* 2005). Water also brings in the dissolved oxygen for use by the growing embryo. Entrance of oxygen is also facilitated, and as a result, the rate of transpiration is accelerated. Seed germination incorporate those events that commence with the uptake of water by quiescent dry seed, and terminate elongation of embryonic axis (Bewley and Black, 1994). Water uptake by a seed is tripe phase, phase I rapid initial uptake; phase II plateau phase, and phase III further increase of water uptake , however, when only germination occurs (Bewley, 1997). The amount of water taken into seed for germination depend anatomically, physiological nature, and plant species, most seeds critical water (moisture) content for seed germination occur i.e. corn *(Zea mays)* 30%, wheat *(Triticimae sativum)* 40%, and soybean (*Glycine max*) 50% (Wash and Nyomora, 2012). If the internal water (moisture) content decrease below or increase above the critical moisture content seed essentially decay. **(II) Supply of oxygen**: Oxygen is necessary for respiration which release the energy needed for growth. Germinating seeds respire very actively/feebly and need sufficient oxygen. The germinating seeds obtain this oxygen from the air contained in the soil. It is for this reason that most seeds sown deeper in the soil or in water logged soils ($i.e.$ oxygen deficient) often fail to germinate due to insufficient oxygen. Seeds of many species will not germinate at oxygen level considerably lower than the normal present in the atmosphere. Ploughing and hoeing aerate the soil and facilitate good germination. **(III) Suitable temperature**: Moderate warmth is necessary for the vital activities of protoplasm, and, therefore, for seed germination. Some seeds are sensitive to temperature, while other can germinate in wide range of temperature (Michael, 2005). Though germination can take place over a wide range of temperature (5-40℃), the optimum for most of the crop plants is around 25-30℃. The germination in most cases stops at 0 and 45℃. Above optimum seeds will not germinate because some seed enzymes which are protein in nature are denatured including the seed embryo (Bewley and Black, 1994). For *Lupinus albus* seed the minimum germination temperature is 13℃ and the optimum temperature is 14to 17℃. Night temperatures should not fall below 2℃(www.prota. org).At temperatures above 30℃ the rate of growth and flowering are adversely affected and maturity is accelerated (Weiss, 2000). It is reported to tolerate an annual precipitation of 660-1790 mm and an annual temperature range of 13.6-27.5℃ (Duke, 1983). **(IV) Light**: Light also has influence on germination of some seeds, but in most cases light regards germination at the early stages. The presence or absence of light may or may not have effect on seed germination. However the light factor is not an important factor as water, temperature, and oxygen. According to Neff *et al* (2009), why seeds don't germinate in light is that light is reported to decompose carbolic acid gas, expel oxygen which is germinating factor and fix carbon, thus hardening all parts of seeds which prevent germination. Darkness has no effect to carbolic acid gas, and oxygen remains undisturbed to favor germination.

3.7.2 Internal factors

Hormones contained in various developmental stages, the seed, and enzymes are some of internal factors which in one way or another can affect seed germination (Neff *et al*., 2009). Many researchers also agree that seed dormancy period, seed viability (power of germination), and thickness or thinness of the seed coat may affect seed germination and hence are factors for seed germination (Finch-Savage and Leubner-Metzger, 2006). In some plants the embryo is not fully mature at the time of seed shedding. Such seeds do not germinate till the embryo attains maturity. The seeds of almost all the plants remain viable or living for a specific period of time. This viability period ranges from a few weeks to many years. Seeds of Lotus have the maximum viability period of 1000 years. Seeds germinate before the ending of their viability periods. In many plants, the freshly shed seeds become dormant due to various reasons like the presence of hard, tough and impermeable seed coats, presence of growth inhibitors and the deficiency of sufficient amount of food, minerals, and enzymes, etc. Dormancy is a simple operational a bloke to completion of germination of an intact viable seeds under favorable conditions (Bewley, 1997). The seeds of some species are prevented from completing germination because the embryo is constrained by its surrounding structures this phenomenon is known as seed coat dormancy (Legesse Negash, 1993) even though; embryos isolated from these seeds are not dormant. The other type of dormancy is found when the embryos of the seeds are dormant, known as embryo dormancy. The third type of dormancy regulates seed germination by the inner tissue of the seed, which is the embryo, the enclosing endosperm and inner integument layer or both (Hartmann and Kester, 1975). Thus, dormancy must be broken to induce germination and various methods are used for this depending on the plant species and type of dormancy. Dormancy is self-guard for some seeds and seedling for suffering damage of death and allow some seeds to germinate when competition from other plants for light and water. Seeds germinate only after the dormancy is overcome or broken either through natural means such as animal gut activities (Manzano *et al*., 2005), wild fire (Van Staden *et al*., 2000), rainfall (Hartmann *et al.*, 2004) or through artificial means such as scarification, seed coat cracking, removing chemical inhibitors through leaching by water (Legesse Negash, 1995, 2002).

3.8 Parasitic weeds, pests and diseases

Common weeds found in lupin crops annual ryegrass and wild radish are the major weeds, both severely reduce lupin yield (Harries *et al*., 2008). They complete for space, light and nutrients within the lupin crop. According to Harries *et al* (2008), each radish plant/m^2 or 25 ryegrass plant/m^2, there is a 5% reduction in lupin yield.

Weed management of lupin crops relies heavily on the use of herbicides. However, with the continuous development of resistance to community used herbicides, weeds in lupin crops, particularly ryegrass and wild radish, have become increasingly more difficult to control .The effectiveness of herbicides on weeds and the amount of damage they may cause to lupin crops depends on wide range of factors such as crop and weed growth stage, soil type, location, lupin variety and weather conditions at the time of herbicide application (Mclarty and Harries, 2009).

Reports on vertebrate pests of lupin are scarce. The house mouse (*Mus domesticus*) and the introduced feral pig (or wild boar) (*Sus scrofa*) are the two major animal pests affecting lupin production. The house mouse can cause considerable losses to lupin crops by eating recently – sown or germinating seedlings, seed heads of maturing lupin and stored grain when the numbers are reasonably high.

Feral pigs can affect lupin production mainly by trampling and destroying crops. Individual losses to lupin crops may reach tens to thousands of dollars. (Chquenot et *al*., 1996). In 2004 feral pigs were believed to have increased in numbers and distribution partly due to increased crops of white lupins , which is a preferred pig food (Cowled *et al*.,(2004).

Lupin crops are more prone to invertebrate pest damage than cereal crops. The major pests affecting lupin crops include; Caterpillars, Lucerne fleas, mites, slugs, snails, aphids and thrips. In establishment phase, lupins are vulnerable to attacks by caterpillars (cut worms and brown pasture looper), Lucerne flea, mite, fly, slug and snail. In severe cases of uncontrolled pest outbreaks at the seedling stage, it may be necessary to re-sow paddocks (Berlandier, 2003).

At flowering stage, lupins are frequently affected by aphids and thrips. Both of them have numerous generations throughout the year. Aphids appear to thrive in dry weather conditions and crops grown in low rain fall zones (less than 325mm) appear to be at greatest risk (Berlandier, 1999). Thrips, mainly onion thrips and plague thrips , mainly cause flower abortion when in high numbers but they rarely cause damage sufficient warrant control (Mangano *et al* .,2008).At podding stage, the larva of native budworm and Lucerne seed web moth feed on seeds within the pods. Newly hatched native bud worm caterpillars feed on foliage and larger caterpillars (over 15 mm long) will feed on lupin pods. Lucerne seed web moth is a very sporadic pests of lupins , causing notable damage only every 8 to 10 years (Berlandier,2003).

Lupins are susceptible to a wide range of diseases. Although lupin diseases caused by bacterial pathogens have been reported (Lu and Gross, 2010), most lupin diseases of agricultural importance are caused by fungal or viral pathogens.

The common fungal diseases of lupins are; anthracnose, brown leaf spot, root rot and phomopsis are the most important lupin diseases. Anthracnose is a serious disease of lupins worldwide. Phomosis can reduce crop yields when lesions develop on stressed lupin plants prior to maturity, which results in lodging of the plants (Thomas *et al*., 2008a).Although, no lupin -specific virus has been reported, cucumber mosaic virus (CMV) and some poyty viruses, including Bean yellow mosaic virus (BYMV), Clover yellow vein virus, Bean common mosaic virus, peanut mottle virus and Bides mottle virus, can all infect lupins (sweetingham *et al*., 1998). CMV and BYMV are the two major viral pathogens of lupin. Both can provide great yield loss under favorable conditions such as rain fall, adjacent alternative host plantation and high aphild population (Thomas *et al.*, 2008a).

3.9 Soil types

Different methods are used to identify the type of soil. A) Texture: - it is the size of soil particles. Soil texture is determined by the proportions of sand, (large size) silt, (medium size) and clay (small size) in the soil. When they are wet, sandy soils feel gritty, silt soils feel smooth and silky, and clay soils feel sticky and plastic, or capable of being molded. Soil texture influences many soil physical properties, such as water-holding capacity and drainage. Coarse-textured sandy soils generally have high infiltration rates but poor water holding capacity. Because of its porous, readily admits air and water, which are essential to plant growth (Hall and Lesser, 1966). Silt particles are much smaller than sand, have a greater surface area, and are generally quite fertile. They do not hold as much moisture as clay soils; however more of the moisture is plant available. Fine-textured clay soil generally has a lower infiltration rate but a good water holding capacity (Brand and Weil, 1999). The tiny, firm-packing clay particles form a nonporous soil that is difficult to till and likely to cake. Being nonporous, the soil can absorb very little water. B) Structure: - it shows the arrangement of soil particles (sand, silt and clay) and pores in the soil and to the ability of the particles to form aggregates (Braunack and Dexter, 1989). Macro-pores allows good aeration, rapid infiltration of water, easy plant root penetration, good water drainage, as well as providing good conditions for soil micro-organisms to thrive. Micro-pores hold water against gravity (capillary action) but not necessarily so tightly that plant cannot extract the water (Brand and Weil, 1999). C) Color: -it indicates the type of materials in the soil- Ex: red soil is rich in iron. Black soil is rich in humus. D) Fertility: - Soils with high nutrient content are fertile soils, if not they are infertile. E) Soil profile: - Soils have three layers from top to bottom. F) Location: - different soils are found in different parts of the world. In equatorial rain forest region soils are red and called late rites. In the temperate zone soils are black and known as chernozems. In the cold zone soils are grey and called podosols.

According to the Ministry of Agriculture (2010), about 19 soil types are identified throughout the country, Ethiopia. The big proportion of the country's landmass is covered by lithosols/liptosols (14.7%), nitosols (13.5%), cambisols (11.1%) and regosols (12%) in order of their importance, the rest includes vertisol (10.5%), fluvisols (7.9%), luvisols (5.8%), acrisol

(5%), xarosols (4.8%), solonchaks (4.2%), yermosols (3.1%) phaeazems (2.9%), rendzinas (1.5%), andosols (1.2%), arenosols (0.81%), gleysols (0.47%), histosols (0.42%), solonetz (0.04%) and chernozems (0.07%). Complexes of soil forming factors have primarily influenced the distribution of the soil types. There is limited information on the fertility status of the various soils. Research showed that potassium; nitrogen; cation exchange capacity (CEC) and organic matter contents of most Ethiopian highland soils are generally high by international standards (EARO, 1998), whereas their phosphorous content is low to very low compared to the African standard most soils in the highlands of Ethiopia are fertile (FAO, 1984c). Contrary to most other African soils, the majority of Ethiopian highlands soils remain relatively fertile at depth. However, most highland soils are deficient in important nutrients and require fertilizer to sustain crop yields. Research has indicated that Ethiopian soils are generally low in available nitrogen and phosphorous and cannot produce high crop yields unless these are supplied. In Ethiopia, lupin is valued for its ability to thrive on less fertile soils where other crops fail. It is usually grown on "light poor soils with coarse texture" basically on almost any soil that is not extremely heavy (Chavan, 1961).Get net and Sharma (1996) also report that lupin seed grows well at pH values between 12 and 14. Some Lupin seed selections are moderately salt tolerant, but flowering may be delayed by increased soil salinity (Bulcha, 2007).

According to Asires Mitku (2008) the dominant soil types of the Amhara Region include black vertisols (43%). As I have interviewed Banja Wereda agricultural extension workers the soil of the study area comprises 75% vertisol, 15% reddish-brown, nitosol and 10% other soil types.

3.9.1 Vertisols (VR) and its key characteristics

Vertisols from Latin Verto, “turn” are clay rich soils that shrink and swell with change in moisture content. The clay minerals adsorb water and increase in volume, swell when wet and during dry periods, the soil volume shrinks, and deep wide cracks form. Surface materials fall into these cracks and are incorporated into the lower horizons when the soil becomes wet again. As this process is repeated, the soil experiences a mixing of surface materials into the subsoil that promotes a more uniform soil profile. Because they swell when wet, vertisols transmit water very slowly and have undergo little leaching. They tend to be fairly high in natural fertility. The basic property of vertisol, that endows them with high water holding capacity in their clay content, which commonly lies between 40-60% and it, may be as high as 80% (Ahmad and Marmut, 1996). The dominant clay mineral in most of the vertisols appears to be montmorillonite. The mineral montmorillonite, which belongs to the smectite family of minerals, is responsible for the general attributes of the soils and their vertic properties. Since montmorillonite has the property of swelling and shrinking, the classification concept of vertisols was based on their shrink-swell potential. This potential is a function the clay content of the soil and the relative amounts of montmorillonite in the clay fraction. Vertisols are usually very dark in color, with widely variable organic matter content (1-6%). They typically form in Ca and Mg rich materials such as limestone, basalt, or in areas of topographic depressions that collect these elements leached from uplands. Vertisols are most commonly formed in warm, sub humid or semi-arid climates, where the natural vegetation is predominantly grass, savanna, open forest, or desert shrub. Large areas of vertisols are found in Northeastern Africa, India, and Australia, with small areas scattered worldwide, make up about 2% of the world's ice-free land surface. The bulk density of Vertisols varies greatly because of their swelling and shrinking nature with changes in soil moisture content. The soils have high bulk density when these are dried and low values when in a swollen stage. The bulk density of a vertisol may vary from approximately 1 to 2 g/cm3 depending on the moisture content.

3.9.1.1 Management related properties of vertisols

Soil management, the basis of all scientific agriculture, which involves six essential practices: proper tillage; maintenance of a proper supply of organic matter in the soil; maintenance of a proper nutrient supply; control of soil pollution; maintenance of the correct soil acidity, and control of erosion (Microsoft Encarta, 2009).It is important that for optimum sustainable benefits from the use of the soils, their particular properties and behavior must be understood and incorporated in management strategies. Proper use of the soil, therefore, starts with appropriate selection of crops to be grown and the adoption of practices suitable for the soils. The use of the soils is considered in three broad categories, that is, for crop production, for pasture both native and improved, and for agro forestry. For crop production on a worldwide basis, vertisols are presently used for a range of crops including cereals, small root crops, oilseeds, fiber crops and sugarcane (Ahmed, 1996).Vertisols, as a class of soils is easily recognized because of their clayey textures, dark colors, and special attributes. These soils are very productive if well managed, but present constraints to low input agriculture. The surface micro variability of vertisols, reflected in their internal soil properties, imposes constraints on their use for agronomic research and agriculture in general. Temporal changes in physical attributes of these soils require accurate timing of agricultural practices for efficient use. As the unique mineralogy of vertisols makes these soils very susceptible to erosion, soil management practices must be geared to reduce soil loss. Although their high natural fertility and positive response to management make vertisols attractive for agriculture, some of their other properties impose critical limitations on low input agriculture. The inherent limitations of vertisols are largely a function of the moisture status of the soils and the narrow range of moisture conditions within which mechanical operations can be conducted. Farmers using traditional methods of agriculture are aware of the high risks associated with the use of these soils. Even with high input technologies, risk a version is difficult since timing of tillage and of other farming operations is critical. As a consequence, the full agricultural potential of vertisols has not yet been exploited in many parts of the world. In order to appreciate the management related properties of vertisols, it is necessary to know not only the general soil properties, but also the properties in different parts of the soil.

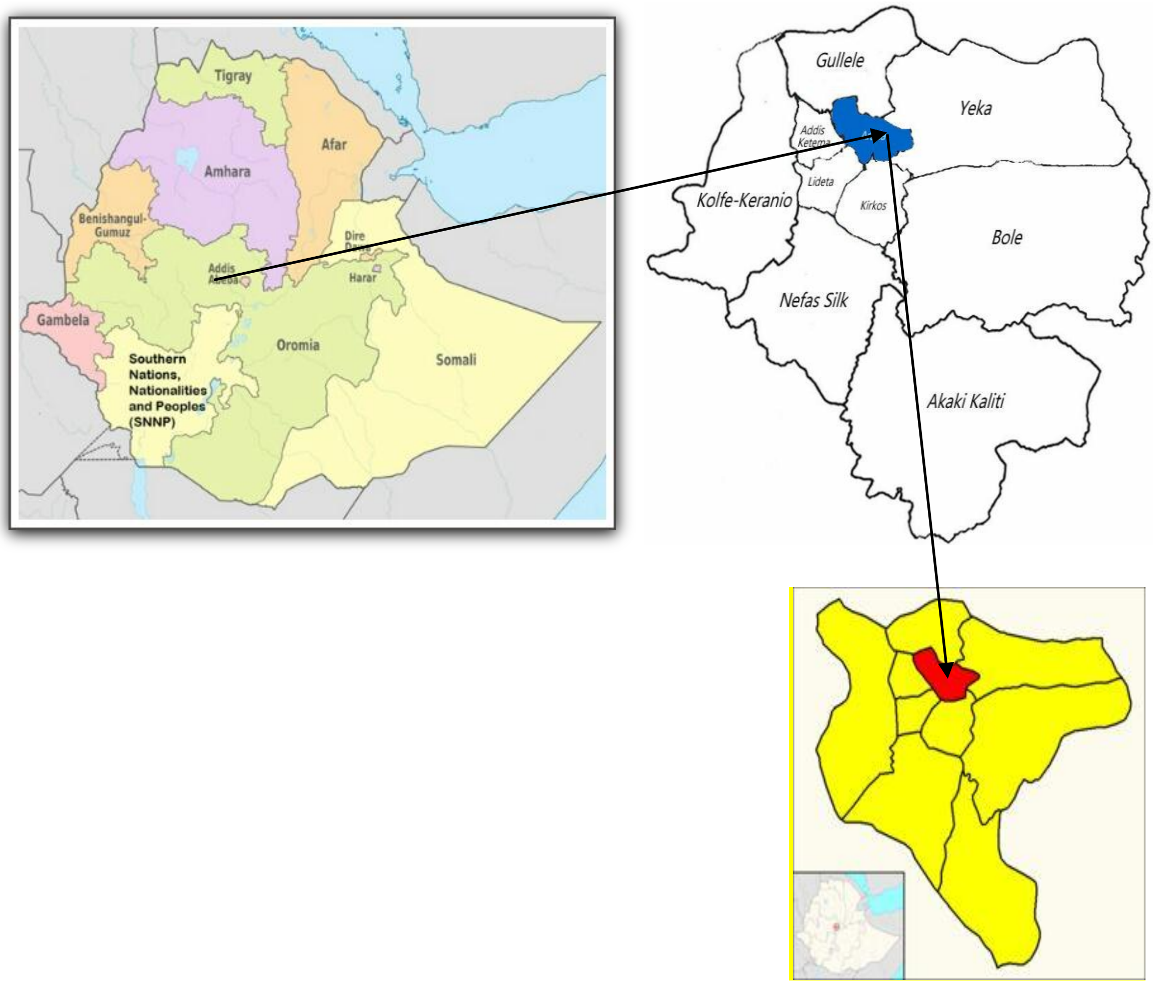
3.10 Effects of compost on growth performance and yield of lupin

Organic fertilizer include compost, farm yard manure, slurry, worm castings, urine, peat, green manure, dried blood, bone meal, fish meal, and feather meal (Haynes and Naidu, 1998). Compost is a finely divided, loose material consisting of decomposed organic matter. It is primarily used as a plant nutrient and soil conditioner to stimulate crop growth. It helps the tilth quality of the soil, stabilize the pH or acidity/alkalinity, and release balanced quantities of many nutrients, and including quite a few not found in most commercial fertilizers. Compost has the added advantage of being natural. Mother Nature has been making compost for a lot longer than man has been around to enjoy the benefits. Composts are slow release organic fertilizers and excellent sources of most plant nutrients to increase crop yields (Sukhdev and Kabal, 2013). According to ANRSBA (2004) 120quintal/ha compost is recommended for Lupin seed production.

4. MATERIALS AND METHODS

4.1 Description of the study area

The study was conducted in Addis Ababa between December 2020 and April 2021. Addis Ababa is found in the very central part of Ethiopia. Located in the foot hills of mount Entoto.It has a latitude and longitude of 9º1´N38º44´Eand an elevation of 2,355m. a. s. l (7,726 ft). The area estimates about 527 square kilometers. The area receives an average annual rain fall of 1143 mm. The minimum and maximum temperatures are 14and 21℃ respectively. The soil of the study site comprises 75% vertisol, 15% reddish-brown, nitosol and 10% other soil types.



Arada sub city

Fig.2: Map showing location of Addis Ababa town in central part of Ethiopia.

A B

Fig. 3: Sample of vertisol (A) and thoroughly mixed sun dried vertisol (B) used for the present study. The whole soil employed for the study was collected from Akena gifi Kebele, Banja Wereda, west Gojjam Zone, Amhara National Regional State.

4.2 Nursery bed preparation

Before starting the actual plastic pot experiment, a rectangular nursery bed of 250cm x 650cm was prepared, which was enough to accommodate the 100 pots. The nursery was fenced wooden and mesh wire materials such that the Lupine plants were protected from wild and domestic animals. The fence has a suitable entrance fitted with appropriate protection so as to ward off animals.

4.3 Seed procurement

Seeds of *Lupinus albus* were purchased during the 3thweek of November 2020 from the local market of Injibara town. Seeds were sieved to remove any debris materials and were stored at room temperature in paper bags.

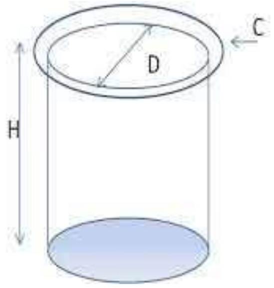
Fig. 4: Seeds of *Lupinus albus*.

4.4 Soil sampling and analysis

Soil samples were collected from the same site of bare field. Samples were randomly removed to the end of the vertisols horizon with the help of pick axe. Soil sampling was avoided where crop rotation was intentionally avoided. Since farmers in the locality used commercial fertilizers, this may add chemical residues to the soil and influence Lupin plant growth. A large composite soil sample was then prepared by drying the vertisol in sun, and thoroughly mixed so as to ensure sample homogeneity as much as possible. Composite soil sub sample was made from the powdered soil and was then subjected to various analyses in laboratory of the Injibara Soil Testing and Fertility Improvement Center.

4.5 Compost amount and application

Circular plastic pots were used for the present study (depth 20 cm, diameter 10 cm).



$A = \pi r^2$h Where, r is the radius of a circle (r =diameter (D)/2)

$$\text{Pi } (\pi) = 3.14$$

$$A = 3.14 \times (5\text{cm})^2 h = 3.14 \times 25\ \text{cm}^2 \times 20\text{cm} = 1570\ \text{cm}^2$$

$$1\text{m} = 100\text{cm}\ (1\text{m}^2 = 10{,}000\text{cm}^2) \Rightarrow 1570\ \text{cm}^2 = 0.16\ \text{m}^2$$

$$1\ \text{hectare} = 100\text{m} \times 100\text{m} = 10{,}000\ \text{m}^2$$

Compost application

$10{,}000\ m^2 = 120$ quintal, 120quintal = 12000kg (1quintal = 100kg)

$10{,}000\ m^2 = 12000kg$

$0.16m^2 = ? \Rightarrow 0.192kg = 192gm$

The required quantity of all organic sources of nutrients, composts were weighted as per treatments using digital balance SF-400 and mixed with the soil one day before the time of planting (9.6gm compost per pot was applied) .In control treatments no additional compost were added.

Fig. 5: Sample of compost for the present study, obtained from the local market of Injibara town, and the compost was obtained from Banja woreda Rural Development Agricultural Office and Tree Planting Center.

4.5.1 Raw materials used for composting and the manufacturing processes

Technically, compost may be made from any organic materials, from any parts of an organism, plant or animal that contains carbon. Compost also requires a source of nitrogen, oxygen, and water, plus small amounts of a variety of elements usually found in organic material, including phosphorus, copper, potassium, calcium, and others. In order to the organic materials to be combined with the other materials and decompose into compost, several living organisms and microorganisms are needed. These include sow bugs, which help digest the materials and transport bacteria; earthworms, which aerate the materials with their tunnels; a variety of fungi, which help digest decay-resistant cellulose; mold like bacteria called actinomycetes, which attack raw plant tissues; and many others. The most common raw materials used to make compost are yard wastes such as grass clippings, leaves, weeds, and small pruning’s from shrubs and trees. Most home garden compost piles and municipal compost facilities used yard wastes exclusively because of the large volume of materials available.

The production of compost required both a mechanical and a biological process. The raw materials must first be separated, collected, and shredded by mechanical means before the biological decomposition process can begin. In some cases, the decomposition process itself is aided by mechanical agitation or aeration of the materials. After decomposition, the finished compost is mechanically screened and bagged for distribution (Chong-Ho Wang *et al*., 2005). For the present study 2 and 5 m depth and width respectively pit was prepared then raw materials, such as; leaves (appendix 6), dung, nitosol and ash were mixed together during the mid of August, 2020. Rain keep the raw materials wet and aided the decomposition process, producing rich compost. The mixture of different raw materials were turned and mixed once every 15 days for about three months.

4.6 Planting of seeds of *Lupinus albus* and planting method under nursery bed conditions

100 plastic bags(depth 20 cm, diameter 10 cm) were filled with 1kg of vertisol, among these 50 bags contained only vertisol, and the rest 50 contained soils mixed with compost(Figure 6: A). Each plastic bag were picked up by using sharp nail of appropriate size at the bottom 7 narrow holes, and at both sides 14 narrow holes. The pots were labeled and randomly arranged on the prepared nursery bed. Lottery methods are used to randomize the placement of plastic bags.

Three hundred fifty (350) seeds were planted on December 23, 2020 by hand in planting plastic bags and tried to finish planting in a day (three seeds per pot). Before planting the seeds water the soil so as to ensure enough moisture for the seeds. Three healthy looking seeds of Lupin were planted in the middle of each at the depth of 2 (cm) following Bulcha (2007).This was because correct planting depth gives good germination. Just after the planting, the seeds were well covered in the soil, a small amount of water was given and bird watching was done till the seedlings got well established. Each bag containing the planted seeds was watered the same amount of tap water twice a day (200 ml morning, 200 ml late evening) initially, from December 23-31, 2020 and was provided with a daily dose of 400 ml thereafter using a watering can and were allowed to grow for four months and a week under nursery bed conditions, where the mean minimum and maximum temperatures during the study period were 21.3 ± 23.1 ℃noon and 14.7± 17.3℃nights respectively.

Fig. 6: Randomized plastic bags under nursery bed conditions (A). Watering equal amount of tap water (B).

4.7 Data collection and statistical analysis

Data on seed germination response were collected every two days, after the first day of germination, for about 15 consecutive counts. Seeds were considered germinated at the time when protrusion of radicle. The final germination was recorded, and expressed in terms of germination parameters such as germination percentages (GP) mean germination time (MGT), and germination vigor (GV) were calculated according to Lbourian and Agudo (1987), as follows.

1. Determination of germination days: The duration of seed germination was recorded.
2. Determination of Germination percentage. It is the proportion of the seeds that germinate from all seeds subjected to the right conditions for growth. Germination percentage (GP) = $(n/N)\times 100$; where: $n =$ total number of germinated seeds in plastic sleeves.$N =$Total number of planted.
3. Mean germination time: $MGT = (\sum niti)\ /$ nwhere: $ni =$ percentage of seeds germinated between consecutive counts.

   $ti =$Time (in day) taken since germination experiment started.

   $n =$Total number of seed germinated.

After germination had occurred and the seedlings had grown to a height of 5 to 7 cm, keep only one of the most vigorous and looked health seedlings as judged by eye and removed the others. From each treatments totally 17 plastic sleeves totally 34 were selected by simple random sampling technique. Plant height, intermodal length, number of leaves, leaf area, number of branches per plant and RCD were considered as an important growth parameters of the present study. Similarly, number of capitulae/plant, number of seeds/plant, seeds weight, 1000 seeds weight, chaff dry weight and total dry weight were also considered as yield parameters. To compare growth responses of seedlings under nursery bed conditions, height (cm) increment measurements every 5 days for the first 30 days and every 7 days until anthesis each from the ground to the tip of the apex. Likewise, intermodal length (cm), number of leaves and leaf area (mm^2) were measured periodically at 15, 30, 45, 60, 75, 90 days after germination and number of capitulate (heads) per plant, number of branches per plant, total dry weight (gm), chaff dry weight (gm), RCD, seed yield (gm) and 1000 seeds weight (gm) were recorded at harvest. Because the feature to be measured, leaf area has an irregular shape, its area cannot be directly calculated by using mathematical formula. Therefore, to found the area of the leaves (two leaves from each sampled plant) was spread over millimeter graph paper, a uniform interval 1mm and the outline of leaves were drawn while still attached to the plant. Then count the number of grid squares within the leaves (number of full squares,¾,½ and ¼ squares) and add the number of grid squares within the leaves to get the total number of squares. The approximate areas of the leaves were calculated using $area=S^2$.

The data of plant parameters were analyzed and their means were computed. The Analysis of variance (ANOVA) was carried out for germination, growth and yield parameters of the study using SPSS version 20. Duncan’s post hoc test ($p\leq 0.05$) was used to determine the homogeneity subsets whenever significant differences existed among mean values presented in the appendices and excel program, excel 2007 to illustrate and compare data on Figures.

4.8 Harvesting

Crop was harvested when majority of leaves (nearly 80%) in plants senescened and capitulae turned into yellowish in color. Harvesting was done on 113 and 120 days in vertisol only, and VR+Compost after germination respectively for biomass determination. The roots of harvested seedling were watered too much to minimize the detachment of fine roots, the detached parts were tied on the corresponding part. The shoot and root of the fresh seedlings were carefully separated by cutting with dissecting knife. The respective shoot and root of seedlings were labeled and arranged. Dry matter data has been recorded after drying the seedling in the sun for four days so as to attain constant dry weight. The dried shoot and root of each seedling were measured separately to determine shoot and root weight and together to get total dry weight by using a digital balance SF-400. The ripen capitulae (head) of each treatments were collected using scissor and stored in plastic bags separately. The collected capitulae were sun dried separately for the determination of seed yields per plant. Threshing was done on winnowing and the chaffs were separated so as to keep seeds clean. The seeds were weighted on TANITA 1479X and stored in plastic bags.

Fig. 7: Sun dried capitulae of *Lupinus albus* obtained from control (A), seeds puresoil and compost (B) respectively. Threshing was done on winnowing (C) to separate seeds from the chaffs for the determination of seed yields.

5. RESULTS

5.1 Germination parameters of white Lupin as influenced by compost under nursery bed conditions

5.1.1 Germination percentage

Results on percentage germination of *Lpinus albus* obtained from plants where compost was added, and the control experiment provided in (Fig. 12). Seed germination began within five days in all treatments under nursery conditions. Maximum germination percentage was observed where compost is added, higher by 62.8% compared to control treatments (50.4%). However there was no significant difference with in treatments the various treatments ($p \leq 0.05$).

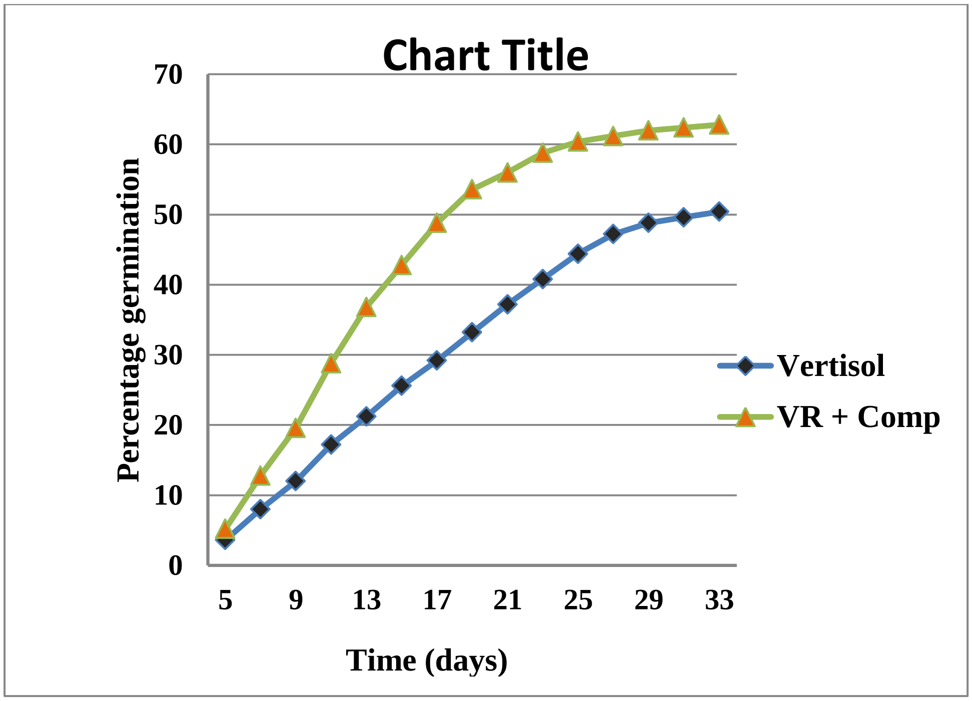


Fig. 8: Germination percentages of *L.albus* seeds. Data points represent mean percentage germination on the respective days.

5.1.2 Mean germination time

The effects of application of compost on mean germination time are shown in Figure 9. Maximum mean germination time was obtained from seeds planted with control treatments (11.7%) compared to compost (10.6%). Minimum mean germination time was obtained from compost treatments. However the difference in mean germination rate between the two treatments is significant.

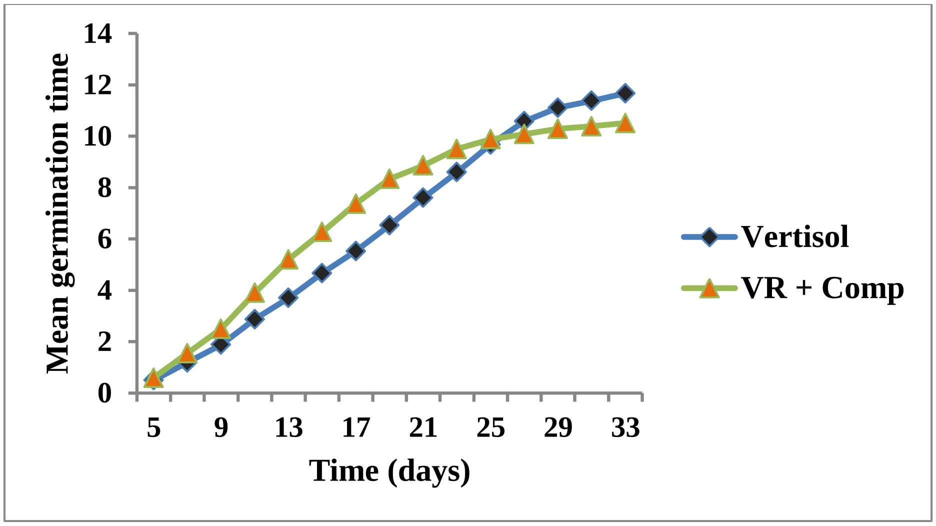


Fig.9: Mean germination time of *L. albus* seeds in vertisol only and VR+Compost. Data points represent mean germination time on the respective days.

5.1.3 Germination vigor

Germination vigor percentage of vertisol only and VR+Compost seeds planted in plastic sleeves under nursery conditions were calculated. The germination vigor percentage of these different treatments showed no significant difference at $p \leq 0.05$. However maximum germination vigor percentage was obtained in compost treatments (2.4%) compared to control treatments (1.8%) as shown in Figure10below.

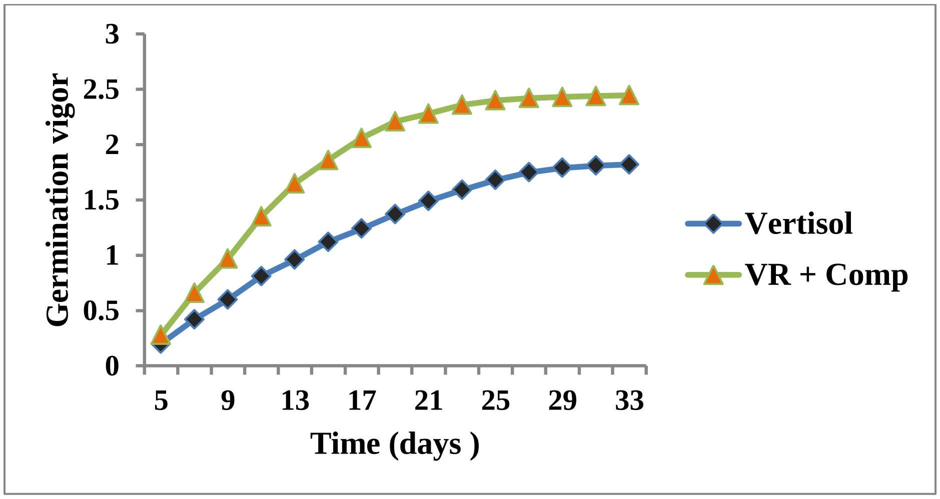


Fig.10: Germination vigor of *L. albus* seeds in vertisol only and VR+ Compost. Data points represent germination vigor on the respective days.

5.2Flowering and maturity of white lupin as influenced by compost under nursery bed conditions

As shown in Table 2a pplication of compost fasten flowering and maturity of lupin. The start of flowering by 50% and complete flowering and maturity in VR+compost groups' by12, 7, 13, and 14 days respectively earlier compared to the control. The corresponding days in the VR only by7, 1, 6 and 7 days respectively.

Table 2: Treatment employed, planting date, flowering and days of maturation. Seedlings grown in VR+compost showedearlier start of flowering, 50% and complete flowering as well as days of maturation.

Treatments	**Planting date**	**Start of germination**	**Start of flowering**	**50% flowering**	**Complete flowering**	**Days of maturation**
Vertisol only	December 23/2019	December 27/2019	72 DAG	88 DAG	95 DAG	120 DAG
VR + Comp	December 23/2019	December 27/2019	67 DAG	82 DAG	88 DAG	113DAG

5.3 Growth parameters of white Lupin as influenced by compost under nursery bed conditions

5.3.1 Plant height increment

Seedlings grown in vertisol only and VR+Compost have shown significant differences in their mean height. However in the 1st, 2nd, 3rd, 4th, 5th, 6th, 7th, 8th, and 9th weeks $i.e.$ 5, 10, 15, 20, 25, 30, 37, 44, and 51 days there was no difference in height. Seedlings grown in the control experiment, mean height of 0.7, 1.6, 2.5, 3.2, 3.9, 4.3, 4.6, 4.9, and 5.3 cm respectively. The corresponding mean heights for plants grown in VR + Comp were 0.9, 1.9, 2.7, 3.8, 4.7, 5.1, 5.5, 5.9, and 6.4 cm respectively. After 10th, 11th, 12th, 13th, 14th, and 15th weeks $i.e.$ 58, 65, 72, 79, 86, and 93 days plants grown in VR+compost showed better significant growth ($p \leq 0.01$) with mean height of 7.3, 10.4, 15.5, 22.5, 30.5, and 41.5 cm respectively. The control plants resulted mean height of 5.6, 6.5, 8.8, 12.5, 16.7, and 25 cm respectively as shown in Figure 11. In general application of compost at rates of 50 and 30 kg/ha respectively improved the vegetative growth by 195% compared to the control.

Similarly, application of compost at rates of 120 quintal/ha improved the vegetative growth by 66%.

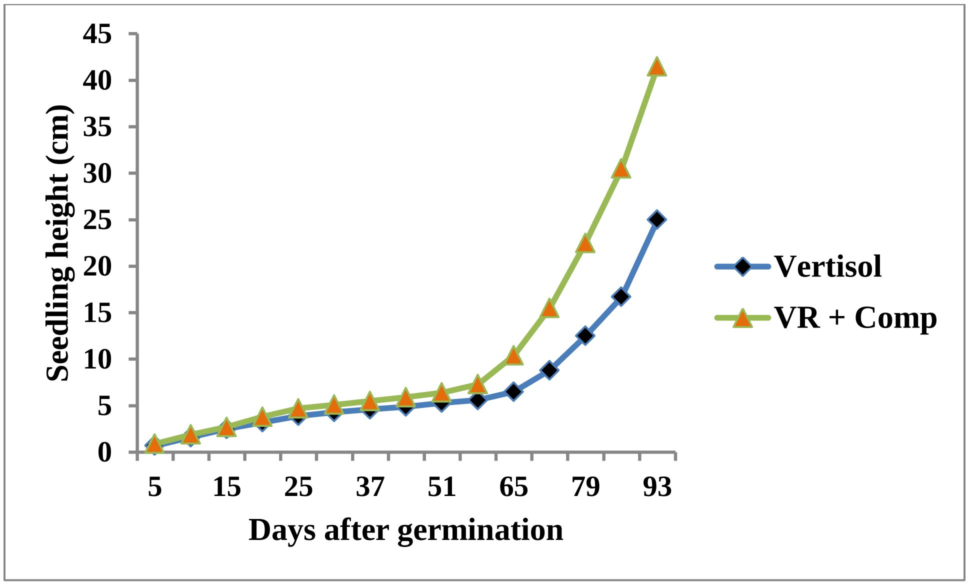


Fig. 11: Mean height (cm) of *L. albus* seedlings grown in vertisol only and VR+Compost. Data points represent the mean height increment on the respective days.

5.3.2 Internodal length

The mean internodal length of seedlings grown in vertisol only and VR+Compost are shown in Figure 12.Plants grown in VR+compost showed better significant internodal length ($p \leq 0.01$).The highest internodal length difference was observed in the 10th and 12th weeks i.e. 75 and 90 days with mean internodal length of the control were 2.8 & 5.3 cm and VR+Comp 6.7 & 11.9 cm respectively. In 2nd, 4th, 6th and 8th weeks there were no big mean internodal length differences. The mean internodal length of the control groups were 0.7, 0.9, 1.1 & 1.5 cm respectively. The corresponding values in VR+Comp groups resulted in 1.4, 1.8, 2.5 & 3.4 cm respectively.

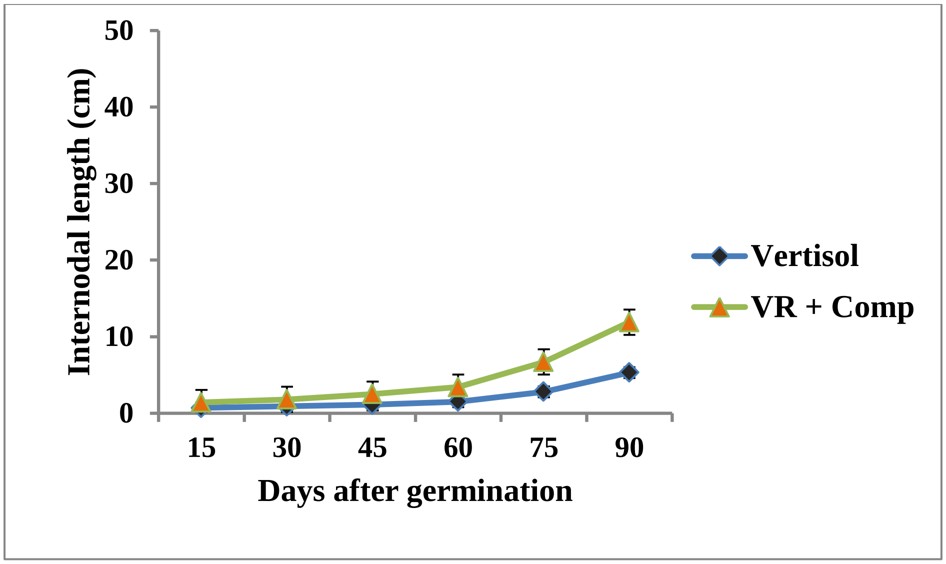


Fig. 12: Mean internodal length (cm) of *L. albus* seedlings grown in vertisol only and VR+Compost. Error bars indicate ±SE.

5.3.3 Number of branches/plant

Maximum mean number of branches was registered in VR+ Comp (7) compared to the control treatments (3). The control treatments had significantly lowest number of branches/plant amongthe treatments ($p \leq 0.01$) as shown in Figure 13.

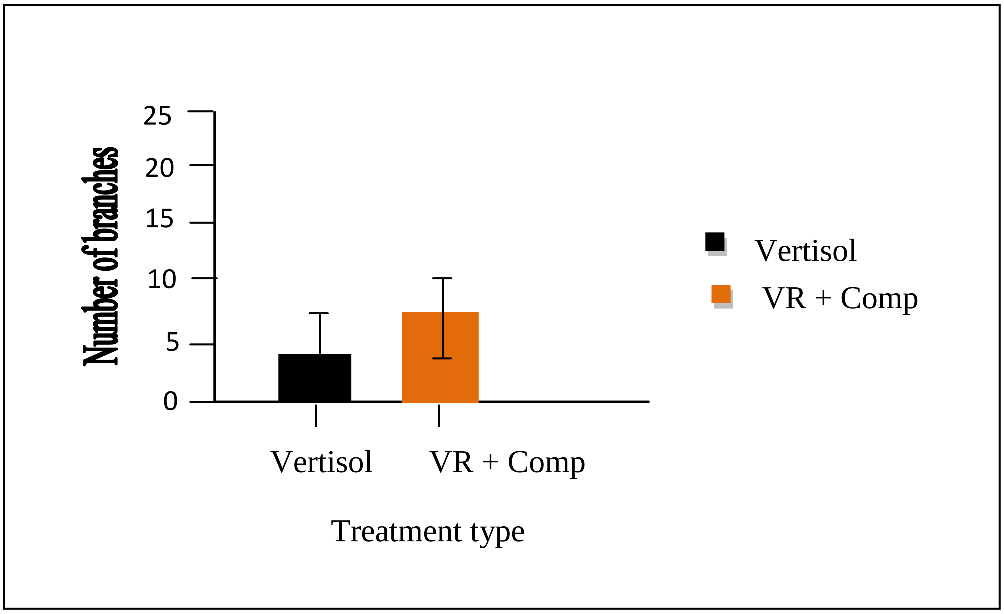


Fig. 13: Mean number of branches of *L. albus* seedlings grown in vertisol only and VR+Compost. Vertical bars indicate ±SE.

5.3.4 Leaf number

The mean number of leaves produced per plant was highly significant ($p \leq 0.01$) for seedlings grown in VR+compost (26) compared to those grown in vertisol only (19) as provided in Figure 18.

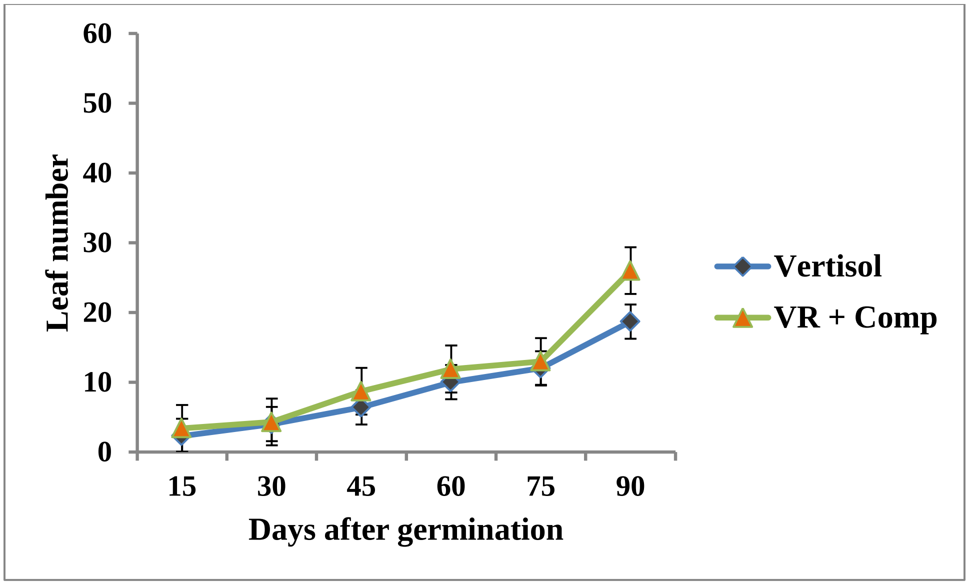


Fig. 14: Mean leaf number of *L. albus* seedlings grown in vertisol only and VR+Compost. Vertical bars indicate ±SE.

5.3.5 Leaf area

Seedlings grown in VR+compost showed highly significant ($p \leq 0.01$),maximum mean leaf area value of 43.2 mm^2 compared to those grown in vertisol only (26.2 mm^2) as shown in Figure 15 below.

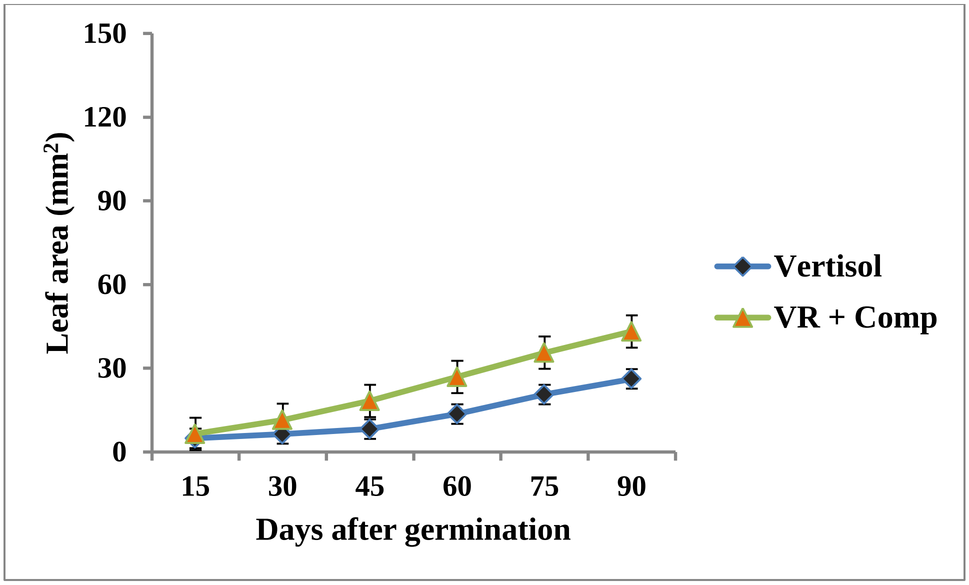


Fig. 15: Mean leaf area (mm^2) of *L. albus* seedlings grown in vertisol and VR+Compost. Vertical bars indicate ±SE.

5.3.6 Root collar diameter (RCD)

Significantly maximum RCD (*p*≤ 0.01) was obtained in compost treatments (1.3 cm) compared to control treatments (1.2 cm) as shown below in Figure 16.

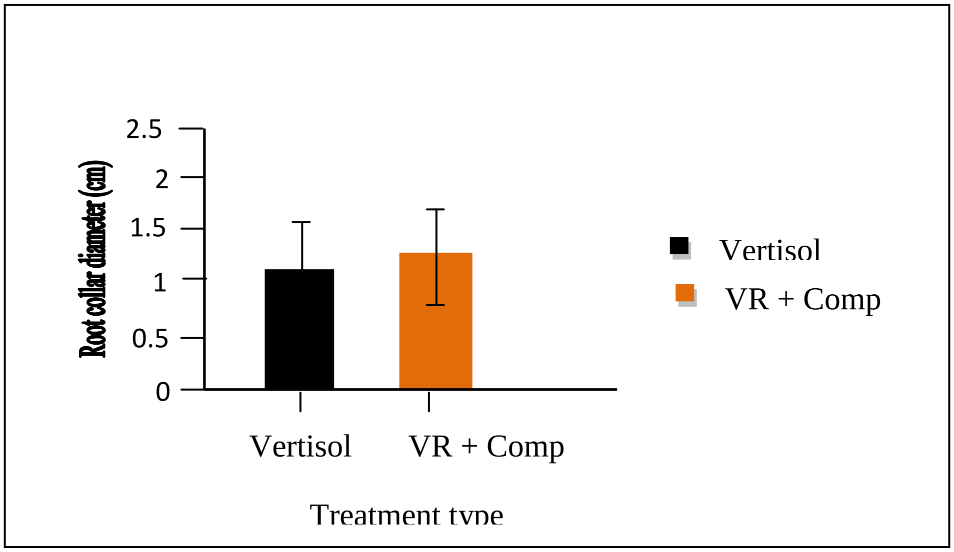


Fig. 16: Mean root collar diameter (cm) of *L. albus* seedlings grown in vertisol only and VR+ Compost. Vertical bars indicate ±SE.

5.4 Yield parameters of white Lupin as influenced by compost under nursery bed conditions

5.4.1 Number of capitulae per plant

Significantly highest number of capitulae/plant was recorded ($p \leq 0.01$) VR + Compost (8) treatments compared to control treatments (4). The control treatments had the lowest number of capitulae/plant amongthe treatments as shown in Figure 17.

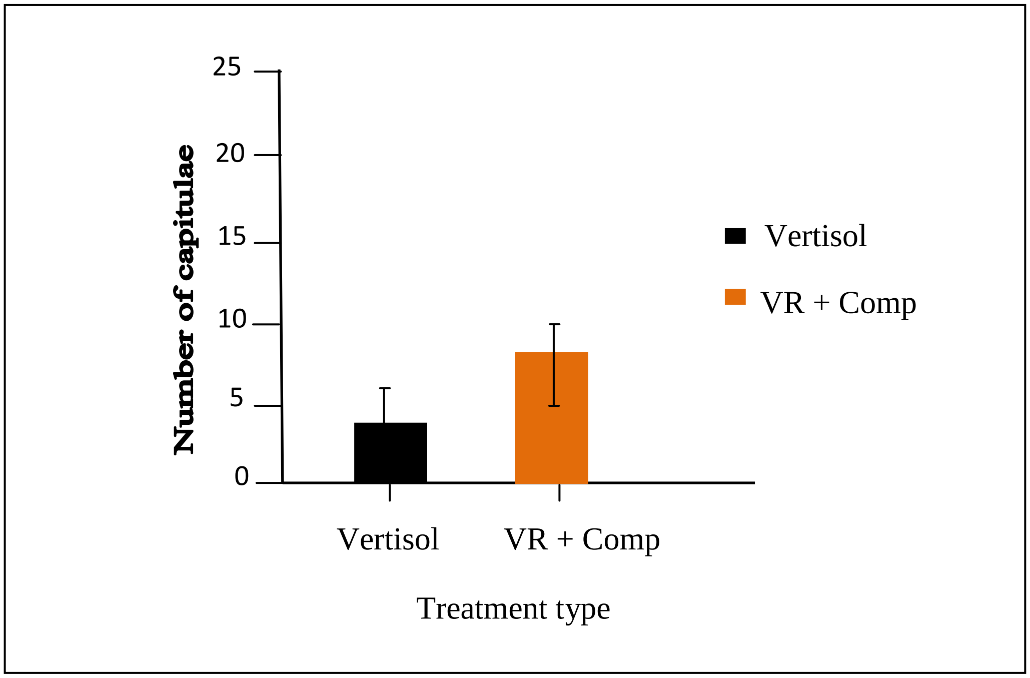


Fig. 17: Mean number of capitulae per plant of *L. albus* seedlings grown in vertisol only and VR+Compost. Vertical bars indicate ±SE.

5.4.2 Number of seeds per plant

Plants grown in VR+compost had significantly ($p \leq 0.01$) highest value of mean number of seeds/plant (80) compared to control treatments (50). Application of compost at rate of 120 quintal/ha increased the yield by 60% as shown in Figure 18 below.

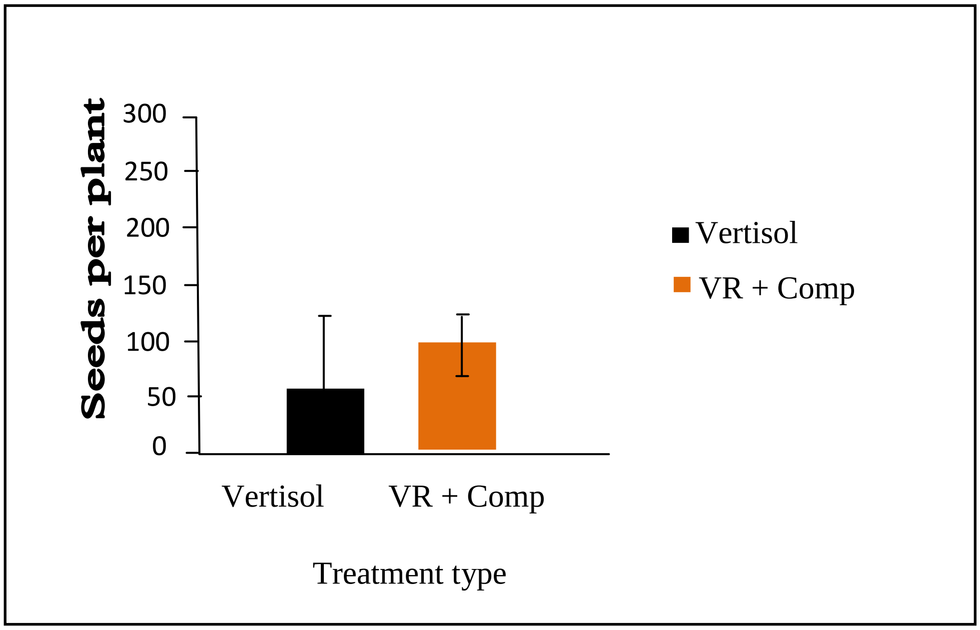


Fig.18: Mean number of seeds /plant of *L. albus* seedlings grown in vertisol only and VR+Compost. Vertical bars indicate ±SE.

5.4.3 Seeds weight per plant (gm)

Mean seeds weight had significantly ($p \leq 0.01$) maximum in VR+compost treatments with the value of 0.47 gm compared to control treatments (0.33 gm) as shown below in Figure 19.

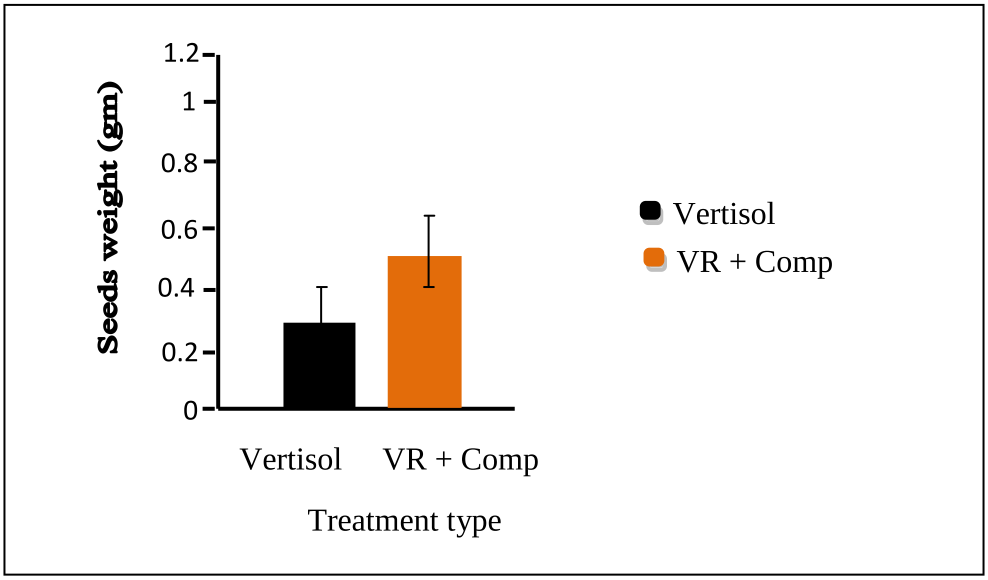


Fig. 19: Mean seeds weight (gm) per plant of *L. albus* seedlings grown in vertisol only and VR+Compost. Vertical bars indicate ±SE.

5.4.4 Thousand seeds weight (gm)

1000 seeds were taken randomly from the sampled plants of each treatments then weighed by triple beam balance model TANITA 1479X made in India to determine 1000 seeds weight from each treatments. Though slight differences of 1000 seeds weight was recorded between VR+Comp and vertisol, maximum 1000 seeds weight was recorded in VR+compost treatments (4.7 gm) and (3.3 gm) of 1000 seeds weight was recorded in control treatments respectively (Figure 20).

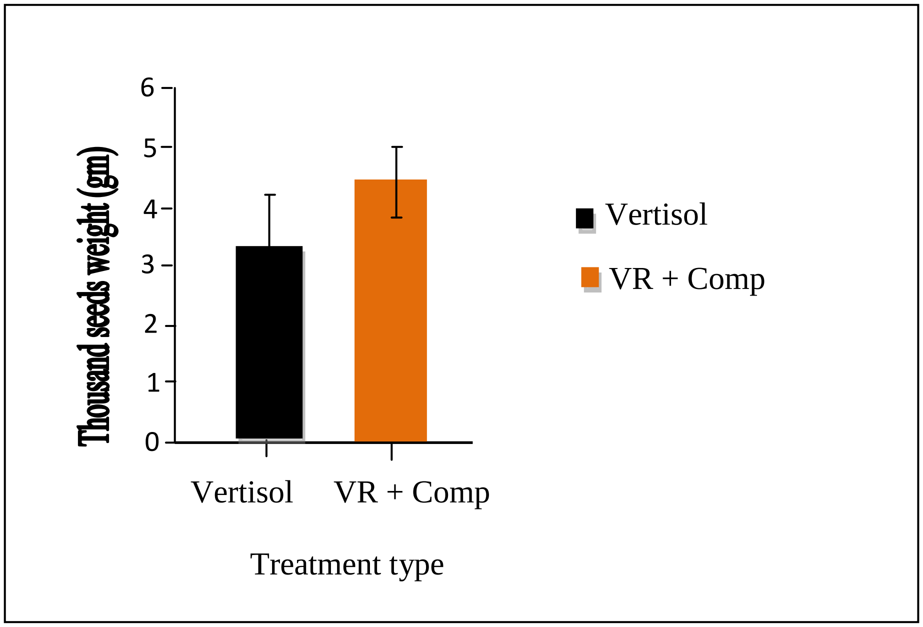


Fig. 20: Thousand seeds weight (gm) of *L. albus* seedlings grown in vertisol only and VR+Compost. Vertical bars indicate ±SE.

5.4.5 Biomass production

The VR+Compost treatments had highest biomass production of 5.2 gm compared to control treatments (3.1 gm). The highest mean shoot, root and total dry weight (gm) was recorded in VR+Compost treatments as shown below in Figure21, 22 and 23 respectively. Plants grown in VR+Compost also exhibited the highest chaff dry weight(1.5 gm) compare to control treatments (1.3 gm) (Figure 25).However, the highest mean shoot to root dry weight (gm) ratio was recorded in control treatments (4.4) compared to VR+Compost treatments (4.7) as shown in Figure 24.

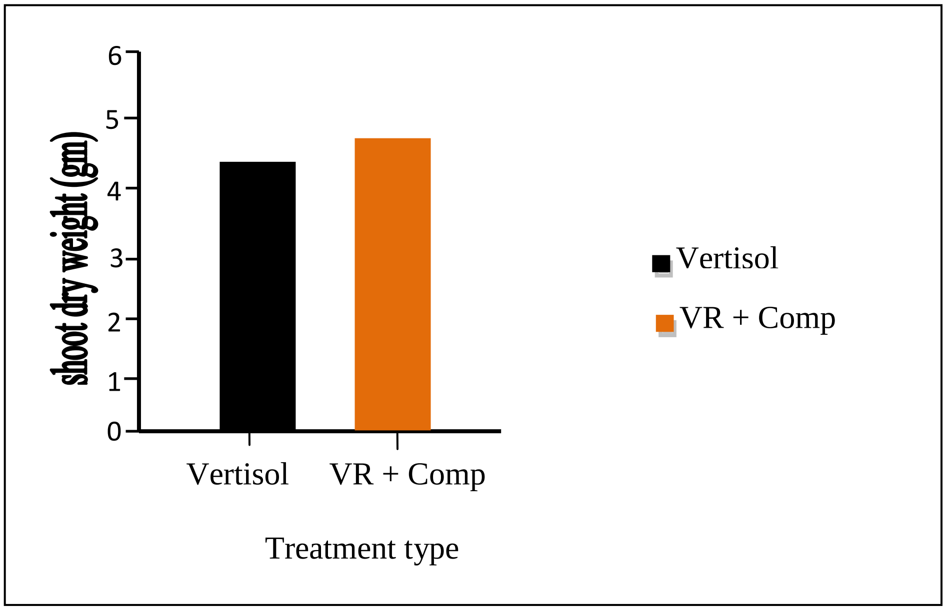


Fig. 21: Mean shoot dry weight (gm) of *L. albus* seedlings grown in two treatments. Seedlings grown in VR+Compost showed the maximum value compared to the vertisol only. Error bars represent ± S.E.

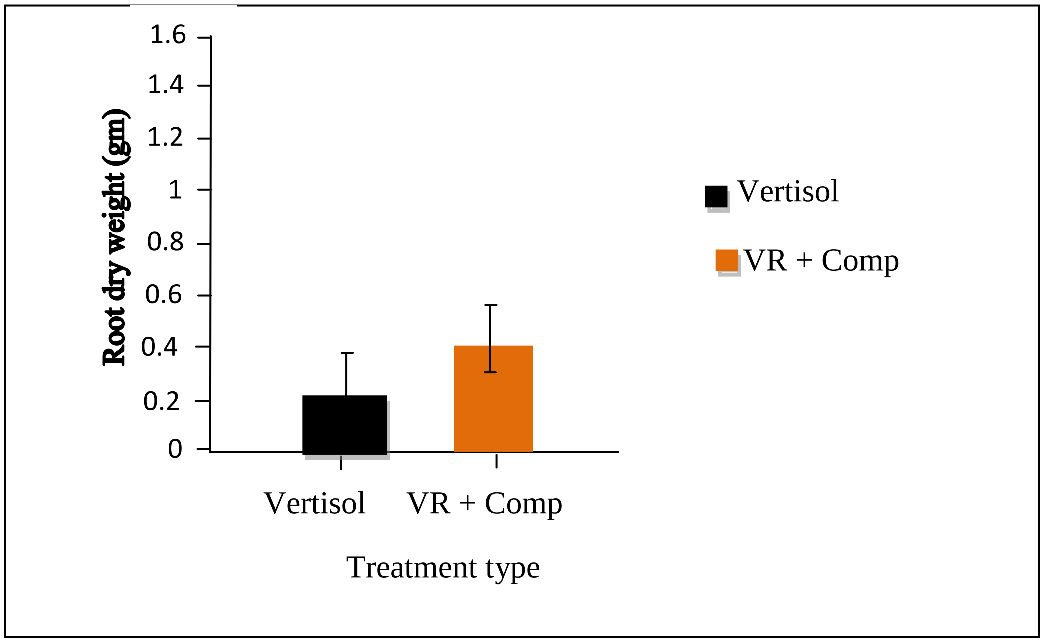


Fig. 22: Mean root dry weight (gm) of *L. albus* seedlings grown in two treatments. Seedlings grown in VR+Compost showed the maximum value compared to thevertisol only. Error bars represent± S.E.

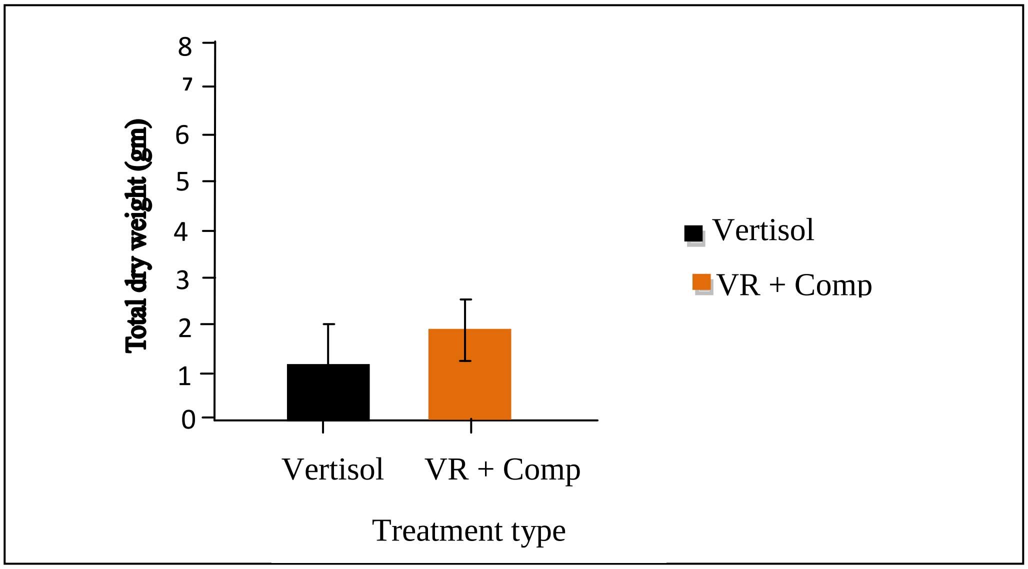


Fig. 23: Mean total dry weight (gm) of *L. albus* seedlings grown in two treatments. Seedlings grown in VR+Compost exhibited the highest dry weights compare to those located in Vertisol only. Error bars represent± S.E.

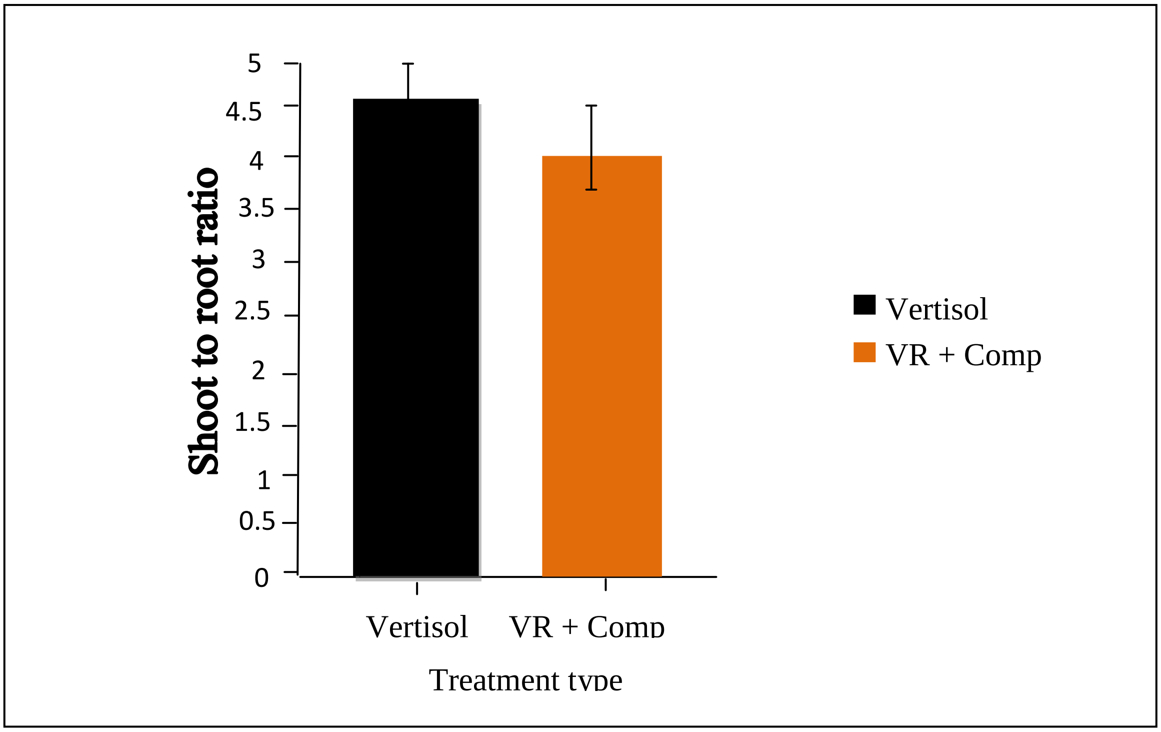


Fig. 24: Mean shoot to root dry weight (gm) ratio of *L. albus* seedlings grown in two treatments. Seedlings grown in the control treatments exhibited the highest shoot to root ratio compare to those located in VR+Compost. Error bars represent± S.E.

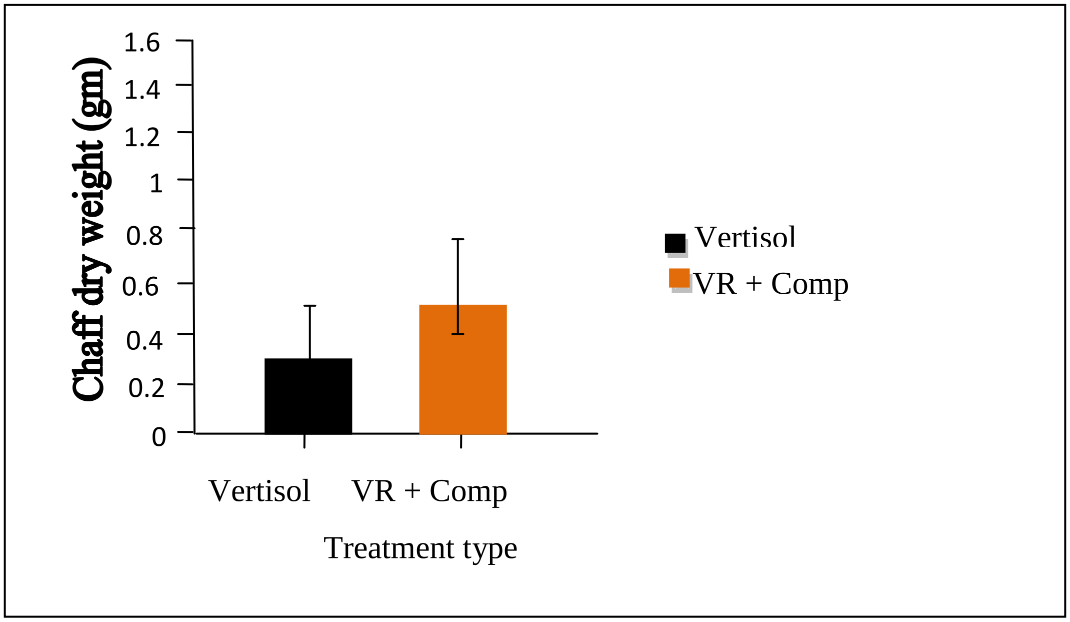


Fig. 25: Mean chaff dry weight (gm) of *L. albus* seedlings grown in two treatments. Seedlings grown in VR+Compost exhibited the highest chaff dry weight compare to those located in Vertisol only. Error bars represent± S.E.

5.5 Results of soil analysis

The results of vertisol analyzed for texture, pH, OC, TN, Av. P, and Av. K are presented in Table 2. This shows the vertisol used for the present study was below the standard in terms of organic carbon (1.17%compared to the standard average value of 4-10%), total N (0.101%compared to the standard average value of 0.125-0.225%) and available P (2 ppm compared to the standard average value of 8-12 ppm). However, the vertisol used contained high available K (267 kg/ha compared to the standard average value of 100-250 kg/ha) (Frank, 1990).

Table 3: The results of physico-chemical properties of vertisols analyzed in Injibara Soil testing and fertility Improvement Center Laboratory used for the present study.

S. No.	**Constituent**	**Analytical value**	**Interpretation**	**Method of determination**
A	Physical properties			
	Texture		Clay soil class	Hydrometer method
1	Sand (%)	8		
2	Silt (%)	16		
3	Clay (%)	76		
B	Chemical properties			
1	Soil pH	6.85	Slightly acidic	Distilled water method
2	Organic Carbon (OC %)	1.17	Very low	Walkely & Black method
3	Total Nitrogen (TN %)	0.10	Low	Kjieldhal method
4	Av. P (ppm)	2	Very low	Olsen method
5	Av. K (kg/ha)	267	High	Ammonium acetate method

5.6 Plant materials used to prepare compost

The compost used for the present study was prepared from dung, nitosol, ash and different plant materials. The plant materials were used in their vegetative stages. Those plants used for compost manufacture were presented in Appendix 6.

Table 4: List of plants used for compost preparation for the present study. The plant materials were used at their vegetative stages (data obtained from agricultural extension workers of Banja Woreda .

S. No.	**Local Amharic name**	**English name**	**Scientific name**
1	Sensel/Semiza	Poison arrow tree	*Justica shimperiana*
2	Gerawa	Bitter leaf	*Vernonia amygdalina*
3	Yekura hareg	Corton	*Cucumis dipsaceus*
4	Astenager	Jimsonweed	*Datura stramonium*
5	Sesbania	Sesbania	*Sesbania sesban*
6	Yeferenge tid	Mexican cypress	*Cupressus lusitanica*
7	Serdo	Bermuda grass	*Cynodon dactylon*
8	Muja	Snowdenia	*Snowdenia polystachya*
9	Telenje	Chaff flower	*Achyranthes aspera*
10	Yahiya eshoh	Milk thistle	*Silybum marianum*
11	Chakema/Gullo	Caster bean	*Ricinus communis*
12	Lite	Cheeseweed	*Malva parviflora*
13	Bisana	Corton	*Corton macrostachyus*

6. DISCUSSIONS

6.1 Germination parameters of white lupin as influenced by compost under nursery bed conditions

6.1.1 Seed germination

Not all the seeds planted in the plastic sleeves germinated. However, more than 50% of the seed were germinated in this study. Some of the seeds did not germinate may be due to seed dormancy mechanisms which are specific to the species. That plants develop different dormancy mechanisms so as to avoid unfavorable environmental conditions (Bewley and Black, 1994; Bradbeer, 1988; Legesse Negash, 1995; 2010).Maximum germination percentage was recorded in VR+Compost (62%). This may be due to ahigher nitrogen content in compost facilitate seed dormancy breaking and stimulating seed germination and emergency (Agenbag and Villiers, 1989).The potential role of nitrogen, for instance nitrate is known with assimilating seed germination (Bewley and Black, 1982; Hilhorst and Karssen, 1992; Baskin and Baskin, 1998).

6.2 Flowering and maturity of white lupin as influenced by compost under nursery bed conditions

A significant variation was noted among the treatments in relation to days for flowering and maturity. The minimum days for start of flowering, 50%and complete flowering and maturity was recorded in VR+Compost. Similar result was obtained by Jirali *et al*. (1988), they opined that lupine produced maximum number of flowers at 75 days after sowing produced maximum yield. Salim and Saena (1993) reported that early flowering was associated with high harvest index, large number of capitulae and high seed mass.

6.3 Growth parameters of white lupin as influenced by compost under nursery bed conditions

6.3.1 Height increment

Plant height is a simple measurement of plant growth and it depends on number of nodes and length of effective nodes. In this study a significant effects was observed due to the application of compost on plant height. Maximum plant height was noted in compost treatments (73.8 cm), while minimum plant height was in the control treatments (25 cm). An increase of plant height in VR+Compost treatments would likely to be associated with nitrogen and phosphorus supply promoting the plant height by 21% (Taiz and Zeiger, 2006).

6.3.2 Branches per plant

Application of compost at rates of 120 quintal/ha positively influence on production of branches/plant at maturity. The number of branchesper plant were 7 and 3 inVR + Compost and control experiment, respectively .The lowest number of branches/plant in the control treatments probably because no compost was applied (Mondal *et al.*, 1992). In this study, VR+Compost caused to increase the number of branches/plant of lupine. This increased number of branches/plant in VR+Compost might be due to the higher phosphorous and nitrogen in compost (Table 3b) may promote vegetative growth of the crops (ICAR, 1992).Similarly, Mohan (2008) reported that number of branches/plant significantly increased with application of nutrients in compost.

6.3.3 Leaf number

Application of compost significantly increased the number of leaves. Maximum number of leaves was registered in VR+Compost (50). This might be due to favorable effect of high nutrient availability. The major component of chlorophyll is nitrogen, and it promotes vegetative growth and green foliage (Jones, 1983). The control treatments produced significantly minimum mean number of leaves value (19).

6.3.4 Leaf area

Leaf area fairly gives a good idea of photosynthetic capacity of the plant. It is an important variable for most eco physiological studies in terrestrial ecosystem concerning light interception, evapo-transpiration, photosynthetic efficiency, fertilizers, and irrigation response and plant growth (Blanco and Folegatti, 2005). It is also valuable in studies of plant nutrition, plant competition, plant-soil-water relations, plant protection measurement and heat transfer in plants (Mohsenin, 1986). Leaf area is an important parameter in understanding photosynthesis, light interception, water and nutrient use and crop growth and yield potential (Smart, 1974; Williams, 1987). It has been observed in the present study that the effect of compost had profound influence on leaf area of lupine at different crop growth stages. Maximum leaf area was noted in VR+Compost (137 mm^2). This might be due to compost provide better nutritional environment (Table 3b). An increase in leaf area beyond optimum level causes lodging and reduction in yield (Nichiporovich, 1970). However, optimum leaf area reaches well before anthesis and fell progressively as water stress increases (Fisher and Khan, 1996).

6.3.5 Root collar diameter

The RCD is defined as the diameter of the main stem measured at or within a specified distance from the root collar. The highest mean RCD was obtained in VR+compost groups (1.8 cm).Compost treatments increased the seedling root collar diameter by 29% (Taiz and Zeiger, 2006). Nutrients are critical determinants of plant growth and productivity, and both plant growth and root morphology are important parameters for evaluating the effects of supplied nutrient (Razaq *et al*., 2017).

6.4 Yield parameters of white lupin as influenced by compost under nursery bed conditions

6.4.1 Capitulae per plant

The VR+Compost treatments had significantly highest number of capitulate/plant (8) compared to the control (4). This was due to the production of highest plant height and number of branches, correspondingly increased number of capitulae/plant (Cheema, *et al*., 2001 and Sharma, *et al*., 1994). The poor vegetative growth (height, branches and foliage) of plants in control groups were due to less accumulation of food materials and photosynthates by the plants resulted into production of minimum number of capitulate/plant (Venkatakrishanan and Ravichandran, 1998).

6.4.2 Number of seeds/plant

Application of compost rates of 120 quintal/ha had positive effects on seed of lupin under nursery bed conditions. Owing to superiority in growth parameters due to efficient accumulation of desired food materials and photosynthates in VR+Compost the number of seeds/plant higher than the control treatments. Plant height possessed the positive association with grain yield (Lic and Chin, 1980).The decreased seed yield of lupine in the control groups might be due to a decreased in plant height and number of branches and there by leading to reduced number of capitulae/plant and number of seeds/capitulum. Sharma, *et al*., (1994) reported that improvements in seed yield attributed to increments in yield components and associated with better nutrition, plant growth and increased nutrient uptake (Sharma, 1990a). Moreover, the lower organic matter, lower total nitrogen and phosphorus contents observed on the vertisols analyzed had also positively influenced crop yield and increased lupine seed yield at VR+Compost.

6.4.3 Seed weight

The highest seeds weight and 1000 seeds weight recorded in VR+Compostwere 0.47& 1.7 gm respectively. The minimum value was registered in control groups about 0.3 & 1.2 gm respectively. One thousand seeds (achenes) weight is ranges from 4 to 7 gm (Weiss, 2000), with about 31 seeds per head. The significant difference in seed weight inVR + Compost may be due to addition of compost supply adequate phosphorous and nitrogen to the crop (Nambaiar and abrol, 1989).

6.4.4 Biomass production

The VR+Compost groups had highest biomass production of 5.2 gm compared to the control (3.1 gm). This was due to VR+Compost treatments received supply of more N and P resulted into more utilization of food nutrients as well as more accumulation of photosynthates compared to the controlled treatment. Compost treatments increased the seedling mean dry weight of the stems and leaves by 72% (Taiz and Zeiger, 2006).The lupine seeds which are large and white contain 30 to 40% good quality edible seed. It is mainly grown in tribal pockets with the use of minimum agro inputs, particularly compost leading to very low productivity (Sharma, 1993). Mondal *et al,* (1992) and Ramamurthy and Shivshankar (1996) have reported higher dry matter accumulation by plants due to balanced supply of essential elements to the crop.

7 CONCLUSIONS AND RECOMMENDATIONS

7.1 Conclusions

Application of compost on the lupine plants grown provide at the rates of 120 quintal/ha improved the vegetative growth by 66% and yield increased by 82%. This was because compost is sources of mineral elements, which plants require for effective growth and development.

Composts have been shown to have much beneficial effect on soils and plants; however their effectiveness may be limited because of lack of understanding of the link between compost properties and its effect on soil properties, plant growth and nutrient uptake.

The study showed that the effect of compost applied as much on soil nutrient availability and plant growth varies with compost application. Composts with low total N and P have little effect on soil properties and plant growth whereas increased availability of these nutrients maximizes plant growth. The effect of compost on nutrient availability is a function of two mechanisms: N and P already present in the compost in available forms leaching in to the underlying soil and mobilization of N and P in the compost over time with the rate of mobilization varying with compost type.

Lupinus albus could be one of the protein supplements in areas where the consumption of the seed is accepted by the society. The protein content of *Lupinus albus* resembles that of soybean and generally contains more protein than many legumes consumed in Ethiopia. Additionally, *Lupinus albus* can give better yield than other comparable crops like soybean and chickpeas. It's useful agricultural features, like being resistant to water deficit, being diseases resistant, capable of nitrogen fixing, etc and the above mentioned facts can predict the good potential of *Lupinus albus* in alleviating protein malnourishment problems.

7.2 Recommendations

Farmers have to use different inputs in order to enhance crop productivity where soil nutrient was one of the main challenges reduce crop production. On the contrary, extension workers have to advise the farmers to use different inputs such as compost which is easily accessible and eco-friendly. However, application of compost at rates of 120 quintal/hashould be recommended in lupine seed production of similar climatic and soil conditions.

The local white lupin in Ethiopia is a valuable crop for the smallholder farmers due to its multipurpose functions in the mixed crop livestock farming systems of the study areas. This is explained by the existence of the cultivation practice of the crop under a very serious shortage of cropland. Its soil fertility maintenance value and food value during food shortage season of the year are important. However, its bitter taste due to its high alkaloid content remains a big challenge for efficient utilization of the crop by the local farmers and emerging food and feed industries. Hence, any lupin improvement strategy has to focus on minimizing the alkaloid content of the crop either by introducing sweet varieties or some other simple technical and mechanical means that could be easily adopted by local subsistent farmers. In addition to this, any development activity towards the improvement of lupin production and utilization to be effective has to involve women as part of the activity.

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9. APPENDICES

Appendices 1: Statistical analyses of germination percentage, germination time, early growth parameters and yield of *Lupinus albus* (white lupin) using ANOVA single factor.

Germination parameters

Germination (%)

Days	Vertisol	Vertisol+comp
5	3.6	5.2
7	4.4	7.6
9	4	6.8
11	5.2	9.2
13	4	8
15	4.4	6
17	3.6	6
19	4	4.8
21	4	2.4
23	3.6	2.8
25	3.6	1.6
27	2.8	0.8
29	1.6	0.8
31	0.8	0.4
33	0.8	0.4

Anova: Single Factor

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
Vertisol	15	50.4	3.36	1.709714
VR+comp	15	62.8	4.186667	9.254095

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	9.052444	2	4.526222	0.588379	0.559738	3.219942
Within Groups	323.0933	42	7.692698			
Total	332.1458	44				

Germination mean time

Days	**Vertisol**	**Vertisol+ comp**
5	0.5	0.59
7	0.69	0.96
9	0.69	0.95
11	0.99	1.4
13	0.83	1.3
15	0.97	1.07
17	0.86	1.1
19	1.0	0.97
21	1.07	0.52
23	1.0	0.64
25	1.08	*0.38*
27	0.9	0.2
29	0.53	0.21
31	0.27	0.1
33	0.29	0.12

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
Vertisol	15	11.67	0.778	0.07369
VR+comp	15	10.51	0.70067	0.19192

ANOVA

Source of Variation	*SS*	*Df*	*SM*	*F*	*P-value*	*F crit*
Between Groups	0.06421	2	0.03211	0.18455	0.83215	3.21994
Within Groups	7.30671	42	0.17397			
Total	7.37092	44				

Seed mean number/plant

Sample	Veri	Vertisol+comp
1	51	39
2	45	38
3	60	71
4	16	84
5	34	95
6	67	58
7	73	96
8	18	70
9	25	62
10	87	100
11	23	71
12	37	79
13	57	87
14	31	84
15	72	69
16	61	52
17	27	59
18	21	56
19	27	94
20	51	71

Anova: Single Factor

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
Vertisol	20	1801	90.05	3666.155
Vertisol +comp	20	3284	164.2	11844.38

ANOVA

Source of Variation	*SS*	*Df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	746431.2	2	373215.6	15.14063	5.32E-06	3.158843
Within Groups	1405047	57	24649.94			
Total	2151478	59				

Seed weight/plant

Sample	Vertisol	VR+comp
1	0.2	0.4
2	0.3	0.2
3	0.2	0.5
4	0.2	1.0
5	0.2	0.9
6	0.4	0.3
7	0.6	1.1
8	0.5	0.5
9	0.1	0.8
10	0.5	0.4
11	0.3	0.8
12	0.2	0.3
13	0.3	0.3
14	0.2	0.4
15	0.4	0.6
16	0.3	0.3
17	0.1	0.2
18	0.4	0.5
19	0.2	0.3
20	0.5	0.4

Anova: Single Factor

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
Vertiso	20	6.1	0.305	0.0205
VR +comp	20	10.2	0.51	0.072526

ANOVA

Source of Variation	*SS*	*Df*	*MS*	*F*	*P-value* *fcrit*
Between Groups	3.589	2	1.7945	24.25575	2.39-E08 3.158843
Within Groups	4.217	57	0.073982		
Total	7.806	59			

Root dry weight

Sample	Vertisol	VR+comp
1	1.6	1.2
2	1.5	0.7
3	1.0	1.1
4	0.3	2.8
5	0.7	2.7
6	1.4	1.0
7	2.2	4.1
8	1.9	1.3
9	0.3	2.6
10	2.1	3.3
11	0.4	2.6
12	0.7	1.2
13	1.1	1.7
14	0.9	2.2
15	1. 5	1.3
16	1.6	1.1
17	0.3	1.1
18	1.4	1.8
19	0.6	2.0
20	1.5	2.2

Anova: Single Factor

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
Vertisol	20	23	1.15	0.367895
VR+comp	20	38	1.9	0.807368

ANOVA

Source of Variation	*SS*	*Df*	*MS*	*F*	*P-value Fcrit*
Between Groups	216.3	2	108.15	32.20263	4.38E-10
Within Groups	191.43	57	3.358421		3.158843
Total	407.73	59			

Appendix 2: 15 Days old *L. albus*Seedlingsgrown in equal sized plastic bags under nursery bed conditions where the daily minima and maxima temperatures during the study period were 21.3 ± 23.1 ℃ noon and 14.7± 17.3℃ nights respectively.

A B

Appendix 3: 37 Days old *L. albus*seedlingsgrown in vertisol only (A), and VR+Comp (B) under nursery bed conditions at Addis Ababa town in 2020.

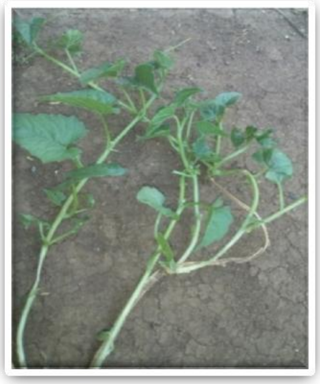
A B

Appendix 4: 90 Days old*L. albus*seedlingsgrown in vertisol only (A), and VR+Comp (B) under nursery bed conditions at Addis Ababa town in 2020.


A B

Appendix5: Roots of *L. albus*seedlings grown in vertisol only (A), and VR+Comp (B) under nursery bed conditions after harvesting the seeds.





ሰንሰል/ስሚዛ/*Juusticia schimperiana*ግራዋ/*Vernonia amygdalina*የቁራ ሐረግ/*Cucumis dipsaceus*



አስተናግር/*Datura stramonium*ሳስባንያ/*Sesbania sesban* የፈረንጅ ፅድ/*Cupressus lusitanica*



ሰርዶ/*Cynodon dacctylon*ሙጃ/*Snowdenia polystachya*ጠለንጅ/*Achyranthes aspera*



የአህያ እሾህ/*Silybum marianum*ጫቅማ/ጉሎ/*Ricinus communi*ልት/*Malva parviflora*

ብሳና/*Corton macrostachyu*

Appendix 6: List of plant samples photo used for compost manufacture. The plant samples were collected from Injibara, Banja Wereda, west Gojjam Zone, Amhara National Regional State.

DECLARATION

I, the undersigned, declare that this Thesis is my original work, has not been presented for a degree in any other University and that all sources of materials used for the Thesis has been fully acknowledged.

Name Agegnehu Melese

Signature______________

Date _________________

This Thesis has been submitted for examination with my approval as a university advisor.

____

Legesse Negash (Prof.)

Addis Ababa, Ethiopia

August, 2021