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Effect of Sowing Date on Morphological Parameters, Yield and Nutritional Performance of Lablab (Lablab Purpureus) and Maize (Zea Mays) Intercroping Under Rainfed Condition in Bahir Dar Zuria District, Northwestern Ethiopia

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M.Sc. Thesis

By

Habtie Ambaw Birhanie

March, 2024

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M.Sc. Thesis

By

Habtie Ambaw Birhanie

A Thesis Submitted in Partial Fulfillment of the Requirements for the Degree of Master of Science (M.Sc.) in Animal Production

Major Advisor: Fentahun Meheret (Assi. Prof.)

Co- Advisor: Melkamu Bezabih (Ph.D.)

March, 2024

Bahir Dar, Ethiopia

THESIS APPROVAL SHEET

As members of the Board of Examiners of the Master of Sciences (M.Sc.) thesis open defense examination, we have read and evaluated this thesis prepared by Mr. Habtie Ambaw Birhanie entitled "**Effect of Sowing Date on Morphological Parameters, Yield and Nutritional Performance of Lablab (*Lablab Purpureus*) and Maize (*Zea Mays*) Intercropping Under Rainfed Condition in Bahir Dar Zuria District, Northwestern Ethiopia**". We hereby certify that the thesis is accepted for fulfilling the requirements for the award of the degree of Master of Sciences (M.Sc.) in **Animal Production.**

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DECLARATION

This is to certify that this thesis titled "Effect of sowing date on morphological parameters, yield and nutritional performance of lablab (*lablab purpureus*) and maize (*zea mays*) intercropping under rainfed condition in bahir dar zuria district, northwestern ethiopia" Submitted in partial fulfillment of the requirement for the award of the degree of master of science in "Animal Production" to the graduate program of college of agriculture and environmental sciences, Bahir Dar University by Mr. Habtie Ambaw Birhanie (ID. No. BDU/1401221) is an authentic work carried out by him under our guidance. The materials embodied in this project work have not been submitted earlier for an award of any degree or diploma to the best of our knowledge and belief.

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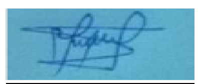
STATEMENT OF THE AUTHOR

I hereby declare that this thesis is my work and that all sources of materials used for this thesis have been duly acknowledged. This thesis has been submitted in partial fulfillment of the requirements of M.Sc. degree in Animal Production at Bahir Dar University and is deposited at the University's Library to be made available to borrowers under the rules of the library. I solemnly declare that this thesis is not submitted to any other institution anywhere for the award of any academic degree, diploma, or certificate. Brief quotations from this thesis are allowable without special permission provided that accurate acknowledgment of the source is made. Requests for extended quotation from or reproduction of this manuscript in whole or in part may be granted by the head of the major department or the dean of the School of Graduate Studies when in his judgment the proposed use of the material is in the interest of scholarship. In all other instances, however, the author must obtain permission.

Name: Habtie Ambaw, Signature 

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LIST OF ABBREVIATIONS

ADF	Acid Detergent Fiber
ADL	Acid Detergent Lignin
ANOVA	Analysis of Variance
BDZWAO	Bahir Dar Zuria Woreda Agriculture Office
BNF	Biological Nitrogen Fixation
BYA	Biomass Yield Advantages
CGR	Crop Growth Rate
CP	Crude Protein
CPY	Crude Protein Yield
CSA	Central Statistics Authority
DM	Dry Matter
DMY	Dry Matter Yield
DWss	Dry Weight sub-sample
FAO	Food and Agriculture Organization of United Nation
FWss	Fresh Weight sub-sample
GB	Gross Benefit
GDP	Growth Domestic Product
GLM	General Linear Model
IGAD	Intergovernmental Authority on Development
ILRI	International Livestock Research Institution
SSILP	Small-Scale Innovation Laboratory Project
IVDMD	In Vitro Dry Matter Digestibility
LA	Leaf Area
LER	Land Equivalent Ratio
LSD	Least Significant Difference
ME	Metabolized Energy
MGY	Maize Grain Yield
MJ	Mega Joule
MM	Millimeter

MRR	Marginal Rate of Returns
NAR	Net Assimilation Rate
NB	Net Benefit
NBPP	Number of branches Per Plant
NDF	Neutral Detergent Fiber
NIRS	Near- Infrared Reflectance Spectroscopy
NLPP	Number of leaves per plant
NN	Number of Nodule
OM	Organic Matter
PH	Plant Height
RCBD	Randomized Complete Block Design
RL	Root Length
SAS	Statistical Analysis System
TC	Total Cost
TFC	Total fixed cost
TFW	Total Fresh Weight
TN	Total Nitrogen
TVC	Total variable cost

Effect of Sowing Date on Morphological Parameters, Yield and Nutritional Performance of Lablab (*Lablab Purpureus*) and Maize (*Zea Mays*) Intercropping Under Rainfed Condition in Bahir Dar Zuria District, Northwestern Ethiopia

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ABSTRACT

The current study was conducted with the objectives of evaluating the effect of intercropping dates on the performances of maize and lablab morphological parameters, dry matter yield, maize grain yield, and nutritional values under rained condition. The treatments arrangement was laid using randomized completed block design (RCBD). The treatment was T5= sowing lablab alone (SOL), T1= sowing alone maize (SOM), T2= similar sowing date of lablab and maize at intercropping (ML0), lablab sowing after 20, 40 days of maize planting. The treatments were randomly assigned in each plot and replicated three times. All agronomic practices were performed during trial. In this experimental trail, dataset from morphological parameters, maize grain yield, dry matter yield and chemical composition were recorded from five middle rows (2nd, 3rd, 4th, 5th, and 6th) using ten plants per row by excluding the border rows effect. From the total area of $(25m)^2$ each of plot size ($2m^2$) was harvested at recommended maturity stages both used for collection of samples to determine forage yield and chemical composition are DM, ASH, OM, CP, NDF ADF and ADL. Sub-samples of each harvest were weighed for fresh weight, dry weight, and subjected to chemical compositions analysis and determined in vitro dry matter digestibility (IVOMD) after calibration of near infrared reflectance spectroscopy (NIRS). All recorded dataset were managed using Microsoft (MS) excel 2010 and subjected to analysis using the General Linear Model of the ANOVA procedure of SAS (9.0). The results showed that morphological attributes, dry matter yield, and maize grain yield and their nutritional values were statistically significantly ($P<0.05$) affected by sowing dates. Whereas, root length, acid detergent fiber (ADF %) of maize, and root length and ADL% of lablab were not statistically significant ($P>0.05$). The highest total dry matter yield (14.83t/ha) was found from lablab when it was intercropped with maize after twenty days and the lowest dry matter yield (5.31t/ha) was found from lablab alone.

Better land equivalent ratio ranging from 1.54-1.89 was obtained which is significantly different among the treatments T4 and T3. The highest value of crude protein (8.67%), CP yield (0.92t/ha) and the lowest crude fiber fractions of maize were obtained from ML20 treatment. In addition, the highest value of CP (17.12%) with the lowest values of crude fiber fractions was observed from the ML20 treatment. However, the highest crude protein yield (1.62) was recorded from lablab alone. A significant of (P<0.001) strong positive correlations were observed between CP and CPY, NDF and ADL, and also NDF has a positive moderate correlation with ADF respectively. Based on the current study, the feed production from ML20 would be more beneficial which had highest economic feasibility observed due to optimum dry matter yield, maize grain yield, and quality parameters. It was concluded that among employed experiments better dry matter yield and forage quality was recorded use as an alternative forage resource for animals feed production. Therefore, among the trail experiment was done recommended at lablab mixtured maize planted after twenty days in the study area and similar agro-ecological.

Keywords: Intercropping Dates, Rain-fed Conditions, DMY, quality, Maize and Lablab.

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CHAPTER ONE: INTRODUCTION

1.1 Background and Justification

Ethiopia is a country in the tropical Africa endowed with largest livestock. It had about 70 million cattle, 42.9 million sheep, 52.5 million goats, 13.33 million equines, 8.1 million camels, and 57 million poultries (CSA, 2021). This number in livestock sector has been contributing a significant role to the Ethiopian economy by providing food, cash income, promoting saving, social functions, and employment. It had sharing of 16.5% of the national GDP and 47% of the agricultural GDP (IGAD, 2011). However, the contributions of livestock are limited mainly due to poor feed nutrition and management practices, disease, low genetic potential of the indigenous cows, lack of extension services, and inadequate information to improve animal performance (Aynalem Hailu *et al*., 2011). Among these constraints, inadequate quantity and quality of feed resources were identified as major limiting factors to the development of livestock production sectors and productivity of livestock in peri-urban and urban (Boufennara et al., 2012; Belay Duguma *et al*., 2012). It is interconnected to drought, climate changes, land shortage and degradations, and seasonal abundance which are inadequate especially during the dry season (Alemayehu Mengistu *et al*., 2017).

The livestock feed resources in Ethiopia are classified as natural pasture, crop residues, improved forage, agro-industrial by-products, and hay (CSA, 2021), where the first two feed resources are the major feed contributors for the livestock production. Natural pastures contribute about 80-85% of animal feed in country (Sefa Salo, 2017). On other hand, crop residue is available in those areas in which livestock and crop production are practiced (Sefa Salo, 2017). Around 30 million tonnes of DM (Adugna Tolera et al., 2012) of agricultural crop residues are produced annually on the national scale, of which 70% are used as animal feed. However, those major feed resources are inherently low in their nutritional values which cannot even provide to maintenance animal body (Mengistu *et al*., 2017). Among major feed resources, natural grazing lands which have been overgrazed and in shrinkage due to expansion of cultivated land due to increasing population size which demands more food. It also is under degradation which provides low biomass, and has poor forage species diversity. As a result, it is contributing low nutrition which a cause for low livestock productivity and reproductive efficiency of livestock (Shimelis Mengistu *et al*., 2016). Hence, A number of strategies are proposed to alleviate those problems of which introduction of improved forages has been provoked as the best strategy at stallholder levels to improve the livestock feeding practices in the countries. It is utilized by smallholder farmers using different mechanisms of forage development strategies like backyard forage development system, under-sowing of cereal crops with forage legumes, forage development on stock exclusion area, forage development on conservation structures and over-sowing on existing grazing/pasture land even though, their contribution potential in the livestock sector is very low 1% (CSA, 2021).These intercropping strategies having its advantages in the productivity of forage, solving land shortages related to recent land competition due to urban expansion and crop cultivation increases results in grazing area decline, yield stability, pest control, and nutrient use efficiency (Hailu Gebru, 2015). According to Singh (2020) noted that the benefits of cereal-legume intercropping mainly depend on the choice of the right crop combination, proper under-sowing dates, different growing habits, and level of competition for shading, and nutrition. Similarly, Mut *et al*., (2017) reported that sowing time is an extremely critical factor for achievement of high yield and quality feed production during intercropping.

This cropping system to use substantially increases forage quantity and quality (protein) (Mthembu *et al*., 2018). Maize-lablab is one of intercropping system which improves maize yield with yield advantage of 39.50% to 59.03% in South Africa (Mthembu *et al*., 2018) and 17.68% in Ethiopia (Redae & Tekle, 2020) over sole maize crop farming practice. Hence, optimization of intercropping dates for lablab and maize simultaneously benefits crop-livestock farming system. According to Abraha Lemlem (2013), Indicated that intercropping of cowpea, lablab, and maize is more advantageous than mono-crop maize. However, there is limited information about the optimum sowing dates on lablab intercropping with maize, in the study area where more dominant farming practice crop types is maize that was more nutrient demand required crop. It demands fertilizer such as green manure produced during cultivation of legumes like lablab forage crop. Therefore, in the district at small scale innovation laboratory project site for intercropping of lablab with maize is not done for the solution to alleviate cultivating land increase and grazing land reduce due to increasing human population and urbanization expansion causes on animal fodder in terms of quality and quantities forage yield decline. Belel MD (2014) suggested that intercropping is the lead in improving quality and quantity of food and feed for crop-livestock farming and similarly improving soil fertility also this system offers a potentially increasing fodder yield without appreciable reduction of maize grain production. Among the annual forage legumes, Lablab (*Lablab purpureus L*.) is one of the herbaceous forage legumes which are identified for its adaptability and good forage yield (SARC, 1999). Lablab is an erect, short-lived herbaceous crop often grown as annual forages (Kikafunda, 2001). It is preferred for good forage production, nutritional quality, palatability, and shade-tolerant so it is suitable for intercropping. Knowing information on plant height, days to maturity, growth habit, and other morphological characteristics of legumes forage are important to integrate with other forages (Gezahegn Kebede *et al*., 2013). Lablab species which has creeping or climbing growth habit has better compatibility with cereal under-sowing systems (Gezahegn Kebede *et al*., 2020). Moreover, studies on the effects of an integrated optimum intercropping dates of lablab with maize production management overall have not been so far conducted in the study area. Therefore, the objective of this study was to assess the effect of intercropping dates on morphological parameters, dry matter yield, grain yield, and nutritive values of lablab (*Lablab purpureus*) and maize (*Zea mays*) grown under rain condition in the district.

1.2 Statement of the Problem

Despite the large and diverse livestock genetic resources, the productivity and economic contribution of animals remain low due to feed shortages in terms of quantity and quality, limited knowledge of producer, the poor genetic potential of indigenous animals, and prevalence of disease and parasites, (Selamawit Demeke *et al*., 2017; Ashenafi Mengistu *et al*., 2019). Among these constraints, the shortage of feed is one of the major problems that affect livestock productivity, especially during the dry season (Alemayehu Mengistu *et al*., 2017). As natural grazing lands is a major feed resource, utilizations are gradually shrinking due to expansion of arable land to satisfy the food needs of the increasing human population. Hence, livestock is forced to graze in marginal areas with combination of low-quality crop residues as major feed resources has been resulted a poor livestock performance. It was not possible to bridge the gap between every increasing demand for animal products and the level of production. Furthermore, traditional livestock feed system mainly depends upon natural pasture hay and crop residues, which have low crude protein and other chemical compositions. However, it is tremendous technology released to alleviate feed shortages like improved forage introduction and production. However, the utilization of technology is not more than 1% in Ethiopia (CSA, 2021). To fulfill this gap, producing improved forage in the livestock sector is advisable. For that reason, the legume and cereal crop of maize intercropping system is one of these technologies applied to enhancement of biomass production and forage quality. However, in maize and legume, intercropping date is an extremely critical issue in achieving high dry matter yield and quality of forages (Mut *et al*., 2017; Singh, 2020). Hence, among forage improvement technologies options intercropping dates is used as alternative feed resources in the area where arable land shortage and the demand of animal product nearby market become advantage to expanded livestock products by alleviated animal fed challenges. Therefore, having this research gap, optimum intercropping dates with both crop combinations was evaluation at the midland agro-ecology using rain fed condition at Bahir dar Zuria District, northwest Ethiopia.

1.3 Research objectives

1.3.1 General objective

Effect of sowing date on morphological parameters, yield and nutritional performance of lablab (*Lablab purpureus*) and maize (*Zea mays*) intercropping under rainfed condition in bahir dar zuria district, northwestern ethiopia

1.3.2 Specific objectives

- To assess the effect of intercropped dates on morphological parameters, dry matter yield, maize grain yield of maize on alone and intercropped grown under rain fed condition
- To evaluate the effects of intercropped dates on the chemical composition of lablab with maize grown under rain condition in the study area
- To determine the values of land equivalent ratio on both forages
- To estimate economic feasibility of sowing on production of maize and lablab

1.4 Research Questions

- ? Do sowing dates of maize and lablab affect morphological parameters, dry matter yield, and maize grain yield of lablab with maize grown under rain fed conditions?
- ? What is/are the best optimum sowing dates of maize and lablab fitting the study area?
- ? what is the partial budget analysis of intercropped forages?

1.5 Limitations of the study

The study was conducted to evaluate the agronomic performance of maize as a sole and inter-cropped with lablab legume forages difference sowing dates. But one of the main limitations of this thesis was missing optimum maturity stages of lablab forage harvesting ages.

1.6 Significant of the study

The study was conducted to evaluate the agronomic performance of maize as a sole and inter-cropped with lablab legume forages. There are a lot of different advantages from the current studies majorly including the improvement of research academic career, economical merits, the recent land scarcity related to arable land expanition and population size increases on animal feed problems solving by both maize and lablab forages intercropped using intensive agronomic farming practice among this forage's improvement technology options.

CHAPTER TWO: LITERATURE REVIEW

2.1 Major Feed Resources in Ethiopia

Feed resources in Ethiopia are classified into free grazing pasture, crop residues, improved feed, hay, an industrial by-product, and other feed resources (CSA, 2021). Similarly, Malede Birhan & Adugna Tolera (2014); and Sefa Salo (2017) reported the most endowed feed resources used for animal production in our country Ethiopia are free grazing pasture, preserved hay, produced forage, crop residue, Agro-industrial by-products, aftermath feed, and weeds from cultivated land. From these feed resources, communal grazing pasture land is a large amount of feed resource in Ethiopia (Azage Tegegne *et al*., 2011; Malede Birhan & Adugna Tolera, 2014). According to the CSA (2017) report 54.59, 31.06, 6.81, 1.53, and 5.11% of natural pasture, crop residue products, hay, agro-industrial by-products, forage productions, and other feed resources account for the nation's overall of livestock feed supply respectively. In addition, CSA (2021) reported that grazing pasture (54.54%) is a major type of feed resource followed by crop residue (31.13%), hay (7.35%), other feed type (4.37%), by-products (2.03%), and improved feed (0.57%). However, most feed resources are subjected to seasonal variations and are low in nutritional value and also in quantity (FAO, 2018). Therefore, the productivity of the livestock sector has been challenged by the availability of feed resources, quality of feed, and seasonal availability of feed, as well as the lack of accessibility to veterinary services and infrastructures (Andualem Tonamo, 2016). Besides these causes, Coleman & Moore (2003) revealed that the capability of animal production and reproduction is determined by the availability of quality and quantity of feed.

2.1.1 Natural pasture

Natural pasture is grassland that is suitable for herbivorous animals to graze on, and it is the greatest endowment in Ethiopia which supply 80% of the total animal feed (Sefa Salo, 2017). Natural pasture contains grasses, legumes, various herbaceous and fodder shrubs, and trees are the main sources of feed for animals (Ararsa Derara and Amanuel Bekuma, 2020). According to the reports of Belay Duguma *et al*. (2012); Endale Yadessa (2015) in certain regions of Ethiopia where mixed crop-livestock production is dominating agricultural activity, natural pasture continues to be a significant component of livestock feed. Most brows plants have better nutritional value containing CP contents ranging from 10-25% on a dry matter basis due to they have deep root system that enables them to absorb sufficient amounts of water and nutrients from the soil (Teferi Aregawi *et al*., 2008). The CP content for most immature cereal crops ranged from 7.2-20.20% on a dry matter basis, whereas for matured sorghum hybrid grasses ranged from 5.6-11.5% on a dry matter basis (Emana Megersa *et al*., 2017). Now a day, the development of crop production onto grazing fields, the redistribution of communal lands to the landless, land degradation, tramped all year without break and the resulting loss of fertility on the remaining pasture lands are all contributing factors to the current decline and shrinkage of natural pasture (Tadese Amsalu & Solomon Addisu, 2014; Sefa Salo, 2017). Natural pasture reduced its biomass output due to the extinction of palatable species and invasion of unpleasant species, increased soil erosion, land degradation, and these cause severe feed shortages in the crop-livestock mixed agricultural system (Beyene Teklu *et al*., 2011; Fekede F *et al*., 2011).

2.1.2 Agro-industrial by-products

The major agro-industrial products commonly used in Ethiopia are obtained from different agro-industries such as flour milling industries (wheat bran, wheat short, wheat middling, and rice bran), edible oil extracting plants (Noug cake, cottonseed cake, peanut cake, linseed cake, sesame cake, sunflower cake, etc), breweries and sugar factories (molasses) (Malede Birhan & Adugna Tolera, 2014). But agro-industrial by-products and manufactured feed contribute much less to livestock feed (Alemayehu Mengistu, *et al*., 2017). Additionally, the country's contribution from agro-industrial byproducts is small, limited, and limited to few farms in urban and peri-urban areas (Alemayehu Mengistu, *et al*., 2017). The reports of FAO (2019) the total annual agro-industrial by-products in Ethiopia are about 7.58 million tonnes (DM) and 762,846 tonnes and 73.34x109 MJ of CP and metabolizable energy (ME) respectively. According to the author Sefa Salo (2017) particularly in peri-urban and urban livestock production systems, agro-industrial by-products are valuable for feeding animals.

2.1.3 Crop residues

Crop residue is one of the main feed resources for Animal production in Ethiopia, predominantly in those areas in which livestock and crop production are practiced (Sefa Salo, 2017). The major crop residues available for livestock feeding in the highland area are included residues from wheat, barley, bean, and field pea (Ararsa Derara and Amanuel

Bekuma, 2020). While the major crop residues feed resources in mid-altitude areas including maize, teff, and haricot bean (Solomon Melaku *et al*., 2008; Endale Yadesa, 2015; Ararsa Derara and Amanuel Bekuma, 2020). Hence, around 1.14 billion (FAO 2017) and 30 million (Adugna Tolera *et al*., 2012) tons of DM of agricultural crop residues are produced annually on a global and national scale, respectively, of which 70% are used as animal feed. However, the contribution of crop residues is estimated to reach up to 30-80% of the total dry matter available for livestock in the highlands of Ethiopia (Thorne, 2015). However, smallholder farmers have used these crop by-products for different purposes including livestock feeding, domestic fuel, bedding material, source of income, housing material, and mulching croplands (Adugna Tolera, 2007; Sefa Salo, 2017). Moreover, the availability of different types of crop residues for livestock feeding depends on multiple factors such as agro-ecology, altitude, the season of the year, and the size of land allocated for different crops species by farmers (Tadese Amsalu & Solomon Addisu, 2014; Solomon Zewdu *et al*., 2014). In addition, Poor post-harvest feed handling, low forage improvement, and inefficient utilization practices are critical problems in Accessing consistent and quality livestock feed resources in Ethiopia's livestock sector (Balehegn Mulubrhan *et al*., 2020). The fact that the nutritional value of crop residues is poor and therefore, chemical treatments, the use of different supplements, and physical processing was acknowledged to be of substantial benefit in improving the nutritional value of crop residues (Tesfaye Agajie & Chairatan Ayuth, 2007). Physical processing (chopping/threshing, grinding, soaking/spraying, bailing), chemical treatments (urea molasses, and Effective microorganisms), and feed supplements (salt, molasses, oil seed cakes, milling by-products, and legume forages) are used to improve the nutritive value of crop residues in Ethiopia (Tesfaye Agajie & Chairatan, 2007; Getnet Assefa *et al*., 2022).

2.1.4 Non-conventional feed resources

All feeds that haven't been utilized traditionally for feeding cattle and are not used commonly in the production of livestock feeds are often called non-conventional feed sources (Alemayehu Mengistu & Sisay Amare, 2003). Therefore, non-conventional feeds include vegetable refusals, sugarcane leaves, Enset leaves and fish offal, kitchen waste, and coffee residues that are used as animal feed. However, the categories of non-conventional feeds are varied according to the feeding habit of the society (Endale Yadessa *et al*., 2016). Thus, non-conventional feeds could partly fill the gap in the feed supply and contribute to self-sufficiency in nutrients from locally available feed sources. However, non-conventional feeds are rare and made limited use in livestock feeding, and due to their low cost and availability, small-holder farmers frequently use by-products from nearby breweries and distilleries as a source of non-conventional feed (Yosef Mekasha *et al*., 2003; Ajebu Nurfeta, 2010).

2.1.5 Improved forage production

Improved forage crop production has diversified advantages. Forages can be divided into three categories: legumes, grasses, and multipurpose browses (fodder trees). Improved forages, especially legumes, are required to increase the nutritional content of crop residues even in the presence of abundant crop residues majorly including maize, sorghum, millet stover, and straw, which are frequently fed to ruminants. The main aim of improved forage production in Ethiopia is to increase feed availability and enhance the intake and digestibility of the low nutritional value hay and the crop residues through fresh green forage supplementation (Getachew Assefa, 2021). The attempts to establish improved forages have been reported an inefficient and limited success rate (Abebe Mekoya *et al*., 2008) and have a contribution of less than 1% (CSA, 2018) which requires additional extension and research work in the country. Improved forages can play a much more important to traditional feed resources by providing 8 to 10 times more yield than naturally grown pastures and these forages are of sufficient quality to promote income generation and optimal livestock productivity (Fantahun Dereje *et al*., 2020; Kindu Mekonnen *et al*., 2022). Forage legumes are important for nitrogen fixation and can be utilized as a protein supplement for animals due to their high crude protein content, rich in minerals (calcium, phosphorus), and vitamins A and D (Lukuyu *et al*., 2012).

2.2 Improved Forage Production in Ethiopia and its Challenges and Opportunities

Despite the introduction of new forages, Ethiopia has poor management and utilization of forage resources (Solomon Tefera, *et al*., 2019). Hence, the contribution of improved forage to the total feed resource is still low (0.32 %) because of factors such as the type of livestock production system, lack and unadoptable forage technologies, poor extension services, and others (CSA, 2018). To enhance or improve forage production, these criteria such as selection of forage species, forage development strategies, and servicing of extension practice, and formulation of forage production system are the main consideration (Getachew Assefa, 2021).

2.3 Overview of the Status of intercropping production in Ethiopia

In Ethiopia, the farmers predominantly practice a mixed crop-livestock kind of farming, which is done on small pieces of land ranging from 0.5-4.0 ha. The production of crops and livestock has been closely integrated and they complement each other as livestock provides labor for crop production whereas the crop residues provide 10-50% of livestock feed demand (Douglas, 2014). Intercropping has been a common practice in smallholder farming systems of Ethiopia, with maize (Zea mays L.) being used as the main food crop (cereal) and intercropped with different components of legumes like lablab for different reasons (Abule Ebro, 2016). However, the integration is not always restricted only to cereal legumes as some farmers tend to mix different cereals, an example being maize-wheat or maize-sorghum in some areas. In areas where both crops and livestock farming were practiced, farmers usually integrate food and forage crops including maize sorghum, cowpea, lablab, and vetch (Alemu and Tikunesh, 2014). Although intercropping is known to be an old system and has been practiced for a long, most farmers in Ethiopia have in recent years abandoned the practice as "outdated" and "primitive", and are going for sole cropping (Douglas, 2014).

Much as they practice crop rotation to a smaller extent, most farmers have separate fields/plots dedicated to maize, wheat, teff, and legumes like fava beans, lentils, and dekoko where they practice continuous cropping, and intercropping has not been a common practice. According to Douglas (2014) to some extent has resulted from government and development partners' promotion of monoculture throughout the country. This has resulted in smallholder farmers gradually shifting from the traditional sustainable mixed farming systems to less sustainable continuous and monoculture practices. Nevertheless, different studies on intercropping in the country have indicated the potential of the "old" system in improving soil fertility, increased crop yields and straw yields, and quality for feeding livestock (Abule Ebro, 2016; Douglas, 2014). This points out the potential of the system in improving soil fertility, grain yields, feed quality improvement, and livelihoods of the smallholder mixed farmers in an environmentally friendly way by minimizing the risk of the use of agrochemicals like artificial fertilizers for the current problem of fertilizer shortages.

2.4 Concept and Scope of Intercropping Systems

Intercropping is an agricultural practice of cultivating the collective planting of two or more crop species in the same plot at the same time. This method has been widely used to increase productivity in various continents worldwide. It is a common practice in overall the world and it is mostly practiced by smallholder farmers. The features of an intercropping system differ with soil, climatic condition, economic situation, and preferences of the local community in Africa (Yang *et al*., 2015). Several scientists have been working with cereal-legume intercropping systems and proved them successful compared to the mono-crops. One of the most important reasons for smallholder farmers to intercrop is to minimize the risk of total crop failures and to get different products to take for the family's food and income. The main concept of intercropping cereal crops with legumes forages is increasing total output per unit area and time, besides sustainable and equitable utilization of land resources and farming inputs including the workforce, season, time, and management practice for all crop-livestock related farmland practice in simultaneously both forages (Keighobadi *et al*., 2014).

2.5 Overview Intercropping of forage production system

Intercropping is the way of producing or cultivating two or more forages together on a specific piece of land during the same cultivation period (Guleria & Kumar, 2016). Production of two or more forages together has the effect to increase forage biomass production. One of the most affordable and efficient agronomic techniques to increase forage biomass output, nutritional quality, and financial returns is maize, sorghum and legumes intercropping (Iqbal *et al*., 2019). In highland, moderate altitude, and lowland areas, intercropping of annual leguminous species with grass provides the predominant quantity and quality of forage production strategies (Muluye Fekade, 2019). Intercropping is thus typically carried out in four different methods. Row intercropping is the first intercropping technique. Row intercropping can be done in two different methods. The first is additive series (no sacrifice of main crop lines) and the second is replacement series (main crop row is reduced for each intercrop row) (Iqbal *et al*., 2017). On the other hand, mixed intercropping is a technique in which the seeds of various fodder crops are blended, mixed, and sown in the same row, or broadcast. (Iqbal *et al*., 2019). Relay intercropping techniques include sowing a second crop in a standing crop that is almost finished with its production cycle before harvest (Fitsum Reda *et al*., 2005).

2.6 The Role of Cereal-Legumes Intercropping

Intercropping is regarded as the practical application of basic ecological principles such as diversity, competition, and facilitation in a closed system. It can meet several ecological goals including increasing biological diversity, promoting species interaction, and enabling natural nutrient regulation (Hauggard, N *et al*., 2008), Notable that, intercropping also has several related additional benefits; the most important being the achievement of greater yields in a given piece of land through efficient and complementary resource utilization (Lemlem, 2013). The others include the reduction of soil erosion, weed suppression, increasing moisture retention, maintaining soil fertility, increasing nutrient cycling, and biological nitrogen fixation (Šarūnaitė, L *et al*, 2010; Hauggaard, N *et al*., 2008; Chapagain and Riseman, 2014) which are long-term; and there are also short-term benefits as increasing crop yield and quality (Šarūnaitė *et al.,* 2010). It provides an opportunity for farmers to improve agriculture through increased production, enhanced soil conservation (Lithourgidis *et al*., 2011), and significant labor savings among other benefits. Typically, the different components of intercrop range from different species or families with one crop of primary importance (e.g., food) and the other primarily providing some other benefit (e.g., BNF fixation or livestock feeds).

An effective intercrop combination produces a greater total yield on a piece of land and uses resources more efficiently than would otherwise be used when each crop is grown as a monoculture (Chapagain and Riseman, 2014). Hence, Cultivation of mixed crops also increases protein content in the seeds of cereal component increases the yield of crude protein in the biomass, and increases the content of this component in the yield of the seed’s mixture. Mixtures of legumes with cereals may be used for the production of fodder for monogastric animals (pigs and poultry), if they are grown for seeds, because of the increased protein content compared to the grains of sole cereal forages.

2.6.1 The Role of maize-legume Intercropping on Increased Yield

Under adverse environmental conditions, maize with legume intercropping resulted in improved biomass production compared to mono-cropping (Iqbal *et al*., 2017). Maize-lablab intercropping is among the most important farming system for small-scale farmers in Arid and Semi-Arid Lands of sub-Sahara Africa (Karanja *et al*., 2014). In Ethiopia, lablab is becoming among the most commonly cultivated farmland. Intercropping with lablab leads to higher maize grain yield, which may bring nitrogen into the farming system through biological fixation, as well as to induction of suicidal germination of Striga seeds away from the host roots (Ayana *et al*., 2013). Legwaila *et al*. (2019) reported that maize-lablab intercropping increased maize grain yield by 15-20% over sole maize cropping. This could result from the increasing availability of NO3, TN, available P, organic matter, and NH4 in the soil and the presence of active bacteria in maize root rhizosphere and also could be explained by their placing of some cereal crops with legumes reducing the competition, or the presence of legume improves nutrient uptake.

2.6.2 The Role of Intercropping in weed control

Many environmental factors including soil temperature and moisture status, may affect the growth and development of Striga species either acting directly on the weed or by mediation through the host. In sub-Saharan Africa, Striga is exasperated by its exquisite adaptation to the climatic conditions of the semi-arid tropics, its high fecundity, and the longevity of its seed reserves in tropical soils (Gebisa and Patrick, 2010). Therefore, reducing the seed bank from the infested field must be considered as one strategy for effective control of Striga. Weed infestation poses competition on crops for natural and applied input, such as light and nutrients. It was also the most important constraint on yield and economic return of sorghum and maize production due to the wide space between rows (Mitran T, 2018). Maize was often subjected to severe stress of weed, together with a yield loss of 30-70% on average (Choudhary *et al*., 2014). However, when chemical weed control was applied, herbicide expenditure typically comprised 10-20% of input costs (Saudy, 2015). Hence, environmental and economic costs, as well as increasing herbicide-resistant weed, have led to a desire for less use of agrochemicals. Legumes growing vigorously could reach earlier closure of the canopy when intercropped with maize (Mallikarjuna *et al*., 2011).

2.6.3 The Role of Intercropping on forage quality improvements

Combining the growth of cereal forages with other crops capable of increasing the protein content of the ration has great nutritional and financial value. Combinations of cereals with legumes are seen as one way of achieving this goal. Intercropping cereals with legumes and other fodder crops to provide forage for ensiling offers one method for increasing homegrown protein sources. Moreover, increases in crude protein content by 11-51% were recorded for the various intercrop treatments over corn sole crop. Intercropping field beans with wheat improved forage dry matter and percentage of dry matter compared with bean sole crops and also enhanced crude protein, neutral detergent fiber content, and water-soluble carbohydrates compared with beans and wheat sole crops (Lithourgidis and Dordas, 2010). Forage yield and quality can Cereal forages have obtained a central position in the ruminant's feed because of their higher biomass production (Iqbal *et al*., 2018) One way to increase the quality of forage is to intercrop the cereal forages with legumes such as cowpea, cluster bean, and soybean because legumes contain almost double the quantity of protein than cereals. For small-scale farmers, how to diversify and stabilize income is a relatively important issue. Maize has the potential to supply energy-rich forage for animal diets. Intercropping cowpea with maize improved protein content in forage with lower costs, because cowpea contains about double the protein compared to maize (Eskandari and Ghanbari, 2009). Besides, (Mthembu B, 2018) stated that maize-lablab intercropping could result in more digestible DM in forage than sole maize stover.

2.7 Major factors that influence the expansion of the intercropping system

For the success of the intercropping system, several aspects need to be taken into consideration before and during the cultivation process (Seran and Brintha, 2010). Therefore, Careful planning is required when selecting the component crops of a mixture, taking into account the environmental conditions of an area and the available crops or varieties. The combination of cereals with legumes in mixed cropping offers a particular scope for developing energy-efficient and sustainable agriculture due to the nitrogen fixation capability of the legume and the provision of protein in the form of either grain or forage.

2.7.1 Planting pattern

Inter-row spacing, intra-row spacing, and strip width determine planting patterns under intercropping. An appropriate arrangement can modify the microclimate between component crops as well as further improve radiation utilization, evapotranspiration, and soil temperature. The width of spacing needed to be not only wide enough for weeding and harvesting but narrow enough for interaction between component crops. For instance, keeping the least distance between legume to maize was necessary for the transfer of nitrogen to maize root hairs (Choudhary *et al*., 2014), and the transfer of exudates stimulating the biological N fixation of legumes from maize roots (Dolijanovic *et al*., 2013). Besides, nodulation and nodule longevity of soybean are increased when intercropped with maize, which was attributed to the lower soil temperature favoring rhizobia (Mao *et al.*, 2012).

2.7.2 Compatible crops

Careful planning is required when selecting the component crops of a mixture, taking into account the environmental conditions of an area and the available crops or varieties and choosing the right crop combination is very important in intercropping systems because plant competition could be minimized not only by the spatial arrangement but also by combining those crops best able to exploit soil nutrients. As a result of Intercropping of cereals and legumes would be valuable because the component crops can utilize different sources of Nitrogen. The cereal may be more competitive than the legume for soil mineral N, but the legume can fix N symbiotically if effective strains of Rhizobium are present in the soil. However, some combinations have negative effects on the yield of the components under the intercropping system (Fisher, 1977).

2.7.3 Time of planting

Several studies have proven the effects of the planting time on the performance of the components under intercrop. For instance, planting cowpea simultaneously with maize gave a better yield. Barbosa *et al*. (2008) reported that intercropping corn with cowpea, especially when done early, provides intermediate results, indicating that cowpea controls weed to a certain extent. Addo-Quaye *et al*. (2011) found that maize planted simultaneously with soybean or before soybean recorded significantly higher values of leaf area (LA), crop growth rate (CGR), and net assimilation rate (NAR), compared to when it was later planting times.

2.8 Overview of Maize Production and Productivity

Maize is one of the major staple crops grown in the poorest and most food-insecure regions of Ethiopia. The crop is typically produced under adverse conditions such as low input use and marginal lands. It is well adapted to a wide range of precipitation and temperature levels and is produced from sea level to above 2000 m.a.s.l. Its drought tolerance and adaptation attributes have made it the favorite crop in drier and marginal areas. Ethiopia is often regarded as the center of the domestication of Maize because of the greatest genetic diversity in the country for both cultivated and wild forms (Fetene *et al*., 2011). Maize *(Zea mays* L.), the 'queen of cereals' is an important food crop in many developed and developing countries of the world. It is a versatile crop grown across a wide range of agro-ecological zones, there is no cereal crop on the earth that has so much yield potential. But maize is a soil-exhaustive crop and cultivation of soil-replenishing crops is required in the cropping system. Hence, intercropping legumes in maize can take care of soil fertility concerns and the agricultural sustainability of maize-based cropping systems. Maize-lablab intercropping improves maize yield and yield components considerably that it had a yield advantage of 17.68% in Ethiopia over sole maize crop farming practice (Redae & Tekle, 2020). Geren *et al*. (2008) observed that maize intercropped with legumes was more effective than sole-crop maize in the production of dry matter (DM) and quality feed. The TDM ranged from 23787 to 24664 kg ha-^{1} for intercropped maize compared to 23778 kg ha-^{1} for the sole maize crops.

The large improvement in Ethiopia maize production is driven by both land expansion and yield improvement: yield increased from an average of 4.24t ha-1 (28.75%) in 2019/20 to an average of 4.18t ha-1 in 2020/21 G.c, decreased by 1.41 % percent of maize production, while the area under maize production increased by 11.22% percent (from 2.3 million ha in 2019/20 to 2.6 million ha in 2020/21 (CSA, 2021). Based on the report of (CSA, 2021) the production; area coverage, and productivity recorded about 2.6 million hectares and 41q ha-1 in Ethiopia respectively. In 2021 years, the annual maize production growth rate ranged from 1.99% Amhara region, 2.19% Oromia region, Gambella region 25.80%, and SNNP 1.11% the average national maize production growth rate was achieved with 2.01%. Nevertheless, in each region of Ethiopia regions, the expansion of maize is average low and the ten years mean annual growth is 7% only. In addition, most of the regions showed a decrease in area expansion at the end of interval years and indicated the increase in maize production and productivity was due to the genetic and agronomic improvement of the crop rather than the area increase. Similarly, the productivity of maize increased in most regions and was highest in Afar (8.24%) and followed by Gambella region 25.80% some regions were a low increase in yield/ha but their yield achievement was attained to the national maize productivity. Maize was cultivated by nearly 4.5 million smallholders located in the eastern and northwest parts of the country shows Oromia, Amhara, and Tigray regions are the three major producers of maize covering 86.4% of the total area and 89% of the total production in the last nine years (Kinfe, 2018).

2.9 Effects of Intercropping on Morphological Parameters of Maize

2.9.1 Plant height

Plant height is affected by the intercropping of dates (Ginwal *et al*., 2019). Plant Height of maize at maturity (cm) 143.8, 147.3, 146.5, 144.6 on a mixture of lablab among the different intercropping dates of treatments (SM, ML, ML10, ML20, and ML30) (Meseret Redae and Desta Tekle, 2020). The plant height of maize (*Zea mays*) is higher in intercropping than its sole cropping due to the intercropping legumes' nutritive values supportive. The same result was found by Tessema Tesfaye Atumo (2022) in the 2020 main cropping season of lablab intercropping with maize planting after thirty (ML30) days of maize emerging in plant height greater than sown alone. It is possibly due to light competition between forages grown together in intercropping (Basaran *et al*., 2017). Similarly, to the finding Olujobi OJ *et al*., (2013) reported that biologically fixed N by pigeon pea was transferred to associated N content uptake by maize (Zea mays) was improved plant height in maize-pigeon pea intercropping system.

2.9.2 Leaf Number Attributes

Leaf number is one of the advantageous agronomy parameters of maize that contribute to the total dry matter yield. It is known that fresh matter and then dry matter yields are formed by photosynthesis in leaves, so it is important to determine the effect of technological measures such as seed rate on leaf development and leaf surface formation in a number of leaves on the plant. The number of leaves per plant is a highly significant difference ($P<0.01$) affected by intercropping dates of Limu varieties of maize (Zea mays). It was supported by the finding of Hamd Alla *et al*., (2014) who revealed that the number of leaves increases under sowing cowpea with maize intercropping as compared to sown alone maize. Similarly, Teshome Gutu et al., (2015) investigated that the number of ears per plant showed significant differences due to inter-cropping systems having greater leaves than sole. This greater result might be due to the biological nitrogen fixation. Whereas, the finding of Ginwal et al., (2019) indicated that the leaf number of maize ranges from (11.14-11.35) for maize cultivar J-1006 with cowpea cultivars cowpea (cultivar C-152) and guar (cultivar HG-02) intercropping. The greater number of leaf numbers per plant in the intercropping might be due to the reason intercropping with legumes and hence, better forage canopy, nitrogen fixation, efficient utilization of solar radiation, and efficient utilization of environmental resources.

2.9.3 Leaf Area Parameters

Leaf area is an important parameter for forage production to obtain high biomass and dry matter production indicators attribute. According to the authors of Jing *et al*., (2011), who showed that founding results had significant effects on intercropping with maize and Soybean in microclimates on the leaf area (666.67cm) as compared to sown alone maincrop maize. Beyond this increasing leaf area in intercropping treatment than alone treatment might be due to the legume forages greens green manure nitrogen fixation, optimum intercropping dates especially lablab intercropping with maize planting after a few days the better leaf area was a better performance than other treatments it might be due to the reason related to the optimum under-sown dates of lablab with maize crop intercropping, and inter-species light competition.

2.9.4 Maize grain yield and related components

Determination of maize grain production in cereal crops is essential to ensure that the major stable food crops that are receiving the proper amount of nutrients through their human diet. There was a significant effect ($P<0.01$) on maize grain yield that affect intercropping dates. the finding of Kifle Jogora et al. (2019) outlined that maize grain yield (52.70 qtha1) from the Bekele Girisa site of Dugda district on yield performance of BH-540 maize variety seed rate of 25 kg/ha with 75cm of spacing between the rows, and 25 cm among the plants were used for maize (Zea mays) crop and forage of lablab (Lablab purpureus) was intercropped between the maize rows at a seed rate of 15kg/ha (half of the recommended seed rate for sole production) lablab three weeks after maize planting were recorded higher grain yield than sole maize crop. Similarly, this result was in agreement with the finding of Mergia Abera (2014), corroborating that where inclusion of vetch, cowpea, and lablab increased grain yield of maize by 7.4%, 5.9%, and 5%, respectively. On the other hand, the finding of Tessema Tesfaye (2022), in the 2019 main cropping season of lablab intercropping with maize planting after twenty (ML20) on maize grain yield (63.9qt/ha) greater than sown alone maize crop and lablab intercropping with maize planting after forty (ML40) dates treatment respectively.

These higher maize grain productions were due to may be direct and indirect effects on morphological development related to optimum intercropping dates. Also, this might be the reason intercropping legumes can enhance grain yield because legumes are a good source of biological nitrogen fixation and lower weeds infestation rate for complementary advantages compared to sown alone maize crops. However, this study disagrees with the study of Abraha (2013) who reported that mono-crop (3056 kg/ha) was higher than intercrop (2381 kg/ha). This might be associated with the difference in environmental conditions such as rainfall, soil fertility, temperature, and variety difference both in maize and lablab forages. According to the scholar of the finding of Solomon Abegaz and Likawent Yeheyis, (2016) who conducted cowpea varieties kenkey intercropping with maize variety BH-660 under sown and found a significant effect on the number of cobs per plant (1.5). Similarly, the finding of Taha Mume et al., (2019) found (2.0) number of cobs per plant recorded from vetch (Veciavillosa) and improved maize (Zea mays) variety (BH-660) was planted under sown after 15 days of maize planting intercropping. The reason for these higher gain yields and several cobs per plant results indicated that might be due to the biological nitrogen fixation, low weed infestation rate and the other soil nutrient properly uses like soil moisture conservation and nutrient erosion exposable reduction as compared to the complementary advantages from sowing sole.

2.10 Effects of Intercropping on Yield and Nutritional Values of Maize

The combination of cereal and legumes plays a key role in higher dry matter productivity. The dry matter percentage is part of forage without water. Fibers, crude proteins, ash, carbohydrates, and lipids are driven by the dry matter content of the forage nutritive values of improvement by intercropped legume forages. Dry matter is also very essential as the moisture content will give indications as to how forage will preserve when stored by baling or ensiling (Schroeder, 2012). Due to this reason, efficiently knowing the dry matter content of forage is advantageous for storing dry forages. The dry matter yield of maize (Zea mays) was a statistically significant effect on intercropping dates (Hassan *et al*. (2017). This significant difference was confirmed by (Hassan *et al*. (2017) who reported that intercropping pattern significantly increases dry forage yields. In addition, the scholars Basaran *et al*. (2017) showed that intercropping Sudan grass hybrid (Aneto) and cowpea (Ulkem) had the highest dry matter yield in intercropping than Sudan grass hybrid (Aneto) sown alone.

This could be due to legumes having the ability to fix atmospheric nitrogen and provide nutrients for legume intercropped. The authors of Hassan *et al.* (2013) outlined that dry matter yield (8.01 t/ha) from lablab (*Lablab Purpureus (L.)* Sweet) in combination with the main crop of maize (Zea mays (L)). On the other hand, a scholar of Rahel Kahsay (2021) investigated that Inter-cropping of sorghum varieties with lablab increased both ash and CP concentrations in sorghum stover but lowered NDF, ADF, and ADL concentrations with comparable to sole forage quality attributes. Mutetikka D et al., (2005) reported that the Crude protein (CP) content and CPY increased ($p<0.05$) 1.2-2.2 times on the effect of intercropping maize with lablab than mono-crops (4% CP and 175 kg/ha). The authors reported that in general, the CP content of most cereal crop residues is lower than the critical level of microbial protein synthesis and then exists nitrogen deficiencies; the most important limiting factor in feed intake (Adugna et al., 1999). While the CP content of maize under sown with forage legumes was above the critical level. This indicates that when maize is under-sown with forage legumes; it improves the quality of maize CP more than pure stand maize.

2.11 Overview of Lablab Species Adaptation and Used for Forage Production

Lablab is used as a nitrogen-fixing green manure to improve soil quality and often produces more dry matter than cowpea (Vigna unguiculata), especially during drought, and can produce roughly 2.13 tons of leaf dry matter (Cook *et al*., 2012) and 6.25 tons of total biomass per hectare and each ton of biomass produced 0.0625 ton of nitrogen (Valenzuela & Smith, 2002). Lablab is also very important for feed quality improvement, soil cover, and soil fertility management by fixing atmospheric nitrogen and improving feed supply in quantity and quality forage production (Tessema Tesfaye 2022). Predominantly among the legume lablab and vetches species are known for their adaptability, and versatility (either in green manure or as a pasture), they are used for ruminant feed (ILRI, 2013). lablab (*lablab purpureus*) is the most common annual leguminous forage used for animal feed (Demirhan *et al*., 2018). Intercropping legumes with cereal crops have multiple advantages in terms of improving biomass yield, nutritive value, and land equivalent ratio (Jensen *et al*. 2020). More research has classified vetch species based on growth behaviors, morphological variations, climatic adaption, and other factors. As a result, the growth behaviors of lablab species can be classified as erect, creeping, or climbing nature (Cook *et al*., 2012). In an investigation of the diverse potential of multi-purpose legume lablab (*Lablab purpureus* (L.) Sweet) intercropping for smallholder production systems increased biomass yield and nutritive value of forage were recorded (Nord *et al*. 2020). As reported Belel M (2014) suggested that legume lablab intercropping is the lead in improving and ensuring the quality and quantity of food and feed for crop-livestock farming and similarly improving soil fertility also this system offers a potential for increasing fodder without appreciable reduction of maize grain production. Predominantly lablab species are known for their adaptability, and versatility (either in green manure or as a pasture), and they are used for ruminant feed (Nord *et al*. 2020).

As a result of different studies indicated that, lablab accession/varieties of growth habit on accession 11609, 6529, and ILRI-147 Rongai varieties were grown highly vertically grow erect climbing nature While the growth habit of lablab accession 147 was relatively short and horizontally spread nature. These differences in growing habits are the basis for variation in nutritional values and also define their production potentials. for this reason, lablab species with upright growth habits are more compatible with small cereals in intercropping systems, whereas creeping or climbing growth habits is more compatible with large cereals in intercropping/under-sowing systems and yielded higher green forage yields (Grotelüschen, 2014). Therefore, variation in forage maturity is an essential agronomic feature to consider when selecting partner crops for maximum productivity also choosing companion or mixed crops with the best compatibility and forage yield used in terms of days to maturity.

Table. 3 Summarized Nutritive values of maize stover on alone and inter-cropped forages

Forage species/variates	DMY t/ha	DM (%)	CP (%)	NDF (%)	ADF (%)	ADL (%)	ME(MJ/kg)	IVD MD%	Source
Alone Maize	8.74	89.8	6.9	73.7	47.4	26.3	-	54.6	Mergia Abera, 2014
Maize -lablab mixtured	8.78	90.4	7.2	72.9	45.3	27.6	-	54.8	Mergia Abera, 2014
Sole Surgum	9.80	-	5.6	63.4	47.2	12.1	-	-	Rahel K *et al*., 2021
Sorghum-lablab	9.08	-	7.0	51.0	37.6	7.9	-	-	Rahel Kahsay, 2021
Alone Maize	7.34	90.1	7.04	74.01	42.78	14.0	-	50.23	Mthembu *et al*., 2018
Maize -lablab mixtured	9.01	93.3	9.65	39.68	69.74	13.22	-	57.8	Mthembu *et al*., 2018
Alone Maize	7.65	90.8	4.0	62.5	41.0	-	8.6	55.2	Kabirizi *J et al*., 2005
Maize -lablab mixtured	8.81	90.6	6.2	65.7	40.91	-	9.8	55.6.	Kabirizi *J et al*., 2005
Sorghum -cowpea	6.62	93.7	6.81	57.75	37.16	4.73	-	50.42	Wubshet Tesfaye, 2019
Sole sorghum	3.43	92.7	5.11	63.82	41.38	4.59	-	49.48	Wubshet Tesfaye, 2019
Sudan grass alone	-	-	14.66	38.63	33.12	-	-	-	Erkovan, 2022
Sudan grass intercrop	-	-	15.47	38.94	33.25	-	-	-	Erkovan, 2022
Sorghum hybrid alone	-	-	8.64	55.18	36.52	-	-	-	Lopes *et al*.,2020
Sole desho grass	12.55	89.9	12.69	63.15	31.60	5.89	8.12	58.10	Aychew Zewdu, 2022
Desho grass-vetches	8.72	89.8	15.40	44.43	38.07	3.62	8.72	64.51	Aychew Zewdu, 2022

2.12 Agronomic Adaptability of Lablab Forage Measured Attributes

2.11.1 Plant height

Forage legumes must be integrated with grass in mixed stands or intercropping, so information on plant height and other growth traits of the forage legumes is crucial things. Plant height and growth habits should be taken into account during integration because they affect compatibility in intercropping. In ILRI-147 Rongai varieties has the greatest plant height than other lablab species followed by lablab accession 11609 and 6529 (Grotelüschen, 2014). Followed by, a scholar of Tessema Tesfaye (2022) noted that mean values demonstrated that the plant height of lablab was varied for lablab under-sowing date variation ranges from 143.44 to 172.84 cm with an average length of 156.8 cm. On the other hand, authors Aydın U and Ilkay Y (2016) reported that from maize and cowpea intercropping arrangements on the highest plant height value of cowpea was obtained from intercropping treatments with (161.8 cm) as compared to sown alone cowpea (89.5cm) respectively. This may be due to lablab plant height climbing on the stalk of maize in need of solar radiation and sufficient space (Tessema Tesfaye, 2022).

2.11.2 Number of Branches

Some branching/tillering performances of lablab species are an important agronomic trait for the selection of crops to better forage yield. Environmental, genetic variability and managemental practices have a significant impact on the branching performance of lablab species (Grotelüschen, 2014). Tessema Tesfaye (2022) found that some branches of lablab species intercropping on maize (*Zea mays*) researched finding from (10.67) were recorded. Similarly, this finding by Getachew Haile (2014) indicated that the number of primary branches per plant was significantly affected by the main effect of forage legumes intercropping with the main crop of maize (Zea mays). The result of Tesfaye Alemu *et al*. (2019) outlined (27.66) number of branches were obtained from maize varieties (Melkasa-4) + dolichos lablab species 37.5 cm between maize and dolichos species of lablab row space intercropping maize (Zea mays) with lablab (lablab purpureus) at Habro district (Bareda FTC). These differences in the values number of branches per plant were due to the reason might be related genetic, environmental, and experimental site management variant.

2.11.3 Number of Nodules

Root nodules have more importance for nitrogen acquisition through symbiotic nitrogen fixation in leguminous plants. Root nodules are also used for converting atmospheric nitrogen into soluble nitrogenous compounds and used for increasing leguminous forage production as well as cereal crop mainly maize when intercropping with leguminous forage plants was a very important attribute related to green manure fixation concerned mainly soil nutrient demands crop including that maize and sorghum. The nodule number of lablab varieties ranged from (13.67-29.73) as noted by the authors Kosev & Vasileva (2018). In addition, a scholar of Bimirew Asimare *et al*. (2021) found that several nodules sown alone lablab forage crop was greater than the intercropping of lablab (*lablab purpureus*) within three varieties (Teshale, Misikir, and Girana-1) of sorghum (*Sorghum bicolor*).

2.11.4 Dry matter yield

Dry matter yield refers to the total amount of forage remaining after the water content was removed and it is important for livestock feed because animals' requirements are made as dry matter bias and storing without spoiling (Schroeder, 2012). The dry matter (DM) content of forage plants is the proportion of the total components of the fiber content of the forage. The dry matter content of forage plants increased as the stage of maturity increased and the highest dry matter content of sorghum was recorded from intercropped sorghum with groundnut, followed by sorghum intercropped with lablab, and the lowest dry matter content was obtained from monoculture sorghum plants (Mbahi *et al.*, 2017). The sorghum-legume intercropping significantly increases the dry matter yields of the sorghum (Mbahi *et al*., 2017). While the CP content of maize under sown with legumes forage was above the critical level. This indicates that when maize is under-sown with forage legumes; it improves the quality of maize CP than pure stand maize. Mutetikka *et al*., (2005) reported that the Crude protein (CP) content and CPY increased ($p<0.05$) 1.2-2.2 times on the effect of intercropping maize with lablab than mono-crops (4%CP and 175kg/ha) DMY quality measurements.

CHAPTER THREE: MATERIAL AND METHODS

3.1 Description of the Study Area

The experiment was conducted in Robit Bata Kebele, Bahir Dar Zuria district under the main rain conditions. Bahir Dar Zuria district is one part of the west Gojjam zone, Amhara region. The study area is located 10km far from the regional city of Bahir Dar, and situated 565km northwest of Addis Ababa, the capital of Ethiopia. Bahir Dar Zuria district is located at an elevation of 1800–2500 meters above sea level. The field trial was located at small-scale innovation laboratory project site at 11° 44" N latitude and 37° 25" E longitude respectively. The main rainy season of the area started in mid-July and terminated in mid-September. In this season, an average monthly maximum temperature was recorded between 28.9 and 29.4°C and a minimum between 16°C and 27°C. The area received a precipitation between 1500 to 2200mm and the mean annual is 1,850mm (Bahir Dar National Meteorological Agency, 2022). Sorghum (Sorghum biocular), maize (*Zea mays*), and millets are the most common food crops in the study district. The dominant animal feed resources are natural pasture hay and crop residues include sorghum, maize stover, and millet straw (BDZWAO, 2022).

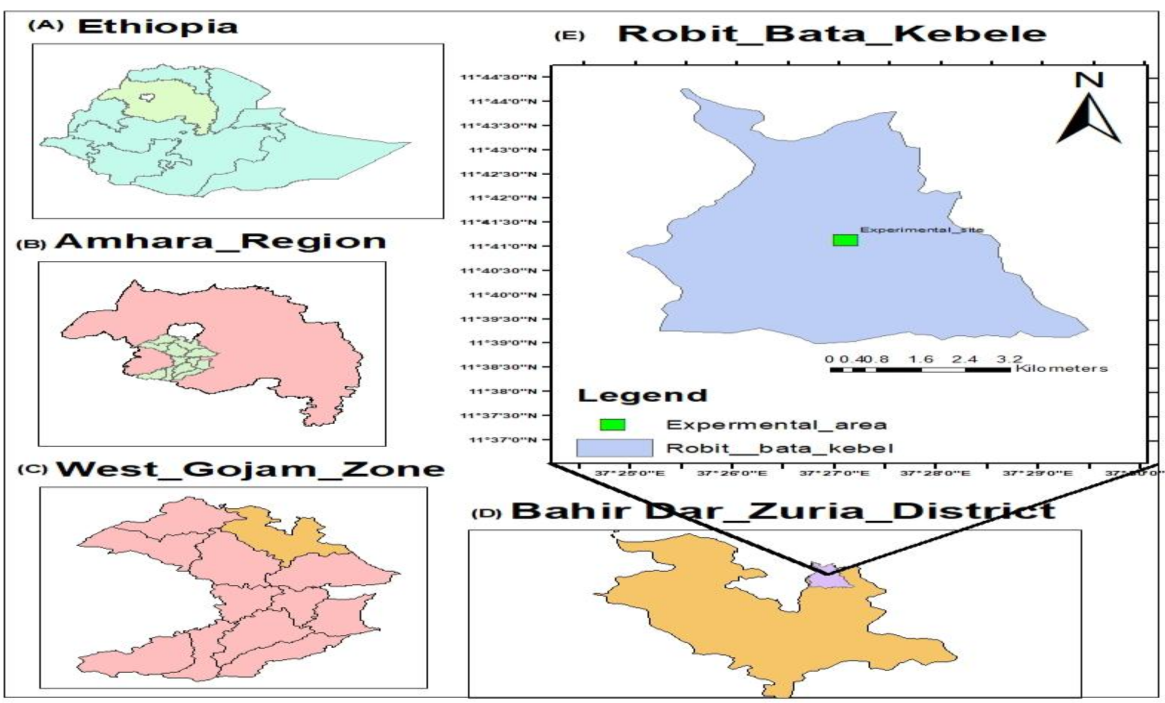

Figure 3.1 Experimental Site Map

3.2 Site Selection, Land Preparation, and Management Practices

The experimental site was selected purposely based on the minimal potential forage production with related to the current land competition due to arable land increases, project site availabilities, and availability of maize production as major crop in the study area. After selecting the experimental site, the land was obtained from voluntary farmers and then cleaned and harrowed by oxen. It was leveled out to maintain a well-prepared land. Limu variety of maize seed was commonly used in the study area by farmers and ILRI-Rongai lablab seed from international livestock research institution (ILRI, and sown in deep soil cover on a well-prepared plot. Sowing plots were prepared in different intercropping date's starting from June 22/2014. It included alone lablab (SOL), alone maize (SOM) and similar planting dates (ML0) and after twenty (ML20) and forty (ML40) days of germination of maize during the main rain season. Follow-up activities of the field trial were held throughout the experimental period (until forage crops were harvested) all experimental plots were managed uniformly during followed agronomy management practice.

3.3 Experimental Design and Treatment Allocation

Experimental design and treatment allocations were done using a randomized complete block design (RCBD) arrangements consisting of one factor (inter-cropping dates) with three replications. The experiment had a total of five (5) treatments with fifteen (15) experimental unit were sole maize (SOM), similar sowing date (ML0), twenty days after maize planting (ML20), forty days after maize planting (ML40) and sole lablab (SOL). Farmers in the field were considered as replicated blocks, and three farmers who volunteer-based to participate in the experiment were selected. Maize variety Limu was planted with the recommended seed rate of 25kg ha^{-1} at the spacing of 75cm between rows and 25cm between plants (Tessema Tesfaye, 2022). it is was sowed at the sowing dates of June, 22/2014, following adequate rain conditions which ensuring germinating seed and for seedling growth of main crop maize. On the other hand, ILRI-Rongi lablab variety was inter-planted at the spacing of 20cm simultaneously in between subsequent maize rows and intercropped with 0.37m apart of 0.75m between maize and lablab planting and also one plot had seven and six rows in maize and lablab respectively.

The seed rate for the lablab in the intercropped plots was 15 kg per hectare, which is 50% of the recommended rate for sole lablab forage establishment (Tessema Tesfaye, 2022). Therefore, the experimental area was laid down by using 3, 4, and 5 triangular methods and the total experiment size was 405m^2 (27m*15m) with 25m^2 (5m*5m) individual plot sizes (Appendix Table 7.3). The space between plots was 0.5m in each plot (Javanmard *et al.*, 2017). The experimental site was kept free from weeds throughout the experimental period by hand with five treatments was layout shown (Table 2).

Table 3.2: Treatment Setup of maize (*Zea mays*) and lablab (*lablab Purpureus*)

Treatments	Treatment descriptions	Remark
T1 (SOM)	Maize Sowing Alone	Total experimental
T2 (ML0)	Similar Date of Planting Both Forages	unites of
T3 (ML20)	Lablab Sowing Twenty Days after Maize Planted	size was
T4 (ML40)	Lablab Sowing Forty Days After Maize Planted	15
T5 (SOL)	Lablab Sowing Alone	

3.4 Data Collection Methods

3.4.1 Morphological and Maize Grain Yield Parameters

The following morphological parameters were used for collection of data thoroughly measured and recorded methodically.

Plant Height (cm): For maize forage, the height agronomic parameter was recorded by using tap meter from ten plants randomly selected from the four middle rows of each plot leaving the two edge rows by considering the border effect. Plant heights were measured from above the soil surface to the tips of the tallest leaf (Natural standing height) for maize (Rayburn *et al*., 2007). After measuring the height of the plant average mean value was determined.

Number of Leaves per Plant: The number of leaves per plant was recorded by selecting ten plants from the middle rows randomly removing the border effect. It was counted and the average value was recorded.

The number of cobs per plant: the number of cobs per plant for maize was counted and recorded after the time of physiologically matured maize grain yield by taking ten plants from each plot. The mean values of cobs were calculated and then the total number of cobs per plant was recorded.

The cob length (cm): The cob length was measured using a centimeter (cm). It was measured from its attachment to the stem to its tip by taking ten cobs length.

Leaf area (cm^2): It was estimated as described by Adesoji *et al*. (2013) as leaf area is equal to the length of the leaf's times maximum width of leaf × 0.75 where 0.75 is the correction factor for maize leaf area measurements.

Root Length (cm): The length of roots measured by thoroughly digging out and immediate washed with water gently to clean the soil and other debris for the purpose of enable of counting and measuring properly it from the crown root part to the tip of the longest root and determined the average length.

Leaf to stem ratio: Leaf to stem ratio was determined by taking a fresh subsample weighted of about 500g from harvested fresh biomass for each treatment and then leaves and stems were alienated carefully. The fractioned subsample of leaf and stem were brought into air dried in an airtight bag and then the leaf-to-stem ratio was calculated by dividing leaf dry weight to stem dry weight (Nguku *et al*., 2016).

Maize Grain yield (t/ha): When maize cobs seeds were mature, a sample plants containing cobs were selected at random from the middle rows. Cob seeds were harvested by hand using sickles were sun-dried 85% (Rayburn *et al*., 2007) and threshed and the grain had weighed the sample to estimate grain yields in kg/plot and its values converted as ton per hector (in t/ha).

3.4.2 Morphological parameters of lablab forage

Plant Height: It was measured at 50% of flowering stages from the soil surface to the end part (tip) of the tallest vine length by using tap meter (Ray *et al*., 2007).

Number of Branches: The number of branches of the lablab was recorded by separating the individual plant from each plot carefully. The branch numbers were counted by only considering the first branch rather than the fine branch.

Number of Leaves per plant: The number of leaves per plant was recorded from ten plants at the middle rows it was counted and recorded the average value.

Number of Nodules: The number of nodules was recorded from each plot of plants. A total of ten plants were dug out and the roots were washed using clean water. The number of nodules was counted and recorded the average values.

Leaf Area (cm^2): It was calculated as Leaf area (about 15 days after flowering) = leaf length × maximum width × 0.75 using the method described by Stickler *et al*. (1961).

Root Length (cm): It was measured from the base of the branch root part to the tip of the largest branch or tap root and was determined by the mean values of the root length from each plant.

3.5 Sampling Methods for Fresh Biomass and Dry Matter Yield (ton/ha)

The harvested plant for weighing fresh biomass and dry forage yield was cut down at 10cm and 5cm for maize and lablab above the ground level as recommended by Rahel Kahsay *et al*. (2021) respectively. Fresh biomass was collected from lablab species when it reaches the 50% flowering stage and maize, after physiologically matured maize grain, and the cobs cover color changed to white is an indicator of grain matured (Radovic *et al*., 2009). The plot size of each treatment was 25m^2 and from each plot, five middle rows (2nd, 3rd, 4th, 5th, and 6th) with a net harvestable area using 2m^2 (2m*1m) with each of per plot and 30m^2 per total harvestable area from fifteen (15) plots used by (50cm excluding) outer rows on both sides of each plot used to calculate dry matter (DM) yield. A fresh herbage yield of the maize and lablab was measured immediately after harvesting using field balance. Fresh biomass yield was measured for each sole crop as well as for both components in the case of intercropping plot samples taken for each treatment respectively. The dry matter percentage was determined by taking about 500g of fresh sub-samples from the total fresh biomass from each plot. Sub-samples were chopped into short lengths (2-5cm) and then packed with an air-tight bag and subjected to oven drying at 65ºC for 72 hours to estimate dry matter yield (ton/ha). The dry matter percentage was determined through the dry weight of the subsample divided by the weight of the fresh subsample and multiplied by 100. After determining the dry matter percentage, the dry matter yield was calculated. The weighed fresh sub-samples (FWss) were oven-dried and reweighted (DWss) to estimate dry matter yield (DMY).

The dry matter yield (DMY) of forages grown in the study area was calculated (James *et al*., 2008) formula, (10×TFW×DWss /(HA×FWss)).

Where: TFW = Total fresh biomass weight in kg

DWss = Dry weight of the sub-sample in grams

FWss = Fresh weight of the sub-sample in grams

HA = Harvested area in m^2, 10 = A constant for conversion of yields in kg/m2 to ton/ ha,

Therefore, to determine crude protein yield (CPY), Dry matter yield (DMY) was determined and then multiplied with the CP content of the feed samples.

3.6 **Evaluation of Land Equivalent Ratio**

LER is defined as the total land area required under sole cropping given compared from yields obtained in the intercropped component of forages (Mthembu *et al*., 2018). LER calculated using the following formula:

LER (maize) =YML/YM----------------eq. (**1**)

LER (lablab) =YLM/YL-----------------eq. (**2**),

Where: YML = yield of maize intercropped with lablab; YM = yield of sole maize, YLM = yield of lablab intercropped with maize; YL = yield of sole lablab.

LER= YML/YM+YLM/YL Therefore, LER=1: No advantage of intercropping, LER<1: Intercropping reduces total yield, LER>1: Intercropping increases total yield thus are more beneficial hence, if the result of LER is greater than intercrop is better than sowing alone.

3.7 Analysis of economic feasibility on intercropped forages

Partial budget analysis is an effective technique for assessing the profitability of comparative treatments. It also provides the foundation for comparing the relative profitability of alternative treatments to evaluate their riskiness and testing how robust profits are in the event of changing product or experiment conduct input prices. Thus, the data were analyzed based on the revised manual published by the partial budget analysis was computed using CIMMYT methodology (CIMMYT, 1988). It takes into account the analysis of total variable cost (TVC), gross benefit (GB), net benefits (NB), and the final analysis of the marginal rate of return was done (MRR). The production costs which show variation (maize seed, and labor costs (plowing, harrowing, weeding, harvesting, planting with the total fixed cost also including seed price and land rent)) between five treatments were identified and converted to per hectare bases. The gross benefit was computed by multiplying the grain and straw yields of the maize and lablab by their current local market price consideration and adding them together. Net benefit was computed by subtracting the total cost of production from the gross benefit obtained. Any treatment with net benefits less than or equal to those treatment with lower cost is considered to be dominant (i.e., inferior). Dominated treatments are omitted from subsequent steps in the marginal analysis. The marginal rate of return was calculated by the ratio of marginal net benefit to marginal variable costs, expressed as a percentage. Hence, the marginal analysis involved comparing the MRR between treatments to the minimum rate of return acceptable to farmers. All the treatments examined for the marginal rate of return analysis were scored MRR greater than 100 % which was more acceptable for field producer farmers. The CIMMYT (1988) revealed that the economic feasibility of both forages maize and lablab intercropping can be calculated based on the following procedure.

Step 1: After adjusting the field yield removal moisture by sun drying for around seven days to narrow the gap in the yield between the experiment plots and farm gate in the farmer field calculated the gross benefits. GB = field gate products × relative price.

Step 2: Calculate the total variable cost (TVC) and the total fixed cost (TVC) during the experiment conduct and it can be calculated by adding all total variable cost (TC) during experiment implementation. TC = TVC+TFC

Step 3: Calculate the net benefit from the field returns that can be implied that NB = GB-TC

Step 4: put the treatments in order of total variable cost (TVC) from the lowest to the higher, then do the dominance analysis. Treatment with a higher total variable cost, but the lowest net benefit (NB) than the treatment found before it is dominated. The dominant treatments were excluded from further economic analysis.

Step 5: The Marginal Rate of Return (MRR), which measures the increase in Net Income, NB) concerning each additional unit of expenditure (TVC), which is the level of intercropping lablab and maize land area expansion, is normally expressed as in percentage or ratio. Therefore, (MRR %) = NB/TVC ×100

3.8 Chemical Composition Determination

Chemical composition analysis of forage samples was carried out using representative samples from respected sample plots. From total fresh biomass 500g sub-samples were taken and stored in an airtight bag and samples were dried in a forced-air draft oven at 65°C for 72 hours for dry matter and other chemical composition was ready to analysis. The dried samples were ground with a mill and the ground sample allow to pass through a 1mm sieve screen aperture of sieve pours from Addis Ababa Animal Nutrition Research Laboratory (ILRI). Representative grounded samples from each treatment plot have waited in an airtight bag until subjected to chemical analysis. Nitrogen and all the other nutritional parameters such as DM, ash, OM, NDF, ADF, ADL, (IVDMD), and (ME) were determined by using Near Infrared Reflectance Spectroscopy (NIRS). Then, the partially dried sample was filled into NIRS cup and scanned using Foss NIRS 5000 with software package WinISI II in the 1108-2492nm ranges from (Win Scan v. 1.5 2000).

3.9 Statistical Analysis

Microsoft excels spreadsheet and SAS version 9.0 (SAS, 2004) software package was used for the data record, data management, and data analysis respectively. After collecting and recording data, the data were checked for its normality. After checking data normality by using Shapiro test techniques, the general linear model procedure (Proc GLM) of the statistical analysis system was used to analyze all variables. Data on morphological characteristics, total DM yields, grain yield, and chemical composition were subjected to analysis of variation (ANOVA). With the assumptions attended, the analysis of variance was performed with the application of the F test. Significant ($P<0.05$) differences between treatment means were compared by applying least significant difference (LSD) option of SAS version 9.0 packages. A simple bivariate Pearson correlation (r) was used to describe the relationships between plant morphology parameters, dry matter yield, and chemical composition. The model for data analysis was.

$Yijk = \mu + Bi + IDj + \varepsilon ijk$, where;

$Yijk$ = dependent variable (Morphological parametrs, dry matter yield, maize grain yield and chemical composition parameters).

μ = Overall mean; IDi = Treatment effect on (sowing dates (T1, T2...Tn),

Bj = Bock effect and eijk = experimental error effect.

CHAPTER FOUR: RESULT AND DISCUSSIONS

4.1 Effects of sowing Dates on Morphological Parameters of Maize

All morphological parameters of maize i.e., plant height, number of leaves per plant, number of cobs per plant, cob length, leaf area, leaf-to-stem ratio, and maize grain yield are presented in Table 2 which is significantly affected ($P<0.05$) by intercropping dates under rain condition. Whereas, root length of maize did not significantly ($P>0.05$) affect by intercropping date. In the current study as summarized in the (Table 2), the better results of morphological parameters of maize such as plant height (PLH), number of leaves per plant (NLPP), number of cobs per plant (NCPP), cob length (CL), leaf area (LA), leaf to stem ratio (LSR), and maize grain yield (MGY) were obtained when lablab intercropping after twenty days of (ML20).

4.1.1 Plant height $_{(cm)}$

Intercropping of maize with lablab had a highly significant effect ($P<0.01$) on plant height. The current results revealed in (Table 2), the overall mean value of plant height of maize was 226.50±2.19cm. The highest plant height (235.67cm) was obtained when lablab intercropped with maize after twenty days (ML20). The medium plant height of maize was recorded from intercropping of lablab after forty dates (231cm) and at the same sowing dates (227.67cm) Whereas, the shortest plant height (211.67cm) was obtained at the treatment of maize sowing alone (SOM). This highest variation of plant height among treatment might be due to intercropping of forage legumes lablab provided nitrogen fixation for the growth of maize more nutrient demands to the crop beneficial than sown alone. The present result of plant height was in line with authors of Ginwal *et al.* (2019) who reported that intercropping of maize with legumes of cowpea and guar produced significantly taller than a pure stand of maize plant height. The same result was found by Tessema Tesfaye, (2022) main rain cropping season of lablab intercropping with maize planting after thirty days on plant height greater than sole maize. These results are also harmonized with the authors Amanullah *et al*. (2016) who stated that intercropping forage cereals with legumes could increase plant height in intercropping forage system having more natural resource beneficial. The increasing plant height in the intercropping system in compared to forage grown alone might be due to the reason of nutrient competition and air circulation to enhance photosynthesis process as compared to alone.

Similar, to the finding of Olujobi *et al*. (2013) who reported that biologically fixed N by pigeon pea was transferred to associated N content uptake by maize was improved plant height in maize-pigeon pea mixture system than sowing alone. In the recent values of plant height mean (226.50±2.19cm) of the current result was highly similar to the finding of Daniel Wana *et al*. (2020) who conducted 25kg/ha seed rate of maize intercropping with lablab between the maize rows at seed rate of 15kg/ha (half of the recommended seed rate for sole production) two weeks after maize planting and slightly lower found a significant effect on plant height (227.5cm). This result is also similar to the authors of Aklilu Mekasha *et al.* (2020) who showed the tallest plant height with an increasing seed amount sorghum (*Sorghum bicolor L.).* These results might be due to high plant density in a specific area causing intra-specific nutrient.

Plant height mean in the current result (226.50±2.19cm) was highly similar to the finding of Daniel Wana *et al*. (2020) who conducted 25kg/ha seed rate of maize intercropped with lablab between the maize rows at seed rate of 15kg/ha (half of the recommended seed rate for sole production) two weeks after maize planting and slightly lower found a significant effect on plant height (227.5cm). This result is also similar to the authors of Aklilu Mekasha *et al.* (2020) who showed tallest plant height with increasing seed amount sorghum (*Sorghum bicolor L.).* These results might be due to high plant density in a specific area causing intra-specific nutrient completion. The highest plant height (235.67cm) recorded from maize with lablab mixture after twenty days (ML20) was akin resulted in a finding by Hamd *et al*., (2015) revealed that (235.67cm) plant height recorded by maize and cowpea (*Vigna unguiculata*) intercropping as compared to them on its solitary. The plant height of maize was highest in intercropped than in alone and this result is supported by Hamd A *et al*., (2014) who showed the plant height of maize is highest in the mixture than its alone. The highest plant height in the recent study was lower than the finding of Tesfaye Gemechu, *et al*. (2019) found on plant height were recorded from BH-540 variety of maize and vetch (*Vicia daycare*) intercropping (284.4cm). This lower result might be due to the genetic variation of maize and environmental effect during field experiment management differences. This might be due to intercropping of fixing nitrogen by legumes. In addition, it might be due to competition with the light, optimum intercropping dates for both crops, and also could be allowed for good aeration in intercropped components. This result is highly agreed with the finding of Basaran *et al*. (2017) who found the highest plant height of sorghum Sudan grass hybrid intercropped with soybean (*Yemsoy*) and cowpea (Ulkem) varieties with different seed ratios. It was possibly due to light competition between intra-species. This result is also supported by the authors of Adeniyan *et al*. (2014) who conducted research on intercropping of maize (Zea mays) and cassava (*Manihot esculenta*) and revealed that intercropping maize was increased in plant height than its alone.

Therefore, the plant height of maize was higher in the intercropped than alone. It might be the reason for the high plant density preventing the passage of sunlight into the bottom leaves, genetic variation, optimum intercropping date, nitrogen fixation, and inter-species light competition in intercropping is responsible for plant growth. Generally, the highest plant height is better agronomical management to achieve more biomass in forage development. Whereas, the recent results were in contradicted with the finding of Getachew Haile (2014) who stated that was no significant difference in plant height days to physiological maturity between sole and intercropped sorghum with lablab and cowpea. Similarly, other scholars Redae Meseret & Tekle Dawit (2020) revealed that there was no significant difference in intercropping dates of lablab with maize sole maize (T1), lablab sown at 10 days after emergence of maize (T2); lablab sown at 20 days after emergence of maize (T3) and lablab sown at thirty days after emergence of maize (T4) on the plant height. It might be due to the reason for the genetic variation, environmental effect, different experiment management practices, and inter-species light competition in intercropping that is responsible for plant growth performance increments for inconsistences results was noted on plant height.

4.1.2 Number of leaves per plant ($_{Count}$)

The number of leaves per plant had a highly significant difference ($P<0.01$) among the treatments with the overall mean value of (12.33±0.69). The largest number of leaves per plant (15.67) was obtained from lablab intercropped with maize when it was planted after twenty dates (ML20). Following that medium number of leaves per plant also (10.67 & 13) in the recent results were obtained from both forages lablab with maize similar sowing date and from maize sowing after forty dates (ML40) treatments respectively. The highest leaf number per plant (15.67) was obtained from lablab intercropping with maize planting after twenty dates (ML20) while the leaves number decreased to (10) when maize sown alone treatment. This result was supported by the finding of Hamd *et al*. (2014) who revealed that the number of leaves increases under sowing cowpea with maize as compared to sown alone maize. Similarly, these results were in line with the finding of Ginwal *et al*. (2019) who outlined that a higher value of leaf number per plant was recorded during intercropping of maize and cowpea Followed by, Teshome Gutu *et al*., (2015) reported that the number of ears per plant showed significant differences due to inter-cropping systems having greater leaves than sole. This greater result might be due to the biological nitrogen fixation on intercropping treatments as compared to pure stands.

The largest number of leaves per plant (15.67) recorded from lablab intercropping with maize planting after twenty days (ML20) was harmonized results of finding Kassaw Dawit (2022) revealed that (15.63) leaves per plant (NLPP) recorded by maize-haricot bean intercropping system. Whereas, the present result was also greater than the finding of Ginwal *et al*., (2019) who indicated that the leaf number of maize ranges from (11.14-11.35) of maize cultivar J-1006 with cowpea cultivar (cultivar C-152) and guar (cultivar HG-02) intercropping system. The greater number of leaf numbers per plant in the intercropping might be due to the reason intercropping with legumes forages. Hence, better forage canopy, and efficient utilization of environmental resources. On the other hand, the current results were greater than the finding of Shahrajabian *et al*. (2021) who showed that the maximum values of leaves per plant were (11.04). whereas, better number of leaves per plant (15.67) obtained from (ML20) from the present result was lower than the finding of Grace J *et al*., (2014) who revealed that the number of leaves which had 27.45 leaves of maize intercropping with lablab treatments. These differences might come from genetics, the species itself, soil type, season of sowing time, altitude, and harvesting stage where the current and previous study was evaluted.

4.1.3 Number of cobs per plant ($_{Count}$)

The number of cobs per plant was highly significantly (P<0.01) affected by intercropping dates of maize and lablab with the overall mean value of (1.50±0.13). The current result indicated that (Table 2) the largest number of cobs per plant (2.1) was obtained from lablab intercropped after twenty days of maize planting (ML20). It was followed by, medium number of cobs per plant (1.53 & 1.33) in the current results were obtained from lablab and maize intercropped at forty days (LM40) and similar planting dates (LM0). On the other hand, the lowest value of cobs per plant (1.03) was obtained from sole maize (SOM) treatment. Besides these greater results of cob on intercropped treatments than sowing alone maize might be due to the reason of biological nitrogen fixation legumes, better weed suppresses, low infestation of weeds, and efficient utilization of environmental resources than sown its sole.

The mean of cobs per plant (1.5±0.13cm) of the current result was highly similar to the finding of Solomon Abegaz and Likawent Yeheyis, (2016) who conducted cowpea varieties kenkey intercropping with maize variety BH-660 under sown and found a significant effect on a number of cobs per plant (1.5). The highest number of cobs per plant (2.1) recorded from lablab and maize intercropping with twenty days after maize planting (LM20) was akin to the finding of Taha Mume *et al*., (2019) who found that (2.0) number of cobs per plant recorded from vetch (Veciavillosa) and improved maize (Zea mays) variety of (BH-660) which was planted after 15 days of maize planting. Whereas, the present result was also lower than the finding of Fekadu Tewolde *et al*., (2022) who reported that the cobs number per plant (3.05) on maize varieties of Alemaya-composite. The reason for these higher results indicated that might be due to the genetic variation and agroecological differences with additional experiment management and environmental effects. Unlike the present results, Awoke Tadesse (2016) reported that the number of cobs per plant for maize was not affected significantly due to intercropping with haricot bean. Similarly, Molla Abate and Getachew Alemayehu (2018) indicated that the effects of intercropping had no significant difference in cob number per plant by intercropping maize with different legumes. On the other hand, Jibril Temesgen *et al*. (2015) revealed that intercropping system indicates a non-significant effect on the number of cobs per plant. The different studies' results that was inconsistency of current and former reports might be due to the genetic production potential of inter-cropped maize with legume/lablab species variation was determined.

4.1.4 Cob length (cm)

The number of cob length per plant in the current study were statistically significant (P<0.01) among treatments as shown in (Table 2). In the present finding, the longest con length (19.13cm) was obtained from lablab under sown at twenty days after the emergence of maize (ML20), and the smallest cob length (13.33cm) was recorded at alone maize (SOM) treatment. Whereas, intermediate cob length was recorded from lablab intercropped with maize at forty days) and lablab intercropped with maize intercropped at the same planting date. Besides this greater result of intercropping than sown as monoculture crops might be due to the reason of legumes provide green manure fixation, and the lowest weed infestation, suppressing weeds with the related inter-nutrient competition and use efficient utilization of environmental resources as compared to sown alone. The recent results indicated that the highest value of cob length (19.13cm) was obtained in intercropped maize with lablab after twenty days (ML20). This result was confirmed by the finding of Alom *et al*. (2009) who harmonizes that the cob length of maize varieties (19.40cm) was found from groundnut varieties (*var. Jhingabadam*) intercropping between normal rows of hybrid maize (var. pacific-984) varieties.

On the other hands, this result also lower than with the finding of Hassan *et al*. (2013) who revealed that cob length (14cm) from sole crops of maize was slightly greater than lablab under combination with maize variety (SAMMAZ 14) results obtained ranges from (12.78-13.57cm) CL as compared to sown alone maize. The current results contradicted by Nwueze *et al*. (2010) indicated that the effects of intercropping had no significant difference in cob length per plant by intercropping maize with different legumes. Behind this variation was due to the genetic variation between maize and lablab varieties and also might be due to agro-ecological differences, experiment site management variation on the factors that affect the causes of different results revealed on cob length. Generally, statistical analysis of the current study results indicated that cob lengths from intercropped maize had the best cob length performed as compared to maize sown as the pure stand treatment

4.1.5 Leaf Area (cm^2)

The current study showed that the highest statistically significant differences ($P<0.01$) was obtained from leaf area of maize when it was intercropped with lablab is presented in the (Table 2). The highest leaf area (666.07cm^2) was obtained from maize planting after twenty days with lablab intercropped. Whereas, the lowest leaf area (466cm^2) was obtained from pure stand of maize (SOM). Beyond this greater leaf area observed better morphological performance than other treatments it might be due to the reason related to the optimum under-sowing dates of lablab with maize, and fewer inter-species nutrient competition. On the other side, the intermediate leaf area (512.67, 595cm^2) in the current study was obtained from maize intercropped with lablab during the same planting date (ML0) and maize intercropped after forty (LM40) while mean values of leaf area (560.08 ±25.86cm^2) in the current result were highly similar to the finding conducted by Amanullah *et al*. (2016) under Sugar Graze and Jumbo Plus sorghum hybrids under three different sowing dates during rainy season sown and found a significant effect on leaf area (560cm2).

On the other hand, the largest leaf area (666.07cm^2) was obtained from intercropping maize with lablab under sown in maize planting after twenty days (LM20) as compared to others intercropping and sown alone treatment. This result is also similar to the authors of Jing *et al*., (2011), who showed that founding results had significant effects on intercropping times with maize and Soybean in microclimates on the leaf area (666.67cm). The current result is slightly greater than the funding of Rahel Kasaye *et al*., (2021) reported that the effects of inter-cropping lablab under main rain season with selected sorghum (*Sorghum bicolor*) varieties (Teshale, Girana-1, and Misikir) on leaf area ranges from (579-631cm2). The difference in these results might be due to the reason of genetic variation and agroecological differences. Unlike the present study results Megersa Dinsa (2020), revealed that the main effect of soybean (*Glycine max L. (Merrill*) and maize cropping system had no significant effect ($P>0.05$) in leaf area attributes. Similarly, Muoneke *et al*., (2007) noted that leaf area performance maize did not significantly influence by its association with soybean. Whereas, Abera *et al*., (2016) also reported that leaf area yield of maize did not significantly influence by its association with the common bean. This may be attributed to the less competitive effect of soybean on maize which uses environmental resources dominantly over intercropping bean and the effect of different agroecological and experiment site management practices.

4.1.6 Root Length (cm)

Root length of maize is not affected by intercropping date is presented in Table 2. These results were in harmonized with the authors of Bhakar *et al*. (2021) who stated that there was no significant (P>0.05) difference among treatments during intercropping sorghum with guar on root length of maize. Non-significance (P>0.05) on root length was observed in different lablabs and maize intercropping dates within the current results (Table 2). Even though, the better root length (40.47-40.60cm) was obtained from lablab with maize intercropping dates as compared to relatively the others of sowing trails.

4.1.7 Leaf-to-stem ratio

. Leaf to stem ratio of the current result was statistically significant (P<0.05) on intercropping dates of treatments in (Table 2Therefore, the mean value of the current results of leaf to steam ratio was 1.50±0.04 which means, the dry weight of the leaf was greater than the dry weight of the stem of maize. In the recent studies, the highest leaf-to-stem ratio (1.83) was obtained from maize intercropping with lablab planted twenty days after maize planting (LM20). Whereas, the lowest value of the leaf-to-stem ratio (1.19) was found at the sowing date of alone maize treatment.

Followed by, the intermediate value of leaf-to-stem ratios (1.36, 1.60) in the present study was found from lablab with maize intercropping level under the same planting date for both crops (ML0) and lablab with maize intercropping of lablab planted at forty days after maize planting (LM40) treatments respectively. Besides these greater values of leaf-to-stem ratio in the current study results revealed that intercropping than sown sole maize might be due to atmospheric nitrogen fixation contribution of lablab legume forages and optimum under sowing legume forages with related to the early and delayed intercropping date determination on less nutrient competition both forages. The highest value of the leaf-to-stem ratio (1.83) in the current study was obtained from lablab under-sown at twenty days after the emergence of maize compared to other intercropping treatments and also from sown alone maize treatments. Under leaf area (the maximum and minimum measurement of leaf length and leaf width) is the most important characteristic used to determine the leaf-to-stem ratio and forage quality. This leads to greater leaf dry weight than stem dry weight and the highest leaf-to-stem ratio was obtained with the direct relationship between forage production and quality feed production. The current results of leaf-to-stem ratios (1.19-1.83) were lower than the finding of Taha Mume *et al*. (2019) who outlined that leaf-to-stem ratio values (2.07) from Agronomic performances of sole oat and vetch mixture. Similarly, the highest leaf-to-stem ratio (1.83) of the present study was lower than the finding of Bizelew Gelayenew *et al*. (2020) who showed that leaf to stem ratio (2.53) was found in sorghum hayrides elephant grass (*Pennicetum purpureum*) planted with vetch (Vicia villosa). Whereas, the recent study was in contrast to the finding of Ginwal *et al.* (2019) who stated that intercropping of maize with legumes (cowpea and guar) in varying row seed ratios and their respective sole treatment has no significant difference in in the leaf to stem ratio. In addition, the finding of Singh, M (2021) revealed that there was no significant difference ($p>0.05$) effect on sorghum and cluster bean as influenced by the mixed cropping system.

The current result was greater than the value of leaf to stem ratio studied by Ali Raza *et al*., (2021) who observed that sorghum with cowpea strip intercropping revealed a significant level of result in the leaf-to-stem ratio (0.59 and 0.69) from the two consecutively studies year (2013, 2014) respectively. When it comes to a plant's ability to absorb light and CO_2, leafy biomass plays a significant role in the increment of leaf to stem ratio. The greater leaf component suggests its potential for carbon sequestration by absorbing and lowering atmospheric CO_2 levels, and the larger leaf-to-stem ratio strongly suggests its competitive advantage to light for photosynthesis enhancement to other related growth parameters of lablabs with maize mixture practice. Leaf to stem ratio is an important factor that helps determine digestibility and palatability for any fodder. In general, different findings of leaf-to-stem ratio differences results showed that it might be due to the reason there are different genetic variations, environmental differences related to agro-ecological and management variation effects.

4.1.8 Maize grain yield (t/ha)

The grain yield of maize was significantly ($P<0.001$) affected by the intercropping dates of lablab with overall production of 44.50qt/ha is summarized in the Table 2. It was maximized result of 52.12 qt/ha when maize intercropped at ML20. The largest grain yield was obtained in this study is due to optimum planting dates which results less inter-nutrient competition in comparison to the other treatments and lablab benefit as good source of biological nitrogen fixation. In the current study, a minimum grain yield (39.30 qt/ha) maize was harvested at ML0 which is comparable to sole maize. It might be due to higher inter-nutrient competition of maize and lablab from seed germination to the growth performance. In the current study high maize grain yield (52.12 qt/ha) harvest at ML20 was supported by the finding of Kifle Jogora *et al*. (2019) who reported that 52.70 qt/ha maize grain yield obtained when maize was intercropped with lablab three weeks after maize plating. In addition, mean value of maize grain yield was (44.50±2.27qt/ha) and higher values (52.12qt/ha) maize grain production were obtained in the current studies. These greater results due to the reason was more grain production than from other might be due to the reason of optimum under planting dates for both forage crops and less inter-nutrient competition as comparable to the other intercropped treatments. Whereas the lower maize grain seed production was (39.30qt/ha) was due to the reason for having a highest intr-nutrient competition on intercropping maize with lablab from having seed germination to the growth performance both crop mixtures under lablab with maize intercropping level with the same planting date for both crops was a drastic reduction of maize grain yield production as compared with other treatments. In general, better maize grain yield was obtained from lablab with maize intercropping when lablab planted twenty days after maize planting (LM20) treatment as compared to their sown mono-crop and with the others early and late intercropping dates of treatments for their reduction maize grain production performances. These higher maize grain productions were due to might be direct and indirect effects on morphological development related to optimum intercropping dates. And also, might be due to the reason of intercropping legumes can enhance grain yield because legumes were a good source of biological nitrogen fixation and lower weeds infestation rate for complementary advantages relatively to sown alone maize.

The current results of maize grain yield (52.12 qt/ha) were supported by the finding of Kifle Jogora et al. (2019) who outlined that maize grain yield (52.70qtha$^{\mathbf{1}}$) at Bekele Girisa site of Dugda district on maize grain yield performance of BH-540 maize variety seed rate of 25 kg/ha with 75cm of spacing between the rows, and 25 cm among the plants were used for maize and lablab was intercropped between the maize rows seed rate of 15kg/ha (half of the recommended seed rate for sole production) lablab three weeks after maize planting. Similarly, this result was in agreement with the finding of Mergia Abera (2014), corroborating that where inclusion of vetch, cowpea, and lablab increased maize grain yield by 7.4%, 5.9%, and 5%, respectively. On the other hand, the finding of Tessema Tesfaye (2022) in the 2019 main cropping season of lablab intercropping with maize planting after twenty (ML20) on maize grain yield (63.9qt/ha) greater than in the recent results were sown alone and intercropping treatment respectively. The higher MGY from the intercropping practice could be due to the use of recommended agronomic practices including optimum intercropping dates, and efficient utilization of resources with related early and delayed under-planting dates for both crops. In addition, under-sown legumes forage helps to suppressing the growth of unwanted weeds and conserve soil moisture as compared to sole maize crop production. However, this result disagrees with the study of Abraha (2013) who reported that mono-crop (3056 kg/ha) was higher than intercrop (2381kg/ha). This might be associated with the difference in environmental conditions such as rainfall, soil fertility, temperature, and variety difference both in maize and lablab and also a condition of cropping season. Similarly, the results of this study were contrary to those reported by Aklilu *et al.* (2007) reported that where the under-sowing legumes forage depressed the grain yield of the companion to the sole cereals grain yield by 3.6 to 9%.

Followed by the finding of Abubeker (2006) also reported that simultaneous planting of lablab with maize studies results indicated that non-significantly (P >0.05) on maize grain yield. In addition to this, Kamara *et al*. (2017) and Solomon, (2014) revealed that the yield of sole cropped maize was higher than grain yield of maize intercropped with soybean. Reduction of maize grain yield might be associated with inter specific nutrient competition between the intercrop components for growth resources (light, water, nutrients, and space). those results variation was due to might be their genetic variation, field experiment difference, soil fertility difference, and agroecological effects with related variation cropping season.

Table 4.1: Morphological parameters of sown alone and inter-cropped maize

	Morphological Measured Parameters							
Treatment	PH (cm)	NLPP (count)	NCPP (count)	CL (cm)	LA (cm2)	RL (cm)	LSR	MGY ($qtha^{-1}$)
T1(SOM)	211.67^{c}	10.0^{c}	1.03^{c}	13.33^{c}	466.0^{c}	40.10^{a}	1.19^{d}	41.01^{bc}
T2	227.67^{b}	10.67^{bc}	1.33^{bc}	16.6^{b}	512.67^{bc}	40.53^{a}	1.36^{c}	39.30^{c}
T3	235.67^{a}	15.67^{a}	2.10^{a}	19.13^{a}	666.07^{a}	40.60^{a}	1.83^{a}	52.12^{a}
T4	231^{ab}	13.0^{b}	1.53^{b}	17.73^{ab}	595.0^{ab}	40.47^{a}	1.60^{b}	45.22^{b}
T5 (SOL)	-	-	-	-	-	-	-	-
Overall mean	226.50	12.33	1.50	16.70	560.08	40.43	1.50	44.50
SEM (±)	2.19	0.69	0.13	0.67	25.86	2.72	0.04	1.54
CV%	1.67	9.75	15.51	6.95	8.80	11.64	4.99	5.98
P-value	<0.0001	<0.01	<0.01	<0.001	<0.01	>0.05	<0.05	<0.001

Whereas, *T1=Treatment one, T2=Treatment two, T3=Treatment three, T4=Treatment four, T5=Treatment five, PH = Plant Height, NLPP = Number of Leaves per plant, NCPP = Number of cobs per Plant, CL = cob Length, LA = Leaf Area, RL = Root Length, LSR= Leaf to Stem Ratio, MGY= Maize grain yield SOM = sole maize, SOL= sole lablab, SEM = Standard Error of Mean, CV% = Coefficient of Variation in percentages,, NS = Non-Significant level, * (p<0.05), ** (p<0.01), *** (p<0.001).*

4.2 Effects of sowing date on morphological parameters of lablab forages

In the current study, all morphological parameters of lablab such as plant height, number of leaves per plant, number of branches per plant, leaf area, and the number of nodules per lablab were statistically significant ($P<0.05$) affected by planting dates with maize indicated in (Table 3). While the root length of the lablab was not statistically significantly ($P>0.05$) on affected by sowing dates with maize. Therefore, most of the growth parameters of lablab that intercropped with maize were higher than that of lablab was not intercropped with maize in the current studies which revealed on the agronomic performance of lablab enhanced by the date of intercropping.

4.2.1 Plant height $_{(cm)}$

In the current study, a statistically significant ($P<0.01$) changes of plant height of lablab were presented in the Table 3. In the present results, the highest plant height (213.83cm) was obtained from lablab and maize intercropped with lablab planted at the twenty days after maize planting (LM20) treatment. Whereas, the shortest plant height (174.87cm) was obtained from lablab forage sown as a pure stand. Increasing plant height in the treatment of intercropping date is due to inter-species light competition and also legumes especially lablabs a great strong claiming nature for physical support to increase plant height.

On the other hand, these significant results of intercropping dates were supported by the authors Aydin and Ilkay (2016) who reported that cowpea with maize intercropping arrangements on the highest plant height value of cowpea were obtained from intercropped components (161.8 cm) as compared to sown alone cowpea (89.5cm) respectively. In contrast to the present study, plant height of common vetch (Vicia sativa L.) was insignificant ($P>0.05$) with Sudan grass (*Sorghum Sudanese (Piper.*)) admixture in different row configurations as noted by Erkovan (2022). Similarly, this result was contradicted by the findings of Rahel Kasaye *et al*. (2021) who reported that the higher plant height obtained from sown alone lablab compared to the intercropping in different three sorghum variates (Misikir, Girana-1, and Teshale). In addition, this finding disagrees with that of Demissie Alemayehu. (2018) noted that sown alone of common bean varieties (Phaseolus (*Vulgaris L.*) on plant height (96.08cm) was greater than maize varieties (BH-661) under intercropping of plant height (32.61cm). This high variation in plant height is due to the forage sowing dates, the difference in genetic, environmental, and management and edaphic differences as factors for this inconsistency results. The present result also was lower than the finding of Yihalem Denekew and Habtemariam Asefa (2012) who noted that the plant height (131.15cm) of vetch (*Vicia villosa*) was intercropping with maize in Mecha district. This less plant height was due to lablab legume genetic variation, environmental effect and agronomic data management differences. Whereas, the result of Asem *et al*. (2020) plant height was significantly affected and produced greater plant height values (230.03cm) lablab with maize intercropping than that of current result plant height (213.83) lablab mixture twenty days after maize planting (LM20). The highest value of plant height in the current result was due to the optimum intercropping date determination effects and also light competition within inter-species is the reasons for incensement of plant height of lablab.

4.2.2 The Number of leaves per plant $_{\text{(Count)}}$

The analysis of variances between sole and inter-cropped lablab forage indicated inter cropping date had significant ($P<0.01$) effect on the number of leaves per plant (Table 3). The maximum number of leaves per plant was recorded from lablab when maize intercropped with lablab at twenty days after maize planting (LM20) while the minimum numbers of leaves were obtained from lablab with maize intercropping level under the same planting date for both lablab and maize (ML0) with overall mean values of leaves number was (34.53). Regarding the variations of leaves number in each forage crop under the same management conditions could be due to the inter-cropping dates variation related to delayed and early intercropping effect on the main crop of maize and inter-nutrient competition, management practice adaptability from the experiment site. The current results noted that the highest number of leaves per plant (42.20) obtained from lablab planted twenty days after maize planting were in line with the finding of Rahel Kahsay *et al*., (2021) who outlined that intercropping three sorghum (*Sorghum bicolor L*.) varieties (Teshale, Misikir, and Girana-1) and legumes for lablab recorded a number of leaves per plant was ranges from (41.8-52.1) studies value. Whereas, this result was greater than the value of leaves per plant studied by Jokthan *et al*. (2014) who observed that both forages intercropping levels had a significant result on the number of leaves per plant from 6-12 weeks after sowing (17 and 25) lablab leaves in flooded irrigation system. Similarly, the other scholars finding of Ginwal *et al*. (2019) reported that cowpea intercropping with maize (M1:1C) seed ratio level had a significant ($P<0.05$) value obtained (114) number of leaves. Those significant values were greater than the value obtained from the current study. Those differences might come from genetics, the species itself, soil type and fertility, the time of sowing season, amount of rainfall, altitude, management system, and where the current and previous study was conducted. In contrast, the lowest value of leaves number was obtained by scholars of Atumo Tessema, and Kalsa Getinet (2020) who stated that the plant leaf number in this experiment was significantly ($P < 0.001$) varied among vetch interplanting with oats grass species and was ranging from 3.3 to 6.9. The inconsistency of current and former reports might be due to the genetic potential of inter-cropped lablab species, harvesting stage, establishment season, and management variation.

4.2.3 Number of branches per plant $_{\text{(Count)}}$

The number of branches in legume forage production is a more important agronomic parameter that determines increasing forage biomass and dry matter yield. Several branches in the current study were statistically significant ($P<0.05$) with in lablab sowing dates. The current study (Table 3) revealed that the overall mean number of branches of lablab was (8.66 ± 0.64). Besides these recent results, the highest value of branch number (10.67) was obtained from lablab planted twenty days after maize planting (LM20). Whereas, the lowest branch number (5.67) was obtained from lablab with maize intercropping level under the same planting dates (ML0). The present study showed that number of branches increased within intercropped treatments may be due to the intra-nutrient competition of simultaneous both forages crops planting and during delayed intercropping dates affecting (NBPP) leading to climate change conditions causing on number of branches per plant decrease. Intercropping treatments had greater value than sown alone in the current studies. This might be due to the reason increasing the branches number may be optimum intercropping dates of lablab was had nature claiming character like physical supported to boost up plant height directly related to increase (NBPP). Hence, its superior plant height provided physical support for climbing lablabs, and it was more suitable for lablab growth and development compared to alone. The current results investigated that number of primary branches per plant of lablab was highly significantly ($P<0.05$) affected by alone and intercropping lablab with maize planting after twenty days had revealed that the same number of branches per plant obtained (10.33 and 10.67) respectively. This result is also supported by the authors of Tessema Tesfaye (2022) who conducted research on intercropping of maize and lablab in the 2018 main cropping season and revealed that the research finding from sowing sole and lablab intercropping with maize planting after twenty days of treatments on branches per plant were (10.67 and 10.67) respectively. Similarly, this finding by Getachew Haile (2014) indicated that the number of primary branches per plant was significantly affected by the main effect of forage legumes intercropping with the main crop of maize. whereas, the number of branches per plant in the present finding (10.67) on lablab planted twenty days after maize planting (LM20) was lower than the result of Tesfaye Alemu *et al.* (2019) who outlined (27.66) number of branches were obtained from maize varieties (Melkasa-4) + dolichos lablab 37.5 cm between maize and dolichos lablab row space intercropping maize (Zea mays) with lablab (lablab purpureus) at Habro district (Bareda FTC). This lower number of branches per plant was due to the reason might be due to related genetic, environmental, and management variations. Meanwhile, the present result was also greater than the finding of Rahel Kahsay *et al.* (2021) who revealed that the number of branches on lablab mixture within different three sorghum varieties (Misikir, Teshale, and Girana-1) ranges from (4.4-8.4, NBPP) values. Contrary to this finding, Awoke Tadesse (2010) showed that branch numbers per plant for haricot bean were not affected significantly ($P>0.05$) due to intercropping with maize. On the other hand, current results were akin to the finding of Akter *et al.* (2022) they showed that the maximum number of branches plant used a hybrid variety of maize (Don-111) plus cowpea intercropping maize sown after three weeks of treatment as compared to sowing alone (9.13 and 6.93) respectively. The differences between current and former reports might be due to the genetic potential and effect of management variation for both studies were conducted.

4.2.4 Number of nodules per plant $_{\text{(Count)}}$

Root nodules have more importance for nitrogen acquisition through symbiotic nitrogen fixation in leguminous plants. Root nodules are also used for converting atmospheric nitrogen into soluble nitrogenous compounds and used for increasing leguminous forage production as well as cereal crop mainly maize when intercropping with leguminous forage plants was a very important attribute related to green manure fixation concerned mainly soil nutrient demands for both maize and sorghum cereal crops. Therefore, root nodules in the present study were statistically significant ($P<0.001$) variations observed under intercropping dates of treatments. The mean value of root nodules (16.83±0.48) in the recent study was found significantly affected by intercropped on maize with lablab as revealed in (Table 3).

Significantly highest root nodules numbers (20.07) were obtained from lablab planted twenty days after maize planting (LM20) intercropped treatment. Whereas, the smallest number of root nodules (13.67) in the current results were obtained from lablab with maize intercropping level under the same planting date for both forage crops (ML0). A recent study on root nodule numbers ranged from (13.67-20.07) which was in line with the nodule number of Vetch (Vicia dasycarpa) and Sudan Grass (*Sorghum Sudanense "Aden-gode*") intercropping ranged from (11.01-31.67) noted by authors of Tenaw Temesgen (2021). On the other hand, the lowest nodule numbers (11.3-13.33) were obtained by the scholar Yang (2017) intercropping of common vetch with grass specie of oat compared to the present study. Similarly, in recent studies, the number of root nodules of lablab was less than the number of nodules (53) reported by the authors of Muluneh Minta and Angaw Tsige (2014) on vetch (*Vicia dasycarpa*) that was un-inoculated with rhizobium bacteria.

Therefore, the highest number of nodules in the optimum intercropping could be increase biological atmospheric nitrogen fixation (Golparvar, 2012) and also leads to increasing forage yield in both forages grown under the experiment. However, unlike the present studies of Berhane Sibhatu *et al.* (2015) noted that sole cowpea was better performing a number of nodules than the intercropping system on cowpea with sorghum (*Sorghum bicolor*) (16,14) nodule values respectively. In addition, a scholar of Rahel Kahsay *et al*. (2021) found that the number of nodules sown alone lablab forage crop was greater than the mixtured lablab (lablab purpureus) with in three varieties (Teshale, Misikir, and Girana-1) of sorghum (*Sorghum bicolor*). A recent study of root nodule numbers ranged from (11.01-20.07) which was lower than the nodule number of vetch varieties ranged from (13.67-29.73) noted by the authors Kosev & Vasileva (2018). The inconsistency of current and former reports might be due to the reason for the genetic potential of lablab species, the effect and establishment season for both studies were implemented.

4.2.5 Root length $_{(cm)}$

The root length of the forage crop of lablab is the most important growth parameter of lablab having a direct relationship to increasing other plant agronomic attributes due to their nutrient uptake from the soil. However, the root number of lablab in the current study was non-significantly (P>0.05) affected by different intercropping dates. The mean value of the root number (37.83±1.72) in the current study was obtained as shown in (Table 3). Therefore, the highest number of roots (40.66) in the current study was obtained in sown alone. The minimum number of root numbers per plant (36.0) was also obtained from lablab and maize intercropping with lablab planted forty days after maize germinated (LM40).

4.2.6 Leaf area $_{(cm2)}$

Leaf area is an important parameter to determine green forage yield and quality of positive effect on forage biomass yield. Leaf areas in the recent studies were statistically significant (P<0.01) on intercropping dates of lablab and maize as shown in (Table 3). In the current study, the tallest leaf area (136.80cm^2) was obtained from lablab and maize intercropping with lablab under-sowing twenty days after maize planting (LM20). The smallest leaf length (103.33cm^2) was recorded at lablab with maize intercropping level with the same planting date for both crops (ML0) treatments. Followed by, the intermediate leaf area (119.03, 131cm^2) was investigated from lablab and maize mixture with lablab planted forty days after maize germinated (LM40) and lablab (SOL) sown sole.

On the other hand, the leaf area of lablab intercropped with maize planting after twenty days had the best leaf area performance compared to others sowing dates and sown alone. It might be due to the optimum intercropping dates of lablab with maize. The reason also might be legume intercropping had a complementary effect on maize providing physical support of ILRI- Rongi varieties of lablab having in nature vertical growth properties as compared to among others legumes forage and having an implication on increasing leaf area. In addition, related to early under-sowing legumes lablab forage crop is simultaneously planted with the main crop of maize during germination having final growth phases where strong soil nutrient competition might be leafing area reduction occurs and also similarly direct effect throughout others agronomic attributes. Meanwhile, delayed inter-cropping maize planting after forty days of lablab intercropping for the causes of leaf area decreases might be due to the reason changes in environmental condition means that rainfall decrease, and temperature increase before addressing the recommended dates of forage leaf length and width growth of maturation stages. The present studies of leaf area results were lower than the value obtained by Jibril Temesgen *et al*. (2015) who noted leaf area (314.64cm^2) was obtained from intercropping of common bean (*Phaseolus vulgaris L*.) with taking place three weeks after emergence maize. In addition, the lowest values of leaf area (103cm^2) were obtained by the scholar Rahel Kahsay *et al*. (2021) on intercropping of lablab with sorghum (*Sorghum bicolor*) were supported to the recent studies from both forages planted in similar date (ML0) on leaf area (103.33cm^2). Inconsistences to the current results authors of Megersa Dinsa & Habtamu Zeleke (2020) revealed that soybean under a sole cropping system had higher leaf area (945.20cm2) than soybean Varieties [*Glycine max L. (Merrill)]* intercropped with maize on leaf area (934.28 cm2) respectively. Similarly, in line with this scholars Kamara *et al*., (2017) also reported that sole soybean had significantly higher leaf area than intercropped soybean with maize. This higher leaf area of soybean under sole cropping pattern may be related to the absence of shading effect of main crop of maize, and then plants can intercept light to their potential and grow vigorously opposite to intercropped soybean, environmental, agro-ecological related differences.

On the other hand, this result was confirmed by Ahmad A *et al*. (2012) found that intercropping corn (*Zea mays*) with cowpea (*Vigna vulgaris*) highest significant ($P<0.05$) effect increase on leaf area as compared with the alone cowpea (*Vigna vulgaris*). In contrast, this result might be related to the fact that plants in a sole cropping system are more advantageous than when they are intercropped since they have better opportunities to capture environmental resources like water, light, and nutrients and also no inter-specific competition under sole cropping system (Gebru, 2015). These differences might come from genetics, soil type, fertility, management effect, and where the recent and previous study was compared.

Table 4.2: Morphological parameters of sown sole and inter-cropped lablab forages

	Morphological Measured Parameters					
Treatment	PH $_{(cm)}$	NLPP $_{(count)}$	NBPP $_{(count)}$	NNPP $_{(count)}$	RL $_{(cm)}$	LA $_{(cm^2)}$
T1(SOM)	-	-	-	-	-	-
T2	202.70^{ab}	26.90^{c}	5.67^{c}	13.67^{d}	38.33^{a}	103.33^{c}
T3	213.83^{a}	42.20^{a}	10.67^{a}	20.07^{a}	39.33^{a}	136.80^{a}
T4	192.73^{b}	32.53^{bc}	8.0^{b}	15.66^{c}	36.0^{a}	119.03^{bc}
T5(SOL)	174.87^{c}	37.47^{ab}	10.33^{a}	18.0^{b}	40.66^{a}	131.0^{b}
Overall mean	196.03	34.53	8.66	16.83	37.83	121.83
SEM (±)	4.12	2.49	0.64	0.48	1.72	3.01
CV%	3.63	12.49	12.76	4.95	7.88	4.27
P-value	<0.01	<0.01	<0.05	<0.001	>0.05	<0.01

Whereas, *T1=Treatment one, T2 =Treatment two, T3=Treatment three, T4=Treatment four, T5=Treatment five, PH = Plant Height, NLPP = Number of Leaves per plant, NNPP= Number of nodules per plant, NBPP = Number of branches per plant, LA = Leaf Area, RL = Root Length, SOM= sole maize, SOL= sole lablab, SEM = Standard Error of Mean, CV% = Coefficient of Variation in percentages, N = Number, cm = centimeter, a, b & c = level of mean difference, NS = Non-Significant level, * (p<0.05), ** (p<0.01), *** (p<0.001).*

4.3 Effects of Sowing Date on Dry Matter Yield

4.3.1 Dry matter yield of maize

The dry matter yield of maize in the present study was statistically significant (P<0.01) on sowing dates as shown in (Table 4). The mean value of dry matter yield (8.12±0.45t/ha) of maize was obtained in the present study. The highest value of DMY (10.22t/ha) of maize in the current study was harvested when lablab was planted at the twenty days (LM20). Whereas, the lowest DMY (6.18t/ha) was found from sown as sole maize crop cultivation in compared with other mixture of treatments. This might be due to the reason, increasing in plant height, number of leaves per plant, better performance of leaves area, and other morphological parameters of maize that could be increasing forage yield when lablab was planted at the twenty days (LM20). On the other hand, DMY (8.78t/ha) was revealed from lablab intercropping with maize emergence after forty dates and lablab with maize planting under the same planting date for both crops (ML0) on dry matter yield (7.29t/ha). Under harvested dry matter yield in the current study was relatively highest in intercropping maize than from its sowing alone maize. Dry matter yields of maize in the current study showed that relatively increasing when optimum in intercropping dates, it might to be due to legume forages provided green manure and nitrogen fixation which increase the forage dry matter yield as compared to sowing alone maize. Therefore, sole maize leads to decrease the dry matter yield as observed by another lablab under sowing maize positive effect on forage production increments. The dry matter yield of maize was statistically significant ($P<0.01$) differences as the intercropping dates as shown in (Table 4). This significant difference in results was confirmed by Hassan *et al*. (2017) who reported that intercropping significantly increases dry forage yields. In addition, Basaran *et al*. (2017) who showed that intercropping Sudan grass hybrid (Aneto) and cowpea (Ulkem) had the highest dry matter yield in intercropping than Sudan grass hybrid (Aneto) sown alone. This could be due to legumes can fix atmospheric nitrogen and provide nutrients for intercropping grass as noted by Mergia Abera *et al*. (2022) researched herbage accumulation and nutritive value of mixtures of desho grass (Pennisetum glaucifolium) and vetch (*Vicia spp*) in southern Ethiopia. This result was in line with a significant increase in biomass yield of corn and cowpea intercropping treatments suggesting beneficial relationship between legume and corn having less competition for the growth factors (nutrient, moisture, light, etc.) as pointed out by Rana *et al*. (2012).

This recent result was supported by authors of Mekonnen *et al*. (2018) investigated on demonstration and evaluation of maize and dolichos lablab varieties mixtured experiment conducted at different districts of east Wollega and west showa zones and promising herbage dry matter yield (9.32 t/ha). The current mean values result of intercropping of maize dry matter yield (8.12t/ha) were in line with the finding of Hassan *et al.* (2013) who outlined that dry matter yield (8.01 t/ha) from maize in combination with lablab forages.

Inconsistent this result on dry matter yield was due to the reason might be related to genetic potential, environmental effect, during experimental management variation and legume forages biological nitrogen fixation. The results of this study were contrary to those reported by Daniel Wana *et al*. (2022) found a non-significant ($P>0.05$) in dry matter yield of intercropping maize varieties of BH-540 with legume forage lablab. Similarly, contradicted the present study, Yihalem and Habtemariam (2012) noted that dry matter forage yield differences among sudan grass (sorghum sudanese) mixture with legumes were non-significantly affected in rainfed conditions. The difference of current and former reports might be due to the genetic and environmental variation, rainfall distribution, soil type for both recent and previous studies.

4.3.2 Dry matter yield of lablab forage

The dry matter yield of lablab was statistically ($P<0.05$) influenced by mixture dates presented in (Table 4). Significantly higher dry matter yield (5.31t/ha) was found from lablab sown a pure stand as compared to others intercropped lablab as seen in (Table 4). While the lowest dry matters yield (2.39t/ha) was found from simultaneously lablab forage intercropping with maize. These significant variations were due to this result might be related to the fact that plants in sole cropping system are more advantageous than when they are intercropped since they have a better opportunity to capture environmental resources like water, light, and nutrients and also no inter-specific competition under sole cropping system (Gebru, 2015). The mean value of DMY (3.8 ± 0.22t/ha) in the present result was higher than the DMY (0.29 ± 0.10t/ha) obtained by Yihalem Denekew and Habtemariam Asefa (2012) of Vetch (*Vicia dasycarpa*) intercropped with maize in Northwest Ethiopia. This might be due to the competition of lablabs on light, temperature, and other nutrient resources. The recent dry matter yield (5.31t/ha) obtained from sole sowing treatment was akin to the result of Muluneh Minta and Angaw Tsige (2014) who showed that (5.45t/ha) dry matter yield was found from uninoculated vetch (Vicia dasycarpa). Similarly, the recent studies revealed that scholar of Rahel Kahsay *et al*. (2021) investigated that 4.08t/ha on dry matter yield from sorghum varieties (Teshale) intercropping with lablab was a line with the current funding (4.61t/ha) on lablab (LM20) and among the legume lablab is strong lovely climbing nature for physical supporting to increases vine length and others of agronomic attributes improvement. This result is comparable to the result of Mergia Abera *et al*. (2022) who stated that the dry matter yield of lablab in the pure stand was greater than the intercropped lablab forage species.

The present study is also in agreement with the finding of Unathi *et al*. (2018) who revealed that the higher dry matter yield production of legumes sown alone relative to its intercropped. This might be due to the fewer disturbances' habitat in the intercropped environment and the times of mixtures of both forages. Moreover, these differences might come from genetics, the species itself, and the amount of rainfall and management effects.

4.3.3 Total dry matter yield

The total dry matter yield of the recent study was significantly ($P<0.001$) affected by intercropping dates (Table 4). The mean dry matter yield (8.65±0.62t/ha) was obtained from intercropped and both alone sown forages. The highest dry matter yield (14.83t/ha) was found in maize with lablab planted at the twenty days after maize planting (LM20). This might be attributed to the highest values of measured morphological attributes and more responsible intercropping treatments increased TDMY comparable to others sole and mixture treatments. Followed by this, the lowest total dry matter yield (6.18t/ha) was obtained from maize sown a pure stand and it is higher than the dry matter yield of (5.31t/ha) obtained from sown alone lablab. The results of this difference due to intercropping of legume forages more increments of others morphological parameters recorded had causes of higher dry matter yield than the rest of the sown sole within a piece of land preparation for both critical problems of animal feed with related to the current aggravated forage land decline directly related to rapid increases crop cultivation area expansion from time to times with in various recent issues. The dry matter yield under mixture treatment was higher than the total dry matter yield obtained from maize and lablab sown as a pure stand. Whereas, the present results were akin to the previous study of Mergia Abera (2014) who stated that the total dry matter yield of intercropping of maize with lablab forage species had the highest dry matter yield than the maize and legume forages (lablab, cowpea, vetch) sown alone.

Similarly, the total dry matter yield (14.83t/ha) found in the existing results was confirmed by the finding of Meseret Tilahun et al. (2019) who showed that (14.39t/ha) total dry matter yield was obtained from maize (*Zea mays*) with vetch Vicia (*dasycarpa*) intercropping components. The highest TDMY (14.83 t/ha) was recorded from the intercropping practices as compared to sole maize stover. This was mainly due to the additional forage dry matter yield (4.61t/ha) obtained from the biomass of lablab which was produced by intercropping system more complementary benefits than sown alone.

The recent study of total dry matter yield was also lower than the value obtained by Alemu Tessema (2022) who reported the mean values of total dry matter yield (27.3t/ha) obtained from 2019 in main cropping seasons under maize and lablab mixture lablab planted under maize after twenty dates. The differences observed between various research findings could be attributed to the differences in soil-related factors, variability in amount and distribution rainfall, probably the physiological stage of the plant at harvest, forage genetic and management variation, might be provided to the agro-ecological difference in which the studies were carried the current results differ from others previse comparable the other studies. Meanwhile, the recent results were a line with the previous study of Mergia Abera *et al*. (2022) who stated that the total dry matter yield of intercropping of Desho grass (*Pennisetum pedicellatum*) with vetch species had the highest DMY than the Desho (*Pennisetum pedicellatum*) and vetch species sown alone. This could be due to grass-legume intercropping having the merit of the efficiency of water and nutrient used (Sani *et al*., 2011; Lima *et al*., 2017) and also due to lower evapotranspiration and also might be the reason intercropping legumes had the advantage to fix N^2 (Unathi *et al*., 2018).

In addition to this, the highest dry matter yields in the intercropped were observed in the recent study due to the beneficial effects of intercropping on nutrient uptake for both forages grown as confirmed by the authors sharma & chander (2006) who conducted research on Sudan grass (*Sorghum sudanense*) with cowpea (*Vigna unguiculata*) intercropping. In comparison with the present study, Reza *et al.* (2013) observed a higher dry weight of sorghum when grown with lima bean (*Phaseolus lunatus*) in additive series at different planting proportions of legume. The significant increase in biomass of corn under corn with cowpea intercropping treatments suggested that a beneficial relationship between legume with corn and less competition for the growth factors (nutrient, moisture, and light, etc.) as revealed by Rana *et al*. (2012). The mean value (8.65±0.62t/ha) of total DMY obtained in the present study was similar to the finding of Ginwal, D *et al*. (2021) who investigated that (8.95 t/ha) of mean DMY found from the sorghum and cowpea intercropped components in 2:1 seed ration respectively.

The recent total dry matter yield (14.83/ha) obtained from lablab planted maize sowing after twenty days of intercropping treatment was higher than the result of Redae and Tekle (2020) who showed that total fodder yield on DM basis (6.62tha-1) found from lablab (lablab purpureus) sown at twenty days after emergence of maize. These differences might come from genetics, the forages production potential species itself, soil type and management system study were conducted for both studies

Table 4.3: Dry matter yields of maize and lablab on their alone and inter-cropping forages.

	Measured Parameters		
Treatment	Maize DMY(t/ha)	Lablab DMY(t/ha)	Total DMY(t/ha)
T1 (SOM)	6.18^{c}	-	6.18^{d}
T2	7.29^{bc}	2.39^{c}	9.68^{c}
T3	10.22^{a}	4.61^{a}	14.83^{a}
T4	8.78^{ab}	3.27^{bc}	12.05^{b}
T5 (SOL)	-	5.31^{b}	5.31^{e}
Overall mean	8.12	3.81	8.65
SEM (±)	0.45	0.22	0.62
CV%	9.53	14.33	10.06
P-value	<0.01	<0.05	<0.001

Whereas, *T1=Treatment one, T2=Treatment two, T3=Treatment three, T4=Treatment four, T5=Treatment five, DMYt/ha = Dry Matter Yield in ton per hectare, SOM = sole maize, SOL= sole lablab, SEM = Standard Error of Mean, CV% = Coefficient of Variation percent, R2 = Coefficient of determination, a, b, c, d & e = level of mean difference, LSD = Least Significant Difference, NS = non-Significant level, * (p<0.05), ** (p<0.01), *** (p<0.001).*

4.4 Effect of Sowing Date Maize and Lablab on Nutritional values

4.4.1 Nutritional values of maize stover

4.4.1.1 Dry matter (DM%)

The dry matter content of maize in the present study was significantly ($P<0.01$) affected by sowing dates revealed in (Table 5). Statistically significant DM (91.08±0.55) mean value was obtained from the recent study. The highest DM (93.67%) was found from lablab and maize intercropping maize planted after twenty days. followed by, DM (91.0%) of lablab and maize intercropping forty days after maize planting in the present study. Meanwhile, the lowest value of DM (89.0%) was found in maize sown alone. This might be the reason of mixturing dates affected the DM% contents of maize stover. The dry matter content of maize was increased when optimum lablab and maize sowing dates with related to the problem of early and delayed planting times of lablab forages and also the reason might be due to their optimum intercropping time may be decreased/fewer inter-species competition and leads to increasing DM contents of the maize DM%. Similar results of mean dry matter (91.08±0.55%) in the present study compared to 90.29% of the mean dry matter of different grass species (desho, Phalaris, oats) intercropping with vetch forage were obtained by scholars of Aychew Zewudu *et al.* (2021) in main rainfed seasons.

The current result was in line with the authors Uher *et al*. (2019) noted that planting of maize and cowpea (*Vigna unguiculata* L.) had significant differences in grown forage qualities. Intercropping dates of maize and lablab in the present study had a significant difference in DM content and it is in line with the finding of Azraf *et al*. (2007) who stated that sorghum (*Sorghum bicolor* L.) intercropped with cowpea (*Vigna unguiculata* L.) had higher forage qualities than Sorghum (*Sorghum bicolor* L.) sown as a pure stand. Followed by the highest values in the recent studies of DM% on maize and lablab mixtured maize planted after twenty days 93.67% was obtained akin to the other authors Wubshet Tesfaye *et al*. (2019) who revealed that intercropping of sorghum (melkam) varieties and cowpea (9333) forage specie dry matter (93.58%) while the present results was lower than the finding of Abebaw Biresaw *et al*., (2021) who found that dry matter content of para grass had significantly affected in different harvesting ages and intercropping with alfalfa (*Medicago sativa*) was recorded DM% (94.85%).

But, in disagreement with the finding of Mergia Abera (2014), the dry matter contents of maize were not significantly different (P>0.05) among the legume species (lablab, vetch, and cowpea intercropping with maize. The inconsistency this study might related to genetic variation, intercropping situations, environmental conditions (like altitude, rainfall, temperature, and soil fertility), management practices and harvesting season differences where current and previous experiments was conducted.

4.5.1.2 Ash contents

The ash content of maize in the present results was highly statistically significant (P<0.001) on sowing dates with lablab presented in (Table 5). The lowest value of total ash (8.0%) content was found from lablab with maize mixture maize planted after twenty days while the highest ash (12.0%) content was recorded from maize sown a pure stand with the mean (9.83±0.29%) values of maize in the recent studies. in the sowing dates was factored for increasing or decreasing the ash content of maize. These lowest values of ash contents on intercropped treatments because maize in the intercropping had better crude protein content and better leaf-to-stem ratios. It might be due to maize in the intercropping having less fiber fraction than its pure stand of maize sowing. According to Linn & Martin (1999), the majority of forage has an ash level that ranges from three to twelve (3-12) obtained similar to the percent results. Whereas, the recent results of ash content ranges (8.0-12.02%) were lower than the finding of Mahmood *et al*. (2013) who noted that ash contents of sorghum ranged from (6.1-9.7%) obtained in their trial of nutritional quality of forages. This result was supported by the found by Rahel Kahsay *et al*. (2021) who investigated (12.1%) ash content of three sorghum varieties (Teshale, Misikir, Girana-1) from intercropped with animal feed lablab. Fewer ash contents of mean values (9.83%) were found in the present study comparable to the mean of ash (10.02%) value obtained by Alemu Tarekegn *et al*. (2020) in two seasons with the same sudan grass (Aden gode) cultivars. This might be due to intercropping legumes helping to decrease cell wall accumulations of maize stover in the present study.

In agreement with the finding of Mergia Abera *et al*. (2022) who showed that when compared to intercropped desho (*Pennisetum pedicellatum*) with *Vicia* species, the pure stand of desho grass (*Pennisetum pedicellatum*) produced a greater ash content. Besides, the present study was in harmony with the finding of Malede Birhan (2018) who noted that the ash content of Triticale (*Xtriticosecale wittmack*) had significantly affected by intercropping with vetch (*Vicia villosa*). The discrepancy in finding might arise from plating systems, environmental conditions, agroecological effects, and management practices where recent and previous studies were evaluted. Followed by, this result is in line with the finding of Malede Birhan (2018) on ash contents of sudan grass (*Aden gode*) were lower in intercropped than its pure stand. On the other hand, the results of ash (12%) in lablab and maize intercropping dates were greater than the results found by Hassan *et al*. (2013) who outlined (8.2%) ash was obtained from the chemical composition of lablab in combination with maize. Whereas, the higher ash content of maize in sole indicated that higher concentration of minerals. This study was in agreement with the finding of Aychew Zewdu (2021) who reported that the highest ash contents were recorded for both sole desho (*Pennisetum pedicellatum*) and Phalaris (*Phalaris aquatica* (*acc6583*)) than mixtured. This greater result might be due to the genetic effect of intercropping of maize and lablab under environmental variation, and also during experimental management variation.

4.5.1.3 Organic Matter

The organic matter content of maize in the recent study was significantly ($P<0.05$) affected by sowing dates similar to ash content due to organic matter obtained through the difference ash content from 100 percent. When treatments applied in the present study had lower value of ash contents, they would have a higher value of organic matter. Hence, higher organic matter (92.02%) was found from lablab and maize intercropping maize planted after twenty dates followed by planting dates of maize and lablab maize planted after forty days with mean value of organic matter (90.33%) presented in (Table 5). Meanwhile, the lowest values of organic matter in the recent study results were obtained (88.0%) from sowing as alone maize as compared to the other intercropped components. A significant difference was obtained in organic matter of maize in the present study similar to Jiao *et al*. (2022) who showed that Sudan grass (*Sorghum sudanense* (*Piper*) Stapf.) organic matter content was significantly affected by mixture application. Similarly, the recent study by Abebaw Biresaw *et al*. (2021)

noted that the organic matter of para grass and alfalfa had significant difference on their sole and intercropped.

In addition, to the same in the current results by Aychew Zewdu (2021) who showed that organic matter of desho (Pennisetum pedicellatum), phalaris (*Phalaris aquatica* (acc6583)) and oat (*Avena sativa*) had a significant difference by their sole and intercropped forages. Besides this, Aysheshim Bantihun *et al*. (2022) showed that organic matter (81.3%-86.5%) contents of grass species such as Desho (*Pennisetum pedicellatum*), Brachiaria (*Brachiaria mutica*), and Napier grasses (*Pennisetum purpureum*) were significantly affected by the harvesting stage and lower than the organic matter in the present studies results. Whereas, the recent results were lower than the founding Tenaw Temesgen (2021) who revealed that on Sudan grass (sorghum sudanese) intercropping with vetch had a significant effect on organic matter contents (94.21%) under different seed rate. Followed by, these results were supported by other authors Mergia Abera (2014) noted those who investigated from intercropping within different legume forages (lablab, vetch, and cowpea) on organic matter higher in intercropping as comparable to alone maize treatment. The inconsistent result could partly be attributed to genetic potential effects and soil healthiness, variety, altitude, intercropped times, plant developmental stage, and overall field related to agro-ecological and environmental interaction effects.

4.5.1.4 Crude protein and Crude protein yield

Crude protein is the most important nutritional values parameter in forage production. The crude protein content of maize is lower than the crude protein content of legumes. Therefore, intercropping maize with legumes is crucial increase the crude protein content of maize stover quality improvements. The current study, increasing CP was observed in intercropping maize. Highly significant ($P<0.001$) differences on maize crude protein were observed in the current results. A significantly highest CP (8.67%) was found from lablab and maize intercropping maize planted after twenty days followed by for both forages intercropping lablab mixtured maize planted after forty dates which has 7.0% CP content as compared to CP (5%) obtained from maize grown alone as shown (Table 5). This might be due to intercropping of maize with legumes having the ability to increase the CP contents of intercropped maize. might be a good morphological performance of maize which leads to an increase in crude protein contents in the recent finding. Crude protein content of most cereal crop residues is lower than 7% which is the critical level of microbial protein synthesis of feed intake (Adugna Tolera, 1999). However, due to lablab-intercropping with maize, the crude protein content of maize stover was above the threshold level. This indicates that maize under-sown with legumes to improve the crude protein quality of stover than pure stand (sole) maize sown. The present study was in agreement with the study of Uher *et al*. (2019) crude protein of maize intercropped significantly higher than its sown sole. This could be due to the higher availability of nitrogen in the intercropping treatment. Current results were also comparable with the finding of Guleria & Kumar (2016) who noted that intercropped maize (*Zea mays* L.) with cowpea (*Vigna unguiculata*) had higher crude protein than alone sown. Followed by, the current study was similar to the finding of Khan *et al*. (2005) who stated that proportion in cereal-legume intercropping had significant effects on forage quality. Therefore, in agreement with the previous studies by Hassan *et al*. (2017); Javanmard *et al*. (2017); Salem *et al*. (2019) who noted that CP was higher in intercropping than forages sown as a pure stand.

Current results of CP (8.67%) in lablab and maize intercropping maize planted after twenty dates were lower than CP (10.90%) obtained by Basaran *et al*. (2017) who revealed that Sudan grass hybrid (Aneto) intercropping with soybean (Yesilsoy) from sowing alone grass. Whereas, the recent results of CP (8.67%) in lablab and maize intercropping maize planted after twenty dates were greater than CP (5.8-7.0%) obtained by Rahel Kahsay *et al.* (2021) who reported that in three different sorghum (Sorghum bicolor) (Misikir, Girana-1, and Teshale) varieties intercropped with lablab (lablab purpureus). This greater value of crude protein could be the high availability of nitrogen in intercropping and also due to less nutrient competition among inter-species due to optimum intercropping leads to more beneficial crude protein increment as compared to sole. Besides this, current results supported by crude protein were slightly lower than the finding of Asem *et al*. (2020) noted that CP (9.18%) of Sudan grass (Sorghum sudanense) had higher in intercropped with cowpea (Vigna unguiculata) compared to its alone. The recent results of increasing CP of maize in intercropping were in line with the previous study by Erkovan (2022) who reported that sudan grass (Sorghum sudanense (piper.) (16.73%) intercropping with common vetch (Vicia sativa L.) had significant differences in CP contents of sole sudan grass (14.66%). Similarly, the changes in the crud protein of forage were more pronounced in maize-legume intercrops than in pure maize stover. Inconsistent, the present study results lower CP (8.67%) from lablab and maize intercropping maize planted after twenty days compared to other scholars of Devendra *et al*. (2021) who revealed that intercropping sorghum and cowpea obtained (CP 16.61%) compared to sowing alone sorghum CP (8.90%). The differences this, result could partly be attributed to soil type, and fertility, variety, altitude, stage of maturity at harvest, intercropped season, plant developmental stage, and overall field-related managements in addition to ago-ecological and environmental interaction effects the basic causes of the current and previous experiments results were conducted inconsistence.

Crude protein yield was significantly ($P<0.01$) affected by intercropping dates of maize and lablab as presented in (Table 5). From these significant results, the highest CP yield (0.92t/ha) was found from lablab and maize intercropping maize planted after twenty days of treatment while the lowest value of CP yield was found from sowing alone (0.54t/ha) maize with a mean value of CP yield (0.71 ± 0.01t/ha). Relatively, crude protein yields were increased with the intercropping components as compared to pure stand treatment. The difference in crude protein yield observation was due to the legume intercropping effect. Whereas, the variations of crude protein yield in the present study might be due to the variations of crude protein contents and dry matter yield difference from intercropping components related to nitrogen application on legume forages. Similar to these results, Hassan *et al*. (2017) noted that crude protein yields were significantly affected by the intercropping pattern of Sudan grass (*Sorghum sudanense* ((P.) Staph) intercropped with (*Vigna sinensis* L.), guar (*Cyamopsis tetragonoloba* L.), and lima bean (*Phaseolus vulgaris* L.). In addition, authors of Mergia Abera *et al.* (2022) showed that significantly increased crude protein yield was observed in Desho (*Pennisetum pedicellatum*) intercropped with vetch species. In contrast, a higher protein yield (0.92t/ha) was found from lablab intercropped maize planting after twenty days as compared to the present CP yield (0.54t/ha) of sole as well as in intercropping of Sudan grass (Aneto) with cowpea (Ulkem) and soybean (Yemsoy) CPY ranges from 1.31-2.16t/ha (Basaran *et al*., 2017). Similar to the present study, the scholars Ghanbari *et al*. (2010); Basaran *et al*. (2017) stated that forage qualities and quantities were highly achieved in intercropping. This could be because crude protein yield per unit area is mostly dependent on dry matter production (Abuneram, 2013). These results demonstrate that to achieve high yield and quality for sowing time in intercropping is a crucial factor as noted by previous scholars

(Singh *et al*., 2008; Seran & Brintha, 2010; Alla *et al*., 2015). The current results of CP yield (0.92t/ha) in lablab and maize intercropped were lower than CP (0.97t/ha) obtained by Devendra *et al*. (2021) who revealed that cowpea and sorghum mixture on crud protein yield.

The variability in CP content between the tested treatment groups might be due to species differences and the symbiosis process; lablab associated with rhizobia symbiotically fix atmospheric N2 and increase available N2 in the soil and return they receive nitrogen assimilated by them, which they use to produce a high percentage of protein. Crude protein was highest in the early stage compared to (90) late stage (120) harvesting ages (Tiruset Tesfaye, 2019). This is a growth dilution effect with an increase in structural carbohydrate content of forage materials harvested at late maturity reducing the percentage of protein in the forage. Besides this, the current results of crude protein yield were higher than the finding of Mergia Abera (2014) corporated that CP yield (0.65t/ha, 0.64t/ha, 0.63t/ha) maize (Zea mays) in intercropped within different legume forages (lablab, vetch, and cowpea) had higher under intercropped more increases CP yield compared to its alone maize (0.60t/ha) respectively. These lower values might be attributed to intercropping legumes on maize to an the increasing the protein content of components as compared to sowing alone maize.

4.5.1.5 Neutral detergent fiber

Neutral detergent fiber (NDF) content is one of the most important factors determining forage nutritional value. When the neutral detergent fiber (NDF) component of forages is high, intake is affected (Lopes *et al*., 2020). The decreasing neutral detergent fiber (NDF) ratio indicates forages had higher quality (Kir & Dursun, 2018). Although, NDF does not assess how digestible the fiber in forages is and it is a useful predictor of "bulk" and hence animal feed consumption quantified techniques (Oh *et al*., 2016). Neutral detergent fiber percentage concerning intercropping dates with lablab (lablab purpureus) was highly significantly ($P<0.001$) affected in the current study as presented in (Table 5). Maize NDF% content results decreased on mixture with lablab compared to its pure stand of maize treatment. The lower value of NDF (51%) was recorded from lablab and maize intercropping maize planted after twenty days followed by both forages intercropped maize planted after forty days which had 52% of NDF relative to its pure stand (68%) revealed in (Table 5). It could be due to the better morphological development of maize due to its legume intercropping effect. This result was akin to the finding of Serap *et al*. (2017) who outlined that the mixing of sorghum (Sorghum bicolor) with soybean NDF (51.6%) had a significantly improved forage quality concerning sorghum grown as a pure stand NDF (55.9%). This finding is also in line with the finding of Asem *et al*. (2020) who noted that intercropping of Sudan grass (*Sorghum sudanense*) with cowpea (*Vigna unguiculata*) significantly enhanced forage quality through decreasing CF% of Sudan grass compared to its sown alone. Besides this, the present NDF% results were in line with Erkovan (2022) who stated that the NDF% content of Sudan grass (*Sorghum sudanense* (piper.) stapf.) was altered by seeding row arrangement in the intercropping with forage legumes were more beneficial on the base mixture reduction of fiber contents. Similar results of NDF% contents of maize in the present study were found by Jares *et al*. (2019) who revealed that the NDF% of maize in sole sown was higher than the intercropped with cowpea (*Vigna unguiculata* L.).

The current results of the NDF% content of maize ranged from (51%-68%) which was lower than the finding of Lopes *et al.* (2020) who outlined that (73.82 to 78.19%) NDF contents of forage sorghum observed. Intercropping of maize with lablab significantly increased forage qualities through decreasing NDF% contents and increasing the digestibility with respect comparable to sowing its alone treatment. This result was akin to the finding of Awad & Ahmed (2012) who outlined that mixing Sudan grass (Sorghum sudanense) with cowpea (Vigna unguiculata L. Walp) significantly improved forage qualities for maize grown as a pure stand. Osman *et al*. (2010) also noted that row seeding configuration is thought to reduce NDF% of forages in intercropping. This reduction of NDF% in the intercropping might be due to the optimum intercropping being thought to be reduced nutrient competition and heat stress in the intercropped than sole sown forages. In comparison to the current results of NDF%, the authors Erkovan (2022) showed that intercropping of common vetch (*Vicia sativa* L.) with Sudan grass (*Sorghum sudanense* (piper.) stapf.) had a significant effect on NDF% and could decrease NDF% content compared to its pure stand. Therefore, legume forage intercropping could decrease NDF% compared to maize sown alone and this was in line with the finding of Erkovan (2022) who stated that in the intercropping had lower NDF% compared to sole sown forages. This might be due to fewer competition conditions and affect NDF% due to nutrient availability and decreasing cellulosic content. The present study was in contrast with Aklilu Mekasha *et al.* (2020) who corporated that increasing seed rate affected decreasing the NDF% content of forage sorghum varieties studied on their nutritive values in Ethiopia. Therefore, NDF% value in lablab and maize intercropping maize planted after twenty days of treatment had better nutritional value than others due to low NDF%. In general, the results in the present study were in agreement with the findings of Song *et al*. (2017), who reported an increase of maize nutritive value with a decrease in NDF and ADF when intercropped with legumes. This might be due to less stover stem thickness and also it might be due to better agronomy development in this treatment as compared to alone.

4.5.1.6 Acid detergent fiber

Acid Detergent Fiber was not significantly (P>0.05) affected by intercropping dates of maize and lablab in the current results as presented in (Table 5). The overall mean value of ADF (40.67±1.2%) however, there was not significantly affected by intercropping dates on lablab and maize. The current results were compared with Erkovan (2022) who revealed that the ADF% contents of Sudan grass (*Sorghum sudanense* (piper.) stapf.) were not significantly different among maize mixtured with common vetch (*Vicia sativa* L.) under rainfed condition. Similarly, the recent results on ADF values had insignificant akin to the finding by Wubshet Tesfaye (2019) who investigated that sorghum and cowpea intercropping had not a significant difference (P>0.05) in acid detergent fiber.

4.5.1.7 Acid detergent lignin

Acid detergent lignin contents of forages are one of the indicators of forage nutritional value. Hence, acid detergent lignin lowers the consumption and digestion of stover, hay, or feed while lowering the quality of those products. Therefore, acid detergent lignin contents of maize in the present study were significantly (P<0.001) affected by lablab intercropping with maize and followed by lablab with maize intercropping maize planted after forty and both forages simultaneously intercropping (ML40, ML0) (10.33%), (12%) of ADL contents respectively and fewer values of ADL recorded from lablab and maize intercropping maize planted after twenty (ML20) (8.67%) intercropping treatment with the mean value of ADL (11.25±0.32%). Less ADL value from both forage mixture maize planted after twenty (8.67%) intercropping means of maize in this intercropping has better nutritional value due to less structural carbohydrate and also due to higher leaf steam ratio. The variation in ADL% might be due to optimum mixture legume could be a factor in increasing and decreasing the lignin content. Whereas, it could be the availability of nitrogen in intercropping due to lablab can fix atmospheric nitrogen through their nodules and reduce fiber synthesis similarly to boost up forage quality improvement by under-sowing on legume maize stover. Therefore, forages with lower acid detergent lignin concentrations are more desirable for livestock production and productivity (Ansah *et al*., 2010).

Ruminants can digest the cellulose and hemicellulose components of fiber but lignin inhibits the rate and extent of digestion especially when the proportion of lignin in fiber contents begins to more and more increases lignin precursors also have anti-microbial properties (Chaves *et al*., 2012). In corroborated with the present study, Malede Birhan (2018) showed that intercropping seed proportion had a significant difference in ADL% of triticale mixture with vetch in Ethiopia. Meanwhile, 9.70% of acid detergent lignin in different seed proportion triticale (*Xtriticosecale wittmack*) with vetch (*Vicia villosa* R.) intercropping were lower than with the present study of maize (Zea mays) ADL (8.67-12%) content. The higher ADL (12%) was obtained from sole maize (Zea mays) and is comparable with the finding of Tenaw Temesgen (2021) who noted that a higher value of ADL (14.05%) was found from sowing alone sudan grass (*sorghum Sudanese*) in Ethiopia. This is also in line with the finding of Rahel Kahsay *et al*. (2020) who noted that intercropping in three sorghum (*Sorghum bicolor*) varieties (Misikir, Teshale, and Girana-1 with lablab significantly enhanced forage quality through decreasing CF% of maize compared to its sown alone. In contrast to the recent results, the smallest ADL (4.7%) alone in sorghum was obtained by the authors Devendra *et al*. (2021) from sorghum and cowpea mixtures at different seeding ratios. Another study conducted by Aychew Zewudu (2021) noted that the ADL (2.75-3.50%) of vetch (Vicia villosa) intercropping in different grass species (desho, Phalaris, and Oates) was less than the current study of ADL% of sown alone maize. This less ADL% was due to the component maize difference variety, genetic variation, and environmental. Whereas, lignin is the prime factor influencing the digestibility of plant cell wall material as it limits cell wall (fiber) digestion by providing a physical barrier to microbial attack, and the concentration both fiber and lignin increases as plants matured. Similarly, inconsistency of current and former reports might be due to the genetic potential of inter-cropped lablab/ differences cereal crops with legume forages species, rainfall distribution, soil type, variation in variety/accession, cropping system and establishment season differences.

4.5.1.8 Metabolizable Energy (ME) (MJ/kg)

In this regard, both sole and inter-cropped maize forage had a significant ($P<0.05$) effect on ME (Table 5). The maximum metabolized energy was recorded from lablab and maize intercropping maize planted after twenty (9.33MJ/kg). Whereas the minimum one was recorded from sole maize (6.37MJ/kg) (Table 5). The ME of all evaluated forage species both sole and inter-cropped contained higher ME values and greater than the lower critical threshold of 7.5 MJ/kg DM (Owen, E. and M.C.N. Jayasuriya, 1989) without considering recent sole maize sowing on metabolized energy values of treatment. The ME of all tested forage types in the current finding was akin to the result made by Aychew Zewudu (2021) who revealed that vetches and different grass species inter-cropped on metabolized energy (8.21-9.59MJ/kg). However, lower than the findings of Diriba Geleti *et al* (2013) from the highest ME of nutritive value of selected browse and herbaceous forage cereal-legumes mixtures. The variations might be pods vs. all forage plant parts, grass vs. legumes, inter-cropping effect, soil type, and overall environmental and managemental conditions.

It has been reported that a mixture of oat-vetch fodder has 9.5 MJ/kg of DM basis of metabolizable energy (ME) (Melkamu Bezabih *et al*., 2016) and this result was in line with the current result in ME of lablab and maize inter-cropped. Followed by, the ME content recorded in the present study in the case of both sole and inter-cropped maize was lower than from compared to that of the findings reported by Abuye Tulu *et al* (2020) from all tested oat genotypes at both location studies. Regarding both sole and intercropping maize with lablab in the recent studies of ME this finding was higher than the result of *Kabirizi et al*. (2005) who reported that the values on metabolize energy (8.7MJ/kg). The differences between the recent and previous reports might be coming from environmental conditions, management systems, and type of genetic differences where the current study was conducted.

4.5.1.9 In vitro organic matter digestibility (IVOMD%)

The interaction between sole and inter-cropping forage lablab and maize had highly significant effect on IVOMD (Table 5). The highest IVOMD was recorded from lablab with maize intercropping maize planted after twenty dates (58.67%) followed by lablab and maize mixture maize planted after forty dates and for both forages intercropping under the same plating dates (52.67, 56.01%) on IVOMD values of treatments respectively. Whereas, the lowest IVOMD was counted from sole maize (50.33%). Forage quality and leaf-to-stem ratio may be increased due to the increments of leaves when IVOMD becomes more and more beneficial inter-cropping maize as compared to sowing alone forages with an overall mean of sole and inter-cropped testing forages on IVOMD 54.42% presented in (Table 5). The IVOMD of all tested forage species was higher than the result made by Beyadglign Hunegnaw (2019) in the case of Brachiaria grass in west Gojam zone Ethiopia. The variation might be species/variety differences, harvesting stage in addition to environmental and genetic factors, and the potentiality of forages adapted to the study area.

The individual and overall mean of IVOMD of all tested forages were higher than the critical threshold level of 50% required for feeds to be considered as having acceptable digestibility (Owen, E. and M.C.N. Jayasuriya, 1989). The higher digestibility could be partially attributed to the higher CP content of the feeds/forages. This would be true, especially for those forages which have a relatively higher amount of CP content which in turn is known to favor high digestibility by animals. But the lowest digestibility records might be associated with a higher proportion of NDF, ADF, and lignin (Moore and Jung, 2001). More specifically, the IVOMD of both sole and inter-cropped maize in this result had a line with the result made by Abuye Tulu *et al* (2020) of all tested oat genotypes at the Bako location.

The differences between the current and previous results might be coming from environmental conditions, the species itself, altitude, the season of sowing time, soil type and cropping system (intercropped types), management system, as well as interaction effects on both between environment and genetics where both studies were determined. Whereas, the current study was in contrast to the finding of Mergia Abera (2014) who noted that intercropped of maize forages with legumes (cowpea vetch and lablab) in varying row ratios has no significant difference P>0.05) in the IVOMD. The present result is akin to the finding of Asem *et al*. (2020) who stated that IVODM were affected by intercropping patterns of Sudan grass (*Sorghum Sudanese*) and cowpea (*Vigna unguiculata*).

On the other hand, the result of Wubshet Tesfaye's (2020) IVODM was a non-significantly difference (P> 0.050) from sorghum (*Sorghum bicolor*) intercropping with cowpea (*Vigna unguiculata)* inconsistencies the recent finding of IVODM. In addition, in vitro organic matter digestibility obtained by the author of Aychew Zewudu (2021) ranged from 50.10%-65.94% of IVODM in sole and intercropping grass species and these results were greater than that obtained in the current study ranged from 50.33% -58.67%. This greater value is may be due to genetic and environmental effects.

Table 4.5: Nutritional values of the sole and inter-cropping maize stover

	Nutritional values Parameters (on DM $_{(\%)}$ basis)									
Treatments	DM $_{(\%)}$	Ash $_{(\%)}$	OM $_{(\%)}$	CP $_{(\%)}$	CPY$_{(t/ha)}$	NDF $_{(\%)}$	ADF $_{(\%)}$	ADL $_{(\%)}$	ME$_{(MJ/kg)}$	IVOMD $_{(\%)}$
T1 (SOM)	89.60^{c}	12.0^{a}	88.0^{c}	5.0^{d}	0.54^{d}	68.0^{a}	43.67^{a}	14.0^{a}	6.37^{c}	50.33^{d}
T2	90.67^{bc}	10.37^{b}	89.63^{bc}	6.0^{c}	0.62^{c}	56.3^{b}	40.67^{a}	12.0^{b}	7.51^{bc}	52.67^{c}
T3	93.67^{a}	8.0^{c}	92.02^{a}	8.67^{a}	0.92^{a}	51.0^{c}	38.0^{a}	8.67^{d}	9.33^{a}	58.67^{a}
T4	91.40^{b}	8.11^{d}	91.89^{ab}	7.0^{b}	0.76^{b}	52.0^{bc}	40.33^{a}	10.33^{c}	$8.0a^{b}$	56.01^{b}
T5 (SOL)	-	-	-	-	-	-	-	-	-	-
Overall mean	91.08	9.83	90.33	6.67	0.71	56.83	40.67	11.25	7.75	54.42
SEM (±)	0.55	0.29	0.75	0.17	0.01	1.38	1.20	0.32	0.44	0.43
CV%	0.97	5.08	1.43	4.33	2.71	4.22	5.10	4.91	9.86	1.37
P-value	<0.01	<0.001	<0.05	<0.001	<0.01	<0.001	>0.05	<0.001	<0.05	<0.01

Whereas, *T1=Treatment one, T2 =Treatment two, T3=Treatment three, T4=Treatment four, T5=Treatment five, DM = Dry matter , OM = Organic matter, CP= Crude protein, CPY = Crude protein yield, NDF = Neutral Detergent Fiber, ADF = Acid Detergent Fiber, ADL = Acid Detergent Lignin, ME = metabolized energy, IVDMD= In vitro organic matter digestibility, SOM= sole maize, SOL= sole lablab, SEM = Standard Error of Mean, CV% = Coefficient of Variation in percentages, N = Number, cm = centimeter, %= percentages, ML/kg = mega joule per kilogram, t/ha = tone per hectar, a, b & c = level of mean difference, NS=Non-Significantlevel,*(p<0.05),**(p<0.01),***(p<0.001).*

4.4.2 Nutritional values of lablab forage

4.5.2.1 Dry Matter (DM%)

The dry matter content of lablab was highly significantly ($P<0.01$) affected by intercropping dates (Table 6). The highest DM (93.12%) content was found in lablab with maize intercropping maize planted after twenty days while the lowest dry matter (88.67%) was recorded from 100% lablab forages sown as a pure stand. In the current study, differences in DM contents among the treatment evaluated might be due to their attributed to intercropping dates also this higher DM yield was a significant variation coming from among the intercropped treatment than sole lablab the causes might be related to the best performance shown in agronomic characteristics. DM percentage of intercropped lablab in this result was greater than Kassahun Desalegn & Wasihun Hassen (2015) found with the DM percentages of *Vicia dasycarpa*, *Vicia villosa*, *Vicia atropurpurea*, *and Vicia sativa* being 92.1, 90.4, 91.05 and 90.7% respectively and lower value of dry matter was obtained from alone lablab forage in the current studies. Similarly, the recent finding was lower than the other author Mergia Abera (2014) who noted that lablab, Vetch, and cowpea with maize intercropped were obtained DM 94.4, 94.8, and 94.3% legume respectively.

Inconsistent, non-significant DM results were obtained by Mergia Abera *et al*. (2022) who revealed vetch intercropping with Desho grass (*Pennisetum pedicellatum*) in Ethiopia. The present results of the dry matter content of lablab were higher than the study of Teshale Jabessa *et al.* (2020) who reported that 89.2% dry matter contents were recorded in *Vicia dasycarpa* on performance evaluation of vetch forages. The current finding was similar to the dry matter content of *Vicia* species noted by Muluneh Minta and Angaw Tsige (2014) who investigated that 93.55, 92.85, 93.50, and 93.16 of *Vicia villosa*, *Vicia dasycarpa*, *Vicia sativa*, *and Vicia narbonensis* respectively. Variations between the current results and those from earlier studies might be related to variations in management, soil type, forage genetic variation, and environmental effect attributable to sowing dates on DM%.

4.5.2.2 Ash Content

Under DM% contents of lablab, ash content in the present study was slightly statistically significantly (P<0.05) affected by mixtured dates presented in (Table 6). Therefore, corroborated with the present results, the highest value of ash (10.67%) content was obtained from sole lablab and the lowest ash (6.06%) from lablab mixtured with maize planted after twenty days of treatment respectively with mean value of ash was 8.08% ±0.57 revealed. These variations in ash content of alone lablab and intercropped treatment due to sowing date and morphological development differences with agronomic performance concern were once effect on ash content. However, relatively similar Ash (8.1%, 12%, & 11.2%) content was recorded from *Vicia sativa*, *Vicia villosa,* and *Vicia dasycarpa (Kassahun Desalegn & Wasihun Hassen, 2015)*. Followed by, akin results of ash contents found in the present study ranged from (6.06-10.32%) with a mean (of 8.08±0.57%) to the results of Usman Semmana *et al*. (2019) who revealed that ash contents of vetch forages ranged from (6.45-9.18%) with a mean value of previse studies were 8.22%. Whereas, the current finding a line with the finding of Tenaw Temesgen (2022) who outline that the highest values of ash content recorded were sown alone vetch (10.12%) in different seed proportion intercropped vetch-sudan grass (sorghum sudanese) (9.46, 8.45, and 6.15%) as comparable to the current studies. In addition, the recent study results lower than author Mergia Abera (2014) sole and lablab-maize mixture of ash content were recorded from (11.05, 7.98%) respectively.

Inconsistent with these results, Eshetie Alemu *et al*. (2018) revealed that vetch (*Vicia dasycarpa*) intercropped with oat (*Avena sativa*) had no significant difference and the ash contents ranged from 10.23-11.90 in different harvest ages. This result disagreed with the result reported by Solomon and Kibrom, (2014), the Ash content of cowpea varieties had a mean of 14.2%. The results of ash content obtained by Eshetie Alemu *et al*. (2018) were greater than the ash content of lablab in the present studies. Besides this, the mean (8.08%) value of ash content in the present study was less than the value obtained by Malede Birhan (2018) who noted that the mean (11.21%) value of ash obtained in different harvesting stages of vetch (*Vicia villosa* R.) mixture with Triticale (*Xtriticosecale wittmack*) in Ethiopia. Unlike, lower ash content (6.06-10.32%) was obtained compared to the results of Demissie Negash *et al*. (2017) ranging from 12.41-12.94% in different seed proportion mixture of vetch (*Vicia villosa*) and oat (*Avena sativa*).

The differences between the current and previous results might be coming from interaction effects between environment and genetics where both studies were conducted.

4.5.2.3. Organic Matter

The organic matter content of lablab in this study was statistically significantly ($P<0.001$) affected by intercropping dates under treatment as presented in (Table 6). Hence, both forages mixture maize planted after twenty days of treatment had the highest value of OM (93.93%) followed by lablab under sown maize planted after forty dates (92.33%) and both forages mixtures under the same dates (91.67%) respectively. However, the lowest OM was recorded from mono- crop of lablab forage (89.67%) with the mean (91.90±0.52%) value of organic matter (Table 6). These variations may be due to in OM content of lablab in sole and intercropping days effect under morphological development differences best performed intercropped lablab forages strong shade loving for physical supported in the causes of increases OM as compared to sole lablab forages grown was observed in the field experiment. Similar to these results on organic matter (93.93%) were obtained from lablab and maize intercropping maize planted after twenty days of treatment with the finding of Tenaw Temesegen (2022) who noted that, 93.85% of organic matter of vetch (*Vicia dasycarpa*). Whereas, the present results of organic matter (89.67-93.93%) on mixture components were significant with relatively similar to the finding of Kassahun Desalegn & Wasihun Hassen (2015) who noted that organic matter ranged from 90.4-92.1% of different vetch species. Followed by, the recent study of sole lablab OM (89.67%) and lower values confirmed by Tenaw Temesegen (2022) who noted that from alone vetch of OM were obtained (89.88%). However, the higher values of organic matter (89.67-93.93%) with the mean value (91.90%) of lablab in the present study were obtained compared to the study results revealed by Usman Semmana *et al*. (2019) who outlined that organic matter of vetch forages ranged from (84.21-84.51%) with a mean value of (84.37%) study conducted on the performance evaluation of vetch species on the highland area of Ethiopia. Whereas, lower organic matter contents of Vetch forages ranging from 73.1-76.6% obtained by the authors Teshale Jabessa *et al.* (2020) compared to the recent finding of lablab ranged from 89.67-93.93% of DM bases. The variations obtained in the current results from previous studies were attributed to sowing dates, and also due to edaphic factors on the effect of inconsistent finding of were revealed.

4.5.2.4. Crude Protein and Crude Protein Yield

Crude protein content in livestock feeding is the most important to increase the animal products such as eggs, meat, milk, and milk products. Plant-source protein is cheap than animal-source protein and hence the development of forage is advisable to increase the protein content of forages for animals. The CP content was significantly affected by both sole and inter-cropping system differences ($P<0.01$) (Table 6). The higher crude protein (CP) content was recorded from lablab and maize intercropped maize planted after twenty dates (17.12%) followed by lablab with maize mixture maize planted after forty dates CP content (15.66%) and both forages intercropped under the same planted dates CP (14.33%) content respectively while significantly lower CP content was obtained from sole lablab (13.33%) with an overall mean value of (15.08±0.46%) presented in (Table 6) were obtained in the current studies finding. Therefore, the highest crude protein was found from intercropped treatments (14.33-17.12% and the lowest (13.33%) was from lablab sown as a pure stand. This intercropping has a significant effect on increasing the crude protein contents of forages. However, early and delayed intercropping dates of lablab under maize showed that decreasing the crude protein value as revealed in the current results.

All intercropped of lablab had CP contents that were higher than the typical diets' 10.6 % CP value but lower than the 32.6% CP value for feed with protein supplements. The outcome is greater than Van Soest (1982) suggested, young herbage had a CP content of up to 14% to 16%. The recent finding of crude protein shown in (Table 6) is significantly akin to the study of Kassahun Desalegn & Wasihun Hassen (2015) who outlined that the crud protein (CP) concentration of *Vicia dasycarpa* was the most promising one (18.9%) compared to 12%, 9.2%, and 9.1% of *Vicia atropurpurea, Vicia villosa, and Vicia sativa* were obtained respectively. While the authors Eshetie Alemu *et al*. (2018) revealed that higher crude protein ranged from (13.33-17.12%) in the present study obtained lower as compared to the crude protein ranged from (13.97-21.38%) in vetch (*Vicia dasycarpa*) mixtures with oat (*Avena sativa*) in Ethiopia. The increase in crude protein in the present study was due to the higher morphological parameters recorded and intercropping could enhance forages to soil nutrient uptake and water use efficiency.

Whereas, the high CP value found in the current study, intercropped forages are corroborated by Berhanu Alemu *et al*. (2007) who found that mixed forages containing up to 25–50% legume generated higher quality and yields of forage than exclusively planted forages. On the other hand, crude protein (17.12%) obtained from lablab mixture with maize planted after twenty dates in the present study was lower than the finding of Usman Semmana *et al*. (2019) who noted that crude proteins ranging from (22.01-22.18%) found from vetch (*Vicia dasycarpa*) accessions. Inconsistency to the present study, the finding of Dura *et al*. (2012) who were noted that crude protein in the intercropped legumes was lower than in the pure stand legumes. Therefore, the variations of the present study might be due to the reason sowing dates, agroecological variation, edaphic factors, and experimental management. In general, the current study results revealed that intercropped lablabs had higher CP content as compared to the alone treatment observed in the field experiment. These ideas supported by Wubshet Tesfaye (2021) who outlined that cowpea with sorghum intercropping under crude protein content recorded the highest values in intercropped cowpea treatments (25.38-29.19%) with the lowest CP value obtained from sole cowpea (24.38-25.44%).

Crude protein yield was significantly ($P<0.05$) affected by sowing dates of lablab with maize. Crude protein yield (CPY) is the result of the plant's total dry matter yield multiplied by the concentration of CP, which is supported by the numbers acquired from CP percent and the dry matter yield derived from each treatment (Geleti Driba, 2014). Sole lablab and lablab with maize intercropped maize planted after twenty and forty dates on CP yield of treatments were significantly different with having higher CP yield (1.62, 1.54, and 1.49t/ha) respectively whereas, the lowest CP yield (0.92t/ha) was recorded from both forages' mixture under the same dates with the overall mean value of 1.39±0.39t/ha. This CP yield difference is due to the intercropping dates having their value to increase CP yield as compared to early both forage mixture at the same time. The lowest and highest CP yield (0.92 &1.62t/ha) in the present results were similar to the lowest and highest CP yield (0.96 & 1.60t/ha) of vetch mixtures with barley at the third harvesting stage obtained by Malede Birhan (2013).

4.5.2.5 Neutral Detergent Fiber

The neutral detergent fiber in the present study was statistically significant ($P<0.01$) on the effect of sowing dates on lablab and maize as shown in (Table 6) below. Results presented in (Table 6), the lowest NDF% was 41.47%, 43.60%, 45.33%, and 48.0% obtained from ML20, ML40, ML0, sole, and lablab with maize intercropping treatments respectively with the overall mean (44.60%). Sowing dates had significant effect on NDF% in the present study finding. When decrease in NDF content has been associated with increase in crude protein content and better performance of leaf-to-stem ratios. These different results of NDF% observed between treatments might be due to variations in the effects of the intercropping date. Hence, the recent results of NDF content of lablab ranged from 41.47%-48.0% with mean value of 44.60±0.25%. This NDF value was below 45-55% of NDF which indicates that lablab (*lablab purpureus*) in the current studies was high quality in nutritional value (Singh & Oosting, 1992).

Similarly, NDF% results reduced on cowpea (*Vigna unguiculata* L. Walp) and lablab (*Lablab purpureus* (L.) Sweet) intercropped with Sudan grass hybrid (*Sorghum bicolor*) obtained by Song *et al*. (2021) while probably greater NDF (49.81%-50.38%) of *Vicia dasycarpa* had been reported by the Scholars Eshetie Alemu *et al*. (2018) comparable from NDF% on lablab (lablab purpureus) in present study were significant difference ($P<0.01$). The finding of Mergia Abera (2014) revealed that sole lablab had NDF (33.8%) content lower than in the present studies and similar investigated on NDF (47.89%) results were obtained under sole cowpea *(Vigna unguiculata* L) by Wubshet Tesfaye (2021).

On the other side, significant results of NDF% were found by Muluneh Minta & Angaw Tsige (2014) who noted that NDF% contents of vetch species ranged from 40.25%-50.17%, and similar results were observed in the recent study ranging from 41.47%-48.0% of NDF contents of lablab. The value of NDF (48.0%) obtained from an alone lablab was lower than the finding of Abdu *et al*., (2015) who found that 61.91% NDF from lablab forage evaluation. Inconsistency to the present study, the higher NDF (87.5%) content of vetch (*Vicia dasycarpa)* was found by the authors Teshale Jabessa *et al*., (2020). A decrease in neutral detergent fiber has been associated with the digestibility of the forage. Hence, a highly digestible lablab was found in the present study on the effect of intercropped.

This difference in NDF contents of lablabs in different intercropping days from the previous studies might be due to the legume forage lablab species difference, sowing dates agroecological variations, and also field experiment management differences on NDF.

4.5.2.6 Acid detergent fiber

Intercropping dates had significant ($P<0.01$) effect on acid detergent fiber (ADF) in the present study as revealed in (Table 6). The lowest ADF (24.13%) content was recorded from ML20 intercropping treatment. Meanwhile, the greater ADF (32.27%) content was found from alone lablab. These variations of ADF% contents of lablab in the present study were due to the plating date of variation under main crop of maize. Therefore, increasing in ADF% contents of lablab was observed with an optimum intercropping date. The recent ADF (24.13-32.27%) contents of lablab were less than the ADF contents found by Song *et al.,* (2021) noted that 38.66-46.30% of lablab intercropped with Sudan grass hybrid (*Sorghum bicolor*).

In addition to these scholars, the lowest ADF contents of *Vicia dasycarpa* were recorded compared by the authors Getu Kitaw *et al*. (2010) who reported that ADF (77.7%) was recorded from *Vicia dasycarpa* at Holleta agricultural research Center in Ethiopia. On the other hand, authors of Kassahun Desalegn & Wasihun Hassen (2015) found that higher ADF (35.1-37.3%) values of vetch species with the higher value of lablab purpureus ADF (24.13-32.27%) contents compared to the present study results. However, the lowest ADF (20.8%) content was found from alfalfa (*Medicago sativa*) intercrop with oat (*Avena sativa*) (Befekadu chemere & Yunus Abdu, 2015) compared to the current studies. Besides these scholars, Muluneh Minta & Angaw Tsige (2014) outlined that the ADF of vetch species had 36.47-41.80% but they found that higher ADF (41.80%) content of *Vicia dasycarpa* comparable to the recent results of lablab. inconsistent value of ADF% contents of lablab in the present study might be due to the reason both forage mixture dates variation in the intercropping system, better morphological development, and better crude protein content variation among the treatments. Whereas, the difference observed in ADF% from the previous study might be environmental, management, and species variation considering as factor of result differences.

4.5.2.7 Acid detergent lignin

Acid Detergent Lignin (ADL) in dry matter basis was not significantly ($P>0.05$) affected by intercropping dates of lablab with maize in the present study as presented in (Table 6). Even though, the ADL content of the lablab in the present study ranged from 5.60- 6.73% with an overall mean value of 6.12±0.30% of ADL. A similar result was found by Wubshet Tesfaye (2021) who noted that ADL content was not significantly affected in the mixtures of sorghum (sorghum bicolor) and cowpea (vigna unguiculata). In addition to this, authors of Demissie Negash *et al*. (2017) also showed that ADL contents of intercropped vetch (*Vicia villosa*) were insignificant that has sown with grass species oat.

4.5.2.8 In vitro dry matter digestibility

The IVOMD obtained in the current study varied between (58.23 and 65.67%) ($P< 0.001$). The highest digestibility was obtained from lablab (*lablab purpureus*) with maize (*Zea mays*) mixture maize planted after forty days (65.67%) followed by in both forages intercropping on maize germinated after twenty days and under the same mixture dates values of in vitro dry matter digestibility (64.33, 62.13%) treatments respectively while the minimum was obtained from sole lablab (58.23%) with overall mean of 62.58%±0.85 (Table 6). The individual and overall mean of IVOMD in both tested forages were higher than the critical threshold level of 50% required for feeds to be considered as having acceptable digestibility (Owen, E. and M.C.N. Jayasuriya, 1989). The higher digestibility could be partially attributed to the higher CP content of the feed/forages. This would be true, especially for those forages which have a relatively higher amount of CP content which in turn is known to favor high digestibility by animals. But the lower digestibility records might be associated with a higher proportion of NDF, ADF, and lignin (Moore and Jung, 2001). In harmony with the present results, the highest value of IVOMD (65.67%) content was obtained from lablab and maize intercropped maize planted after forty dates, and the lowest values of IVOMD in (58.23%) from sole lablab treatment. However, relatively similar IVOMD (66.60%) content was recorded from lablab under sowing maize (Mergia Abera, 2014). The IVOMD of evaluated forage in this result was higher than the result made by Muluken Girma *et al* (2015) of major indigenous fodder trees and shrubs in Northeastern drylands of Ethiopia in the case of the dry season and with the result of Ortiz-Dominguez *et al* (2017) of the nutritional value and in vitro digestibility of legume pods from seven trees species present in the tropical deciduous forest.

All the variations might be due to agroecological effects, altitude, soil type, and fertility with total management settings. This result disagreed with the result reported by Wubshet Tesfaye, (2021), IVOMD content of cowpea with sorghum (*sorghum bicolor*) intercropping non-significant difference ($P > 0.05$). But, the IVOMD of tested lablab forage species in this result was lower than the result made by Diriba Geleti *et al* (2013) from the highest IVOMD of nutritive value of selected browse and herbaceous forage legumes. The differences between the current and previous results might be coming from environmental conditions, the species itself, season of sowing, management system, and genetic potential both studies were determined.

4.5.2.9 Metabolized Energy (MJ/kg)

The metabolized Energy content of lablab in the present study was significantly ($P<0.05$) affected by intercropping dates treatments as shown in (Table 6). Statistically significant DM (8.19±0.08) mean value was obtained from sole and intercropped treatments as presented in (Table 8). The highest ME (9.53MJ/kg) was found from ML20 mixture dates followed by ME (8.47MJ/kg) of ML40 intercropping dates treatment in the recent study. Whereas, under intermediate ME (7.80MJ/kg) content of lablab was obtained from ML0 in both forages under sowing the time treatment. Meanwhile, the lowest value of ME (6.97MJ/kg) was found from the alone treatment of lablab sown as a pure stand. This might be the reason for intercropping dates affecting dry matter contents of the lablab. The metabolized energy content of lablab was shown to increase from intercropping treatments as compared to sown sole lablab forages. The reason might be due to might be decreasing/fewer intra-species competition and leads to increasing ME contents of the legume intercropped forage. The ME of all evaluated forages both inter-cropped treatments contained higher ME values and greater than the lower critical threshold of 7.5 MJ/kg DM (Owen, E. and M.C.N. Jayasuriya, 1989). The ME of all tested forage crops in the current finding was higher than the result made by Ortiz-Dominguez *et al* (2017) of the nutritional value and in vitro digestibility of legume pods from seven tree species present in the tropical deciduous forest. However, lower than the findings of Diriba Geleti *et al* (2013) from the highest ME of nutritive value of selected browse and herbaceous legume forage, but higher than from lower ME of the same author.

Table 4.6: Chemical Composition of sole and inter-cropped lablab forages

	Nutritional value Parameters (on DM $_{(\%)}$ basis)									
Treatments	DM $_{(\%)}$	Ash $_{(\%)}$	OM $_{(\%)}$	CP $_{(\%)}$	CPY$(_{t/ha})$	NDF $_{(\%)}$	ADF $_{(\%)}$	ADL $_{(\%)}$	IVOMD $_{(\%)}$	ME$_{(MJ/kg)}$
T1(SOM)	-	-	-	-	-	-	-	-	-	-
T2	90.0^{bc}	8.33^{ab}	91.67^{b}	14.33^{bc}	0.91^{d}	45.33^{b}	26.40^{b}	6.30^{a}	62.13^{b}	7.80^{c}
T3	93.12^{a}	6.06^{c}	93.93^{a}	17.12^{a}	1.54^{b}	41.47^{d}	24.13^{d}	5.60^{a}	64.33^{ab}	9.53^{a}
T4	91.33^{b}	7.67^{bc}	92.33^{ab}	15.66^{ab}	1.49^{c}	43.60^{c}	25.37^{c}	5.83^{a}	65.67^{a}	8.47^{b}
T5(S OL)	88.67^{c}	10.32^{a}	89.67^{c}	13.33^{c}	1.62^{a}	48.0^{a}	32.27^{a}	6.73^{a}	58.23^{c}	6.97^{d}
Overall mean	90.75	8.08	91.90	15.08	1.39	44.60	27.04	6.12	62.59	8.19
SEM (±)	0.43	0.57	0.52	0.46	0.39	0.25	0.27	0.30	0.85	0.08
CV%	0.82	12.20	0.98	5.30	1.23	0.97	1.73	8.46	2.34	1.67
P-value	<0.01	<0.05	<0.001	<0.01	<0.05	<0.01	<0.01	>0.05	< 0.001	<0.05

Whereas, *T1=Treatment one, T2 =Treatment two, T3=Treatment three, T4=Treatment four, T5=Treatment five, DM = Dry matter, OM = Organic matter, CP= Crude protein, CPY = Crude protein yield, NDF = Neutral Detergent Fiber, ADF = Acid Detergent Fiber, ADL = Acid Detergent Lignin, ME = metabolized energy, IVOMD= In vitro organic matter digestibility, SEM = Standard Error of Mean, CV% = Coefficient of Variation in percentages, N = Number, cm = centimeter, %= percentages, ML/kg = mega joule per kilogram, t/ha = tone per hectar, a, b & c = level of mean difference, NS = Non-Significant level, * (p<0.05), ** (p<0.01), *** (p<0.001).*

4.5 Evaluation of land productivity and economic feasibility on intercrop forages

4.5.1 Land equivalent ratio (LER)

The productivity of this experiment was evaluated by a land equivalent ratio (LER) used to evaluate the output efficiency on intercropping forages. From a significantly ($P<0.05$) land equivalent ratios were higher LERM of maize than intercropped lablab as shown in (Table 7). However, a non-significant ($P>0.05$) effect of LERL was observed mixtured treatments. LERT in the recent study was statistically significant ($P<0.01$) and affected each of intercropped dates. Statistically highest LERT (1.89) was obtained from lablab planted on maize emergence after twenty dates (ML20) (Table 7). Due to the highest dry matter yield recorded and biomass yield advantage was observed from this sowing dates of treatment while the lowest LERT (1.23) was found from lablab and maize intercropping levels under similar planting date for both forages. This lower LERT indicates that there is less intercropping yield advantage than the rest of others treatments on lablab and maize mixture with lablab planted twenty and forty days after maize planting (LM20, LM40) sowing dates of biomass yield advantages (89 and 54%) respectively as compared to the lowest values of land equivalent ratio on the land production efficient to increased forage productivity of treatments.

The higher LERT (1.89) was obtained from lablab and maize intercropping with lablab planted twenty days after maize planting (LM20) and this is indicated that almost 89% of more land would be required for plants the sole forages to produce in the same amount of dry matter yield. Hence, more dry matter production and yield advantages were found from this mixtured components of maize and lablab forages. Followed by, the intermediate LERT (1.54) was obtained from lablab and maize intercropping with lablab planted forty days after maize planting (LM40) which means that 54% of more land would be required for planting the sole forages to produce the same dry matter yield per hectare.Hence, the recent results in (Table 6) showed that intercropped maize and lablab had effects on LERT. These positive effects of LERT from intercropped components were similar to the finding of Hassan *et al.* (2017) who noted that the yield advantage was obtained from Sudan grass (Sorghum sudanense ((P.) Staph) intercropped with cowpea (*Vigna sinensis L.)*, guar (*Cyamopsis tetragonoloba L*.), and lima bean (*Phaseolus vulgaris L*.).

Under LERT in current results ranged from 1.23 to 1.89 and it was a line with the scholars Dariush *et al*. (2006) who revealed that LERT (1.70-1.89) obtained from cereal crop sorghum intercropped with legumes and had yield advantage of intercropping over pure stand forages. Awad & Ahmed (2012) and Asem *et al*. (2020) who were found that intercropping of Sudan grass (*Sorghum sudanense*) and cowpea (*Vigna unguiculata*) had a significant ($P<0.05$) effect on increased forage productivity and land equivalent ratio. Therefore, similar LERT results were observed when maize (*Zea mays L*.) intercropped with cowpea (*Vigna unguiculata L.)* in different seed rates noted by Dahmardeh *et al*. (2010) and it indicated that intercropping had yield advantage compared to monoculture farming practice.Generally, the current results were in agreement with those reported by many investigators including Shri *et al*. (2014); Dwivedi *et al*. (2015) who noted that yield occurs when the intercropped forages due to less competition for the same ecological niches, management practice in smallholder farming on a main crop, less venerable of infestation weed rate related to unwanted weeds suppressing were other advantages and the intra-specific competition on the main crop was minimal. On the other hand, the current results were in agreement with those reported by investigators of Rahel Kahsay *et al*. (2021) they noted that yield occurs when the intercropped of lablab (lablab purpureus) and in three sorghum (Sorghum bicolor) varieties (Girana-1, Teshale, and Misikir) on land equivalent ratio results were found ranges from (1.54-1.87).

In contrast, the present finding that Solomon Kebebew *et al.* (2014) revealed that on-land equivalent ratios were a non-significant ($P>0.05$) effect on maize and soybean intercropping systems under rainfed conditions. Inconsistency to the recent study, the total land equivalent ratio (LERT) revealed by Abera Habte *et al*.(2017) had no statistically significant ($P>0.05$) on intercropping of maize (*Zea mays (L*.)) common bean (*Phaseolus vulgaris (L*.)) intercropping response to a population density of component crop in wolaita zone southern Ethiopia. The advantage mighe be coming from better resource (moisture, light, and nutrient) utilization with low inter-specific interaction and better complementary effects. The inconsistency of current and former reports might be due to the genetic potential of inter-cropped forage effects.

Table 4. 7: Productivity of land on intercropping dates lablab and maize forages

	Yield Measured Parameters			
Treatment	Maize LER	Lablab LER	Total LER	BYA (%)
T2	0.71^{c}	0.51^{a}	1.23^{c}	23
T3	1.38^{a}	0.53^{a}	1.89^{a}	89
T4	1.03^{b}	0.49^{a}	1.54^{b}	54
Overall mean	1.04	0.51	1.55	-
SEM (±)	0.05	0.04	0.04	-
CV%	8.94	12.93	3.96	-
P-value	<0.05	>0.05	<0.01	

Whereas, *T2=Treatment two, T3=Treatment three, T4=Treatment four, LER = land equivalent ratio, BYA% = biomass yield advantage in percentages, SEM = Standard Error of Mean, CV% = Coefficient of Variation percent, a, b & c = level of mean difference, NS = non-Significant level, ** (p<0.01).*

4.5.2 Analysis of economic feasibility on intercropped forages

Economic analysis using a partial budget analysis procedure was done and the results are presented (Table 8). Treatments that produced lower net financial benefits (NFBs) were not significant for investment. They are known as dominated and such treatments were dropped from the further analysis of economic feasibility and were marked “D”. To evaluate the economic benefits of different intercropping practices under partial budget analysis procedures was conducted. In the current market price of maize grain (ETB 28kg^{-1}) while lablab forage seed cost was (ETB 150kg^{-1}) and based on the recent market price in the district asked who had a best local market experienced person to estimate farm gate price of maize grain yield, maize stover, and lablab straw (ETB 2800qt^{-1}), both forages maize stover and lablab straw on a DM basis (ETB4.29kg^{-1}, ETB120qt^{-1}) sale cost respectively. For sole maize weeding one person per day participated three stages and also the other intercropped lablab with maize treatments was weeding practiced one man per day (MPD) two times through the final experiment weeding management for each intercropped treatment and those values convert to hector basis. Followed by, sowing alone lablab forages one man per day in only one-stages weeding practice was done.

The remaining extra costs were calculated uniformly considering the price of agronomic practices such as land plowing, sowing, harrowing, protection of the farm, and harvesting because they were somewhat similar for all treatments. The economic analysis of maize and lablab with in different intercropping results is revealed in (Table 8). The maximum net returns (98279 ETB ha^{-1}) with a marginal rate of returns (1.71) were obtained when lablab and maize intercropping with maize planted after twenty days (T3). followed by, the intermediate net returns (51957 ETB ha^{-1}, 64226 ETB ha^{-1}) with marginal rate of returns (0.9, 1.0) were obtained from lablab and maize intercropping under the same dates (T2) and lablab and maize intercropped with maize planted after forty days (T4) treatments respectively. Whereas, the lowest values of net benefit (6244ETB ha^{-1}) with minimum value in the marginal rate of returns (0.07) were recorded from the recent studies alone maize (T1). However, it appears that the increased forage yield and nutritive value of lablab with maize intercropping could be economically beneficial.

In addition to the economic benefit, lablab with maize under growing intercropping plays vital roles in weed control, soil fertility, soil conservation, and efficient utilization of land and labor resources. The recent studies investigated that, a 100% marginal rate of return was considered as the minimum acceptable rate of return for farmer's recommendations CIMMYT (1988) and also according to this manual CIMMYT (1988), noted that the treatment recommendation is not necessarily based on the highest marginal rate of return, rather than based on the highest net benefit values and the highest grain yield components. Therefore, the maximum net returns (98279ETB ha^{-1}) with the highest marginal rate of returns percentage (171%) were obtained when lablab and maize intercropping with maize planted after twenty days as compared to other intercropped and sole treatments. Hence, the best recommended and economically feasible of lablab with maize mixture production which provided the higher net benefit with an acceptable marginal rate of returns (MRR) this treatment. Therefore, this treatment was recommended for farmers. In this study, the economic return was higher under intercropping management than the other sowing-alone maize farming practices. In line with this result, (Sheri *et al*., 2008) reported that intercropping of faba Bean, Lupin, or field peas and barley gave high economic returns than that of grown separate crops.

Similarly, these results are in agreement with Seran and Brintha (2010) who revealed that the intercropping system gave higher cash returns to smallholder farmers than growing the mono-crops farming system. In general, the increment of higher net return result was obtained from the mixture treatment than sowing alone, which might be the reason for this best performance result showing that raising from the intercropped treatment was higher dry matter production and maize grain yield. Similar findings by Yusuf *et al*. (2015) reported that the highest net benefit was produced in the intercropping treatment of soybean planted fourteen days after maize plating. On the contrary results, who investigated by Zerihun Abebe *et al.* (2017) confirm that the highest net benefit (38808 ETB/ha) and more marginal rate of return (MRR) could be obtained when the climbing bean was intercropped simultaneously with the BH661 variety of maize. Likewise, Kinde Lamessa *et al*. (2015) results reported that intercropping soybean and cowpea with sorghum was more advantageous than alone cropping sorghum. This result supported by scholars of Abuhay Takele and Jibril Mohammed (2016) noted that mixture of haricot beans with maize was more advantageous than sole maize on the best cost analysis of feasibility were evaluated.

Table **4.8:** Analysis of Economic Feasibility of Maize and Lablab Intercropping System

	Field DMY & MGY ($t\ ha^{-1}$)			From field experiment product gates gross benefit in ($ETB\ ha^{-1}$)				Extra cost during the field experiment in ($ETB\ ha^{-1}$)			Net benefit ($ETB\ ha^{-1}$)	Ratio
Treatment	MS	LS	MGY	MS	LS	MGY	GB	TVC	TFC	TC	NB	MRR
T1(SOM)	6.18	-	3.93	26512	-	110,040	136552	90308	40000	130308	6244	0.07
T2	7.29	2.39	4.10	31274	3420	114,800	149494	57538	40000	97537	51957	0.90
T3	10.22	4.61	5.23	43843	5532	146,440	195816	57538	40000	97537	98279	1.71
T4	8.78	3.27	4.53	37666	3924	126,840	168430	64204	40000	104204	64226	1.00
T5 (SOL)	-	5.31	-	-	6372	-	6372	37363	40000	77363	"D"	-

Whereas, *T1=Treatment one, T2=Treatment two, T3=Treatment three, T4=Treatment four, T5=Treatment five, SOM = Sole maize, SOL = Sole lablab, DMY = Dry matter yield, MS = Maize stover, LS = Lablab straw, MGY= Maize grain yield, GB = Gross benefit, TVC = Total variable cost, TFC = Total fixed cost, TC = Total cost, NB = Net benefit, MRR = Marginal rate of returns, D =Indicated that Dominated Treatment,* $t\ ha^{1}$ *= Tone per hectar,* $ETBha^{1}$ *= Ethiopia birr per hectar*.

4.6 Correlations Between Morphological Characteristics, Forage Yield, and Nutritive Value of Maize with Lablab Under Intercropped Forages

The relationship between agronomic characteristics, forage yield, and chemical composition of sowing date on maize with lablab intercropped was shown in (Table 9) below. Hence, plant height in the present result revealed that high positive significant correlation to the number of leaves per plant, dry matter yield, and dry matter content, and has a moderate positive correlation to crude protein, metabolized energy, in vitro dry matter digestibility, and crude protein yield. On the other hand, it has negatively correlated with Ash, NDF, ADF, and ADL. The current finding was in agreement with the finding of Tiruset Tesfaye (2019) who corroborated that on plant height of Desho grass (*Pennisetum pedicellatum*) was moderately correlated with crude protein and crude protein yield. Plant height has also positively correlated with LSR in line with the authors of Bimrew Asmare *et al*., (2017). However, inconsistency with the author of Abebaw Biresaw (2021); Aychew Zewdu *et al*. (2021) who noted that para grass (brachiaria mutica) and desho grass (*Pennisetum pedicellatum*) intercropped with alfalfa (Medicago sativa) and vetch forage species respectively.

Similarly, the current study on PLH was positively correlated with LSR but this results from disagreement with the finding of para grass as reported by Mimilia Zemene (2020). This might be due to the reason attributed to the intercropping dates, forage species variations, and field experiment management differences with agroecological effects. The number of Leaves per leaves (NLPP) was positively correlated with all forage growth and chemical composition parameters excluding the remaining components including Ash, NDF, ADF, and ADL. These results were in line with the finding of Aychew Zewdu (2021) who noted that NLPP had positive correlation with all morphological parameters of desho (*Pennisetum pedicellatum*), oat (*Avena sativa*), and Phalaris (*Phalaris aquatica* (*acc6583*)) intercropping with vetch (*Vicia dasycarpa*). The positive correlation of NLPT with plant height was in line with Genet Tilahun et al. (2017). In addition, Tiruset Tesfaye (2019); Aychew Zewdu (2021) who were reported that NLPP was positively correlated with DM, DMY, CP, and CPY of Desho grass (*Pennisetum pedicellatum*) intercropped with vetch species. NLPT was significantly positively correlated with LSR and this was similar to the finding of Aychew Zewdu (2021) who stated that NLPP was correlated with LSR. while Tiruset Tesfaye (2019) noted that NLPP was not correlated with LSR. The present result of NLPT was similar to the finding of

Beyadglign Hunegnaw (2019) who reported that NLPP has negatively correlated with ash, NDF, and ADF ADL in the case of brachiaria cultivars. This might come from efficient soil nutrient utilization and nitrogen availability in the intercropping leading to increasing leaf number per plant and decreasing Ash, ADF, NDF, and ADL contents of maize in the present inconsistent with current and previous studies finding. LA in the present study was moderately positively correlated with LSR, DMY, DM, CP, CPY ME, and IVDMD and negatively correlated with ash, NDF, ADL, and ADF. These are in line with para grass as reported by Mimila Zemene, 2018. In addition, LA was highly positively correlated with (DM, DMY, CP, CPY, and IVDMD) whereas, medium positively correlated with NLPP, ME, and LSR. This could be leaf have responsible for capturing sunlight for photosynthesis and leads to increasing crude protein. However, LA has negatively correlated with NDF, ADF, and ADL contents. Therefore, LA might have been responsible for increasing the DM, DMY, CP, And CPY while it might have decreased fiber fractions. Present results were similar to the results of Bimrew Asmare et al. (2017) who observed that LA has a positive relationship with plant height, LSR, IVDMD, DM, and DMY.

DMY in the present result has a significantly strong positive correlation with ME, IVDMD, CP, and CPY a line finding with the scholar of (Tiruset Tesfaye, 2019), moderately with DM (Aychew Zewdu, 2021), in the present study significant strong positive correlations were observed between IVDMD, CP with CPY, NDF with ADL and moderately insignificant with ADF similar with the previous studies Aychew Zewudu (2021) Bimrew Asmare *et al*. (2017) but contradict with the results of Yihalem Denekew et al. (2005); Bayble Taye *et al*. (2007); Genet Tilahun *et al*. (2017). This showed that DMY had a direct relationship with growth parameters and CPY in the current study. Similarly, the DMY positive correlation with PH, NLPP, LLPP, and negative correlation with ASH in the current study is in line with desho grass as indicated by (Genet Tilahun *et al.,* 2017). The fiber parameters (NDF, ADF, and ADL) contents were a strong positive correlation with each other and a strong negative correlation with CP content in the current study in line with desho grass Biniyam Mihret *et al.,* 2018), and *Brachiaria* mutica (Mimila Zemene, 2018) as noted by on CP and fiber content parameters. This is because as the fiber content of forage decreases the digestibility and CP increase and vice versal. The CP contents were significantly positively correlated with CPY and negatively correlated with fiber fraction contents like NDF, ADF and ADL forage quality

Table 4.4: Correlation on morphological and chemical composition parameters under effect of maize and lablab sowing dates

	PLH	NLPP	LA	LSR	DMY	DM	Ash	CP	CPY	NDF	ADF	ADL	ME	IVDMD
PLH	1.00	0.66^{**}	0.59	0.75	0.59^{*}	0.65^{**}	-0.60	0.76^{*}	0.70^{*}	-0.78^{*}	-0.55	-0.65	0.73^{*}	0.74^{*}
NLPP		1.00	0.80^{*}	0.90^{**}	0.71^{**}	0.77^{***}	-0.67	0.95^{***}	0.91^{*}	-0.70	-0.67	-0.32	0.93	0.87^{***}
LA			1.00	0.94^{*}	0.74^{**}	0.76^{*}	0.74	0.87^{**}	0.90^{***}	-0.82	-0.62	-0.82	0.75	0.86
LSR				1.00	0.76^{*}	0.83^{**}	0.74	0.97	0.96	-0.83	-0.70	-0.95	0.86	0.93
DMY					1.00	0.90^{*}	0.49	0.70^{**}	0.76^{***}	-0.75	-0.01	-0.77	0.78	0.87^{*}
DM						1.00	-0.44	0.78^{*}	0.77^{*}	-0.74^{*}	-0.53	-0.83	0.86^{**}	0.81
Ash							1.00	-0.73	-0.77	0.84^{**}	0.69^{*}	0.68	-0.65^{*}	-0.74^{*}
CP								1.00	0.97^{***}	-0.81^{*}	-0.78	-0.90^{***}	0.89^{***}	0.93^{**}
CPY									1.00	-0.80	-0.72	-0.87^{**}	0.87^{*}	0.64^{*}
NDF										1.00	0.78	0.83^{***}	-0.74^{*}	-0.86^{*}

ADF	1.00	0.68	-0.59	-0.71
ADL		1.00	-0.82*	-0.79**
ME			1.00	0.86***
IVDMD				1.00

Whereas, *PLH= Plant Height, NLPP = Number of Leaves per Plant, LA = Leaf Area, LSR = Leaf to Stem Ratio, DM = Dry Matter, DMY = Dry Matter Yield, CP = Crude Protein, CPY = Crude protein Yield, NDF = Neutral Detergent Fiber, ADF = Acid Detergent Fiber, ADL =Acid Detergent Lignin, ME = Metabolized Energy, IVDMD= In vitro Dry Matter Digestibility, * (p<0.05), ** (p<0.01), *** (p<0.001).*

CHAPTER FIVE: CONCLUSION AND RECOMMENDATION

5.1 Conclusion

In the current study results indicated that maize (*Zea mays*) and lablab (*Lablab purpureus*) forages intercropped dates together had effects on agronomic parameters, dry matter yield, maize grain yield, and quality parameters for both grown forages. All parameters of maize such as PLH, NLPP, NCPP, CL, LA, LSR, and MGY of the current study were significantly affected by intercropping dates While, significantly higher growth parameters were obtained from lablab mixture maize planted after twenty days. Followed by, a significantly higher PLH, LA, and NNPP of lablab were observed in lablab mixture maize planted after twenty days (ML20) treatment as compared to sole while, 5.31t/ha of dry matter was obtained from sole lablab and significantly higher total DMY (14.83t/ha) was found from lablab mixtured maize planted after twenty dates. LER in the present study is greater than one (>1) in all treatments. Similarly, the highest net benefit returns and marginal rate of returns under the analysis of economic feasibility were recorded (98279 ETB ha^{-1}) and (1.71) ratio from (ML20) in this treatment respectively, and also having their higher dry matter and maize grain yield as compared to other sole and intercropped treatments.

In addition, chemical compositions of maize were affected by intercropped dates, and higher 8.67% CP, 0.92t/ha CPY, and 58.67% IVDMD were found from (ML20) treatment while, lower NDF%, ADF, and ADL% were obtained. On the other side, higher CP% (17.12), CPYt/ha (1.62t/ha), and 65.67% IVDMD of lablab were obtained from ML20 and sole lablab treatment respectively. Whereas, lower NDF% and ADF% contents were found from lablab intercropped maize planted after twenty dates. Correlations of growth and chemical composition of the forage grown were revealed in the present studies and plant height has positive correlations with the number of leaves per plant, dry matter, DMY, CPY, ME, and in vitro dry matter digestibility. The most agronomic performance of parameters was negative and non-significant correlated to NDF, ADF, and ADL content of forages grown in intercropping and in their sole treatments as revealed in the current results.

5.2 Recommendation/Future Directions

Based on the above-provided result conclusions, the following recommendations are forwarded to the next researchers, extension activities for promotion concerns.

- From the implemented treatments (ML20) were recommended increasing morphology with best performance of forage yield and quality for animal feeds.
- Future studies should be conducted on animal performance testing
- Further study is required more legume species that can be compatible with maize intercrop systems.
- Since the experiment was conducted in one season (under rainfed conditions), more studies are needed to examine the effect of forage yield and quality to provide a comprehensive recommendation to satisfy livestock feed requirements.

CHAPTER SIX: REFERENCE

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CHAPTER SEVEN: APPENDIX

APPENDIX 7.1. LIST OF ANOVA TABLES

ANOVA Table for Maize Plant Height

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	5	1211.000000	242.200000	16.90	0.0018
Error	6	86.0000000	14.3333333		
Corrected Total	11	1297.000000			

R-Square	Coeff Var	Root MSE	PH Mean
0.933693	1.671496	3.785939	226.5000

Source	DF	Type I SS	Mean Square	F Value	Pr > F
Treatment	3	977.000000	325.6666667	22.72	0.0011

ANOVA Table of Maize on NLPP

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	5	60.00000000	12.0000000	8.31	0.0114
Error	6	8.66666667	1.44444444		
Corrected Total	11	68.66666667			

R-Square	Coeff Var	Root MSE	NLPP Mean
0.873786	9.744733	1.201850	12.33333

Source	DF	Type I SS	Mean Square	F Value	Pr > F
Treatment	3	59.33333333	19.77777778	13.69	0.0043

ANOVA Table for Maize on NCPP

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	5	1.91500000	0.38300000	7.07	0.0169
Error	6	0.32500000	0.05416667		
Corrected Total	11	2.24000000			

R-Square	Coeff Var	Root MSE	NCPP Mean
0.873786	15.51582	0.232737	1.500000

Source	DF	Type I SS	Mean Square	F Value	Pr > F
Treatment	3	1.82000000	0.60666667	11.20	0.0072

ANOVA Table for Maize on CL

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	5	68.98500000	13.7970000	10.25	0.0067
Error	6	8.07500000	1.34583333		
Corrected Total	11	77.060000			

R-Square	Coeff Var	Root MSE	CL Mean
0.895212	6.946710	1.160101	16.500000

Source	DF	Type I SS	Mean Square	F Value	Pr > F
Treatment	3	55.000000	18.3333333	13.62	0.0044

ANOVA Table for Maize on LA

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	5	76856.16667	15371.23333	7.66	0.0139
Error	6	12035.50000	2005.91667		
Corrected Total	11	88891.66667			
R-Square	Coeff Var	Root MSE	LA Mean		
0. 864605	7.896702	44.78746	567.1667		
Source	DF	Type I SS	Mean Square	F Value	Pr > F
Treatment	3	70495.00000	23498.33333	11.71	0.0064

ANOVA Table for Maize on RL

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	5	213.7841667	42.7568333	1.93	0.2232
Error	6	132.8983333	22.1497222		
Corrected Total	11	346.6825000			
R-Square	Coeff Var	Root MSE	RL Mean		
0.616657	11.64217	4.706349	40.42500		
Source	DF	Type I SS	Mean Square	F Value	Pr > F
Treatment	3	0.4491667	0.1497222	0.01	0.9991

ANOVA Table Table for Maize on MGY

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	5	358.5000000	71.7000000	10.12	0.0069
Error	6	42.5000000	7.0833333		
Corrected Total	11	401.0000000			
R-Square	Coeff Var	Root MSE	MGY Mean		
0.894015	5.980794	2.661453	44.50000		
Source	DF	Type I SS	Mean Square	F Value	Pr > F
Treatment	3	303.0000000	101.0000000	14.26	0.0039

ANOVA Table for Lablab forages on plant height

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	5	3520.613333	704.122667	13.86	0.0030
Error	6	304.873333	50.812222		
Corrected Total	11	3825.486667			
R-Square	Coeff Var	Root MSE	PLH Mean		
0.920305	3.636254	7.128269	196.0333		
Source	DF	Type I SS	Mean Square	F Value	Pr > F
Treatment	3	2451.806667	817.268889	16.08	0.0028

ANOVA Table for Lablab forages on NLPP

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	5	378.6641667	75.7328333	4.07	0.0485
Error	6	111.5983333	18.5997222		
Corrected Total	11	490.2625000			
R-Square	Coeff Var	Root MSE	NLPP Mean		
0.772370	12.49164	4.312740	34.52500		
Source	DF	Type I SS	Mean Square	F Value	Pr > F
Treatment	3	352.3491667	117.4497222	6.31	0.0176

ANOVA Table for Lablab forages on NBPP

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	5	73.33333333	14.66666667	12.00	0.0044
Error	6	7.33333333	1.22222222		
Corrected Total	11	80.66666667			
R-Square	Coeff Var	Root MSE	NBPP Mean		
0.909091	12.75625	1.105542	8.666667		
Source	DF	Type I SS	Mean Square	F Value	Pr > F
Treatment	3	48.66666667	16.22222222	13.27	0.0047

ANOVA Table for Lablab forages on NNPP

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	5	349.5000000	69.90000000	10.66	0.0001
Error	6	4.1666667	0.694444444		
Corrected Total	11	353.6666667			
R-Square	Coeff Var	Root MSE	NNPP Mean		
0.988219	4.950495	0.833333	16.833333		
Source	DF	Type I SS	Mean Square	F Value	Pr > F
Treatment	3	68.3333333	22.7777778	32.80	0.0004

ANOVA Table for Lablab forages on RL

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	5	442.3333333	88.4666667	9.95	0.0872
Error	6	53.3333333	8.8888889		
Corrected Total	11	495.6666667			
R-Square	Coeff Var	Root MSE	RL Mean		
0.892401	7.880416	2.981424	37.83333		
Source	DF	Type I SS	Mean Square	F Value	Pr > F
Treatment	3	101.6666667	33.8888889	3.81	0.0767

ANOVA Table for Lablab forages on LA

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	5	2087.166667	417.433333	15.41	0.0023
Error	6	162.500000	27.083333		
Corrected Total	11	2249.666667			
R-Square	Coeff Var	Root MSE	LA Mean		
0.927767	4.271544	5.204165	121.8333		
Source	DF	Type I SS	Mean Square	F Value	Pr > F
Treatment	3	1915.000000	638.333333	23.57	0.0010

ANOVA Table for Lablab forages on DMYL

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	5	15.79806667	3.15961333	10.64	0.0061
Error	6	1.78240000	0.29706667		
Corrected Total	11	17.58046667			
R-Square	Coeff Var	Root MSE	DMYL Mean		
0.898615	14.33054	0.545038	3.803333		
Source	DF	Type I SS	Mean Square	F Value	Pr > F
Treatment	3	14.90180000	4.96726667	16.72	0.0026

ANOVA Table for Lablab forages on DMYM

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	5	40.73158333	8.14631667	13.61	0.0032
Error	6	3.59248333	0.59874722		
Corrected Total	11	44.32406667			
R-Square	Coeff Var	Root MSE	DMYM Mean		
0.918950	9.533317	0.773788	8.116667		
Source	DF	Type I SS	Mean Square	F Value	Pr > F
Treatment	3	27.90326667	9.30108889	15.53	0.0031

ANOVA Table for Lablab forages on TDMY

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	6	164.8169867	27.4694978	36.29	0.0001
Error	8	6.0552133	0.7569017		
Corrected Total	14	170.8722000			
R-Square	Coeff Var	Root MSE	TDMY Mean		
0.964563	10.05781	0.870001	8.650000		
Source	DF	Type I SS	Mean Square	F Value	Pr > F
Treatment	4	152.0664667	38.0166167	50.23	0.0001

ANOVA Table for Lablab forages on LERL

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	4	0.00957778	0.00239444	0.55	0.7098
Error	4	0.01731111	0.00432778		
Corrected Total	8	0.02688889			

R-Square	Coeff Var	Root MSE	LERL Mean
0.356198	12.92735	0.065786	0.508889

Source	DF	Type I SS	Mean Square	F Value	Pr > F
Treatment	2	0.00115556	0.00057778	0.13	0.8788

ANOVA Table for Lablab forages on LERM

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	4	1.59897778	0.39974444	46.33	0.0013
Error	4	0.03451111	0.00862778		
Corrected Total	8	1.63348889			

R-Square	Coeff Var	Root MSE	LERM Mean
0.978873	8.940882	0.092886	1.038889

Source	DF	Type I SS	Mean Square	F Value	Pr > F
Treatment	2	0.66068889	0.33034444	38.29	0.0025

ANOVA Table for Lablab forages on LERT

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	4	1.41926667	0.35481667	93.78	0.0003
Error	4	0.01513333	0.00378333		
Corrected Total	8	1.43440000			

R-Square	Coeff Var	Root MSE	LERT Mean
0.989450	3.959794	0.061509	1.553333

Source	DF	Type I SS	Mean Square	F Value	Pr > F
Treatment	2	0.64106667	0.32053333	84.72	0.0005

ANOVA for Maize DM%

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	5	42.25000000	8.45000000	10.86	0.0058
Error	6	4.66666667	0.77777778		
Corrected Total	11	46.91666667			

R-Square	Coeff Var	Root MSE	DM Mean
0.900533	0.968253	0.881917	91.08333

Source	DF	Type I SS	Mean Square	F Value	Pr > F
Treatment	3	33.58333333	11.19444444	14.39	0.0038

ANOVA for Maize Ash%

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	5	30.16666667	6.03333333	24.13	0.0007
Error	6	1.50000000	0.25000000		
Corrected Total	11	31.66666667			
R-Square	Coeff Var	Root MSE	Ash Mean		
0.952632	5.084746	0.500000	9.833333		
Source	DF	Type I SS	Mean Square	F Value	Pr > F
Treatment	3	27.00000000	9.00000000	36.00	0.0003

ANOVA for Maize OM%

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	5	50.66666667	10.13333333	6.08	0.0241
Error	6	10.00000000	1.66666667		
Corrected Total	11	60.66666667			
R-Square	Coeff Var	Root MSE	OM Mean		
0.835165	1.429145	1.290994	90.33333		
Source	DF	Type I SS	Mean Square	F Value	Pr > F
Treatment	3	42.00000000	14.00000000	8.40	0.0144

ANOVA for Maize CP%

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	5	22.16666667	4.43333333	53.20	0.0001
Error	6	0.50000000	0.08333333		
Corrected Total	11	22.66666667			
R-Square	Coeff Var	Root MSE	CP Mean		
0.977941	4.330127	0.288675	6.666667		
Source	DF	Type I SS	Mean Square	F Value	Pr > F
Treatment	3	22.00000000	7.33333333	88.00	0.0001

ANOVA for Maize CPY (tha^{-1})

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	5	0.25278333	0.05055667	136.85	0.0001
Error	6	0.00221667	0.00036944		
Corrected Total	11	0.25500000			
R-Square	Coeff Var	Root MSE	CPY Mean		
0.991307	2.707174	0.019221	0.710000		
Source	DF	Type I SS	Mean Square	F Value	Pr > F
Treatment	3	0.24613333	0.08204444	222.08	0.0001

ANOVA for Maize NDF%

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	5	555.1666667	111.0333333	19.31	0.0012
Error	6	34.5000000	5.7500000		
Corrected Total	11	589.6666667			
R-Square	Coeff Var	Root MSE	NDF Mean		
0.941492	4.219207	2.397916	56.83333		
Source	DF	Type I SS	Mean Square	F Value	Pr > F
Treatment	3	547.0000000	182.3333333	31.71	0.0004

ANOVA for Maize ADF%

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	5	50.83333333	10.16666667	2.36	0.1625
Error	6	25.83333333	4.30555556		
Corrected Total	11	76.66666667			
R-Square	Coeff Var	Root MSE	ADF Mean		
0.663043	5.102418	2.074983	40.66667		
Source	DF	Type I SS	Mean Square	F Value	Pr > F
Treatment	3	48.66666667	16.22222222	3.77	0.0784

ANOVA for Maize ADL%

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	5	50.41666667	10.08333333	33.00	0.0003
Error	6	1.83333333	0.30555556		
Corrected Total	11	52.25000000			
R-Square	Coeff Var	Root MSE	ADL Mean		
0.964912	4.913518	0.552771	11.25000		
Source	DF	Type I SS	Mean Square	F Value	Pr > F
Treatment	3	46.91666667	15.63888889	51.18	0.0001

ANOVA for Maize ME (MJ/kg)

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	5	14.75000000	2.95000000	5.06	0.0367
Error	6	3.50000000	0.58333333		
Corrected Total	11	18.25000000			
R-Square	Coeff Var	Root MSE	ME Mean		
0.808219	9.855001	0.763763	7.750000		
Source	DF	Type I SS	Mean Square	F Value	Pr > F
Treatment	3	14.25000000	4.75000000	8.14	0.0155

ANOVA for Maize IVDMD (%)

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	5	123.5833333	24.7166667	44.49	0.0001
Error	6	3.3333333	0.5555556		
Corrected Total	11	126.9166667			

R-Square	Coeff Var	Root MSE	IVDMD Mean
0.973736	1.369720	0.745356	54.41667

Source	DF	Type I SS	Mean Square	F Value	Pr > F
Treatment	3	120.9166667	40.3055556	72.55	<.0001

ANOVA Table for lablab on DM%

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	5	38.91666667	7.78333333	14.01	0.0029
Error	6	3.33333333	0.55555556		
Corrected Total	11	42.2500000			

R-Square	Coeff Var	Root MSE	DM Mean
0.921105	0.821329	0.745356	90.75000

Source	DF	Type I SS	Mean Square	F Value	Pr > F
Treatment	3	30.91666667	10.30555556	18.55	0.0019

ANOVA Table for lablab on Ash

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	5	25.08333333	5.01666667	5.16	0.0351
Error	6	5.83333333	0.97222222		
Corrected Total	11	30.91666667			

R-Square	Coeff Var	Root MSE	Ash Mean
0.811321	12.19810	0.986013	8.083333

Source	DF	Type I SS	Mean Square	F Value	Pr > F
Treatment	3	20.91666667	6.97222222	7.17	0.0207

ANOVA Table for lablab on OM%

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	5	33.63333333	6.72666667	8.26	0.0115
Error	6	4.88666667	0.81444444		
Corrected Total	11	38.5200000			

R-Square	Coeff Var	Root MSE	OM Mean
0.873139	0.982008	0.902466	91.90000

Source	DF	Type I SS	Mean Square	F Value	Pr > F
Treatment	3	28.09333333	9.36444444	11.50	0.0067

ANOVA Table for lablab on CP%

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	5	25.08333333	5.01666667	7.85	0.0131
Error	6	3.83333333	0.63888889		
Corrected Total	11	28.91666667			

R-Square	Coeff Var	Root MSE	CP Mean
0.867435	5.299261	0.799305	15.08333

Source	DF	Type I SS	Mean Square	F Value	Pr > F
Treatment	3	22.91666667	7.63888889	11.96	0.0061

ANOVA Table for lablab on CPY t/ha

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	5	0.95234167	0.19046833	13.03	0.041
Error	6	0.00175000	0.00029167		
Corrected Total	11	0.95409167			

R-Square	Coeff Var	Root MSE	CPY Mean
0.998166	1.229388	0.017078	1.389167

Source	DF	Type I SS	Mean Square	F Value	Pr > F
Treatment	3	0.94282500	0.31427500	1077.51	0.021

ANOVA Table for lablab on NDF%

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	5	77.66166667	15.53233333	83.33	<.0001
Error	6	1.11833333	0.18638889		
Corrected Total	11	78.78000000			

R-Square	Coeff Var	Root MSE	ADF Mean
0.985804	0.968000	0.431728	44.60000

Source	DF	Type I SS	Mean Square	F Value	Pr > F
Treatment	3	68.74666667	22.91555556	122.94	<.0001

ANOVA Table for lablab on ADF

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	5	118.8608333	23.7721667	109.02	<.0001
Error	6	1.3083333	0.2180556		
Corrected Total	11	120.1691667			

R-Square	Coeff Var	Root MSE	ADF Mean
0.989113	1.726832	0.466964	27.04167

Source	DF	Type I SS	Mean Square	F Value	Pr > F
Treatment	3	116.9291667	38.9763889	178.75	<.0001

ANOVA Table for lablab on ADL

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	5	2.97000000	0.59400000	2.22	0.1801
Error	6	1.60666667	0.26777778		
Corrected Total	11	4.57666667			
R-Square	Coeff Var	Root MSE	ADL Mean		
0.878944	8.460041	0.517472	6.116667		
Source	DF	Type I SS	Mean Square	F Value	Pr > F
Treatment	3	2.28333333	0.76111111	2.84	0.1278

ANOVA Table for lablab on ME (MJ/kg)

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	5	11.87583333	2.37516667	125.74	<.0001
Error	6	0.11333333	0.01888889		
Corrected Total	11	11.98916667			
R-Square	Coeff Var	Root MSE	ME Mean		
0.990547	1.677764	0.137437	8.191667		
Source	DF	Type I SS	Mean Square	F Value	Pr > F
Treatment	3	10.58916667	3.52972222	186.87	<.0001

ANOVA Table for lablab on IVDMD%

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	5	105.9441667	21.1888333	9.85	0.0074
Error	6	12.9050000	2.1508333		
Corrected Total	11	118.8491667			
R-Square	Coeff Var	Root MSE	IVDMD Mean		
0.891417	2.343079	1.466572	62.59167		
Source	DF	Type I SS	Mean Square	F Value	Pr > F
Treatment	3	95.08250000	31.69416667	14.74	0.0036

Appendix 7.2. Field Photo with activities throughout the Experiment

Overcrowding trimming practice

Sowing after one month three weeks

Both forages growth 2 month and half of weeks. Sowing alone lablab

Sole maize sowing after two months Both forages weeding practice

Half of maize matured stages Critical observation of maize cob Healthnes

Maize plant Hight measurement Number of cob count for recording

Root length measurement after digging and clean Biomass Yield measurement

Both forages of quality sample preparation

Appendix 7.3 Field experiment layout and on ground implemented design

27m

<u>B1F1</u>	Plot 1 T4	0.5m	Plot 2 T5		Plot 3 T1		Plot 4 T3		Plot 5 T2	
<u>B2F2</u>	Plot 10 T2		Plot 9 T4		Plot 8 T1		Plot 7 T3		Plot 6 T5	**<u>15m</u>** Each plot width 5m
<u>B3F3</u>	Plot 11 T5		Plot 12 T1		Plot 13 T3		Plot 14 T4		Plot 15 T2	

27m*15m = 405m²

Whereas,

Treatments	Treatment descriptions by sowing dates	Remark
T1 (SOM)	Sowing Alone Maize	The Total
T2 (ML0)	Similar Date of Planting Both Forages	experimental
T3(ML20)	Lablab Sowing Twenty Days after Maize Planted	unites were
T4(ML40)	Lablab Sowing Forty Days After Maize Planted	fifteen (<u>15</u>)
T5 (SOL)	Sowing Alone Lablab	

Whereas, *T=Treatment, B = Block (1-3), F= farmers (1-3).*

Biographical Sketch

The author Mr. Habtie Ambaw Birhanie was born in 1995 G.C in Dabat District, North Gondar Zone, Amhara Regional State from his father Ato Ambaw Birhanie, and his mother W/ro. Muketie Tesfahun and He attended his primary education at Janora primary school from 2004 to 2010 (1-8) from those two years termed was passed. Then he moved to Dabat secondary school from 2011-2014 (9-12). After successfully passing the Ethiopian higher education entrance examination, he joined Mekelle University, College of dry land agriculture and natural resources management in 2015 and graduated with a BSc degree in **Animal Production and Technology** in June 2017 with Avery great distinction Award CGPA 3.84. Upon graduation, he worked from West Belesa Agriculture office under the livestock and fishery office as breeding improvement expert for two years served. Then after he worked for one year in an instructor position at TVET College in West Belesa district and then after a few months jobless then, he joined Debark University department of Animal Science Staff currently served. After that, he joined the regular postgraduate program at Bahir Dar University, College of Agriculture and Environmental Sciences on October 2021 to pursue his M.Sc. degree in the field of **Animal Production.**