Forage Legumes in Crop-Livestock Mixed Farming Systems - A Review

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Abstract

The future animal agriculture in the country suggests that the greatest opportunity for sustainable increases in agricultural productivity lie in agricultural intensification through the development of mixed crop-livestock farming systems. The linkage in mixed crop-livestock production systems through feed resources particularly legumes which fix N, and provide high quality feed, can enhance both the level and rate of nutrient cycling in the system, leading to increased soil fertility, improve animal nutrition, and increase the overall production and protect the environment, especially where land resource is limited. Forage legumes integration with cereals by intercropping generally results in higher fodder protein yield than that in cereals alone. Intercropped forage legumes have been reported to have significantly higher crude protein and lower fiber contents than their respective sole cereal residues and this could improve their voluntary intake and digestibility by livestock. There are various methods of integrating forage legumes into crop-livestock farming systems. The type of forage crops, food crops grown in the area, the soil type, the rainfall pattern and other social and economic factors determine the method of integration used for a specific farming system and locality. Forage legumes generally can be integrated into crop-livestock production systems by growing the herbaceous species in natural pastures, on arable land, crop rotation with cereals, sequential cropping, intercropping/under sowing and relay cropping. Generally, the role of forage legumes in the farming system requires studying economic importance as related to farmers benefit, animal performance and the management of natural resource in a multidisciplinary approach.

Key words: Biological Nitrogen Fixation, Forage Legume, Integration, Legumes Adoption, Livestock

Introduction

Livestock is an integral component for most of the agricultural activities in Ethiopia. The share of livestock sub sector in the national economy is estimated to be 12-16% to the total Gross Domestic Product (GDP), 30-35% to the agricultural GDP (LMA, 1999; Ayele et al., 2002); 19% to the export earnings (FAO, 2003); and 31% of the total employment (Getachew, 2003). Livestock contributes to the livelihoods of 60-70% of the Ethiopian population. Besides the well-known contributions as source of food, income and employment, draught power, manure and transport, livestock serve as productive assets that allow households to be self-provisioning, as critical buffer against falling into what is usually unremitting poverty and as springboard that enable some households to advance to relative wealth by the standards of contemporary Ethiopia (Zinash et al., 2001; Ayele et al., 2002; Alemayehu, 2004). Livestock also plays an important role in urban and peri-urban areas for the poor evoking a living out of it and for those involved in commercial activities (Ayele et al., 2002). Generally, the livestock sector is important in Ethiopia for economic development and for poverty reduction.

In order to keep the farming system healthy and sustainable, therefore, legumes should occupy a significant portion of area currently under cereals both as components of multiple cropping and in crop rotation (Pearson et al., 1995). In many parts of Ethiopia, soil is nitrogen deficient and often limits the productivity of the crop. Among the plant nutrients, nitrogen plays a very important role in crop productivity and its deficiency is one of the major yield limiting factors for cereal production. Different researchers (Amanuel et al., 2000; Kefyalew et al., 1999) also reported that continuous cereal production can result in yield decline, particularly where soil fertility and weed control practices are sub-optimal or where soil-borne diseases are common. One way to combat this problem is by using forage legumes, due to the process of symbiosis in legumes where mutual contact between rhizobium bacteria and the leguminous crop occur and roots fix atmospheric nitrogen in the nodules which supply nitrogen to the succeeding crops (Giller, 2001). Annual legumes are utilized in the form of green forage, forage dry matter, forage meal, grain, straw, silage, hay, while some of them are suitable for grazing as well (Mihailovc et al., 2007). These species represent excellent sources of green manure in the modern trends such as sustainable agriculture and organic farming. Getnet et al., (2003) reported that non-conventional forage production system is highly important and appropriate in areas where land shortage is a problem and the agricultural production system is subsistence. Integrating forage legumes with cereals generally results in higher fodder protein yield than cereal alone. Despite farmers’ recognition of the potential contribution of forage legumes to crop-livestock farming systems in the Ethiopian highlands, their integration is relatively low. Growing feeds is a new concept for most farmers and some farmers also mention fear that forages become weeds. Additional factors could be the rigid traditional farming system.
and food habit, whereby farmers give higher priority for crop than animal production. All the above listed factors are potential barriers for Ethiopian farmers to cultivate forage legumes into their farming systems. However, proper integration of forage legumes with cereals offers a potential for increasing forage and consequently, livestock and crop production. Gebremedhin et al., (2003) reported that improved nutrition through adoption of sown forage could substantially increase livestock productivity. Therefore, this research paper summarizes the outputs of forage legumes in crop-livestock mixed farming systems.

Significance of Tropical Legumes in Agriculture

Opportunities for intensification in smallholder farming systems are limited because of the inability of farmers to pay for external inputs. It is generally agreed that agricultural productivity should be increased in environmentally friendly and sustainable ways in order to ensure food availability to the ever growing human population. From the biological perspectives, sustainable agriculture is that which is managed toward greater resource efficiency and conservation while maintaining an environment favorable for the evolution of all species (Golley et al., 1992). A number of workers advise that agricultural sustainability should rely on the use and effective management of internal resources including crop rotation and intercropping of cereals with legumes with more efficient use of fertilizers (Pearson et al., 1995; Beebe et al., 2006), which is considered as economically feasible and ecologically sound (Bohlool et al., 1992). In order to keep the farming system healthy and sustainable, therefore, legumes should occupy a significant portion of area currently under cereals both as components of multiple cropping and in crop rotation (Pearson et al., 1995). Forages, in particular legumes, integrated with crops, trees and livestock can produce synergistic effects and minimize external inputs (Humphreys, 1994; Thomas et al., 1995). Tropical grasses were of lower quality than their temperate counterparts and introduction of adapted legumes into tropical grazing systems would simultaneously address the problem of low N status of leached tropical soils and low dietary protein intake by grazing ruminants. There is an emerging and significant role for legumes as a protein supplement to reduce reliance on expensive concentrates (Franzel and Wambugu, 2005) which often account for a high proportion of direct costs. The future of the tropical ruminant livestock sector seems assured with predictions of continuing strong demand for livestock products due to population increase (Kristjanson et al., 2004), and to an increasingly prosperous middle class in developing countries. However, production systems will need to intensify to meet demand for higher quality products while remaining environmentally sustainable. As production systems intensify, the inability of farmers to adequately feed their livestock year round will be even more important. The outstanding value of legumes in general is needed to meet the dry season feed gap, with the additional benefit of increased intake of associated poor quality roughage (Shelton, 2004b). Tree legumes are multipurpose, and their superior rooting depth delivers excellent water use efficiency and drought
tolerance (Shelton, 2004a). Forages can have both direct and indirect effects in increasing resource and land use efficiency (Humphreys, 1994). Direct effects on crop production include weed suppression, pest and disease reduction (when used in rotation), while indirect effects include their use as green manures, improved fallows, cover crops and live barriers. Production costs are decreased due to the reduced need for external inputs such as fertilizers and pesticides and there are environmental benefits from less contamination of crops and water with pesticide residues, conservation of fossil energy as well as soil improvement through nitrogen fixation. Biological nitrogen fixation makes an integral part of sustainable agro-ecosystems by contributing well over hundred million metric tons of renewable nitrogen per year to the nitrogen economy of the globe (Hardarson and Atkins, 2003; Hubbell and Kidder, 2003). Symbiotic nitrogen fixation is considered as the most important type of fixation for contribution to agricultural sustainability (Hubbell and Kidder, 2003). The amount of nitrogen annually fixed with symbiotic association is estimated to be far more than the amount industrially produced each year (Ishizuka, 1992; Bockman, 1997; Rengel, 2002). The contribution from symbiotic nitrogen fixation may rise by 3-4 folds for perennial forage and tree legumes where leaves can annually be pruned and incorporated into the soil (Pearson et al., 1995; Sanginga, 2003).

Effect of Environment on Growth and Development of Forage Legumes

It is established that a number of elements of growing environment interplay to determine the extent to which yield potential of a given crop genotype is expressed (Collaku et al., 2002). The elements of growing environment, in this sense, may include climatic, paedological, biological and crop management factors that affect crop growth and development (Annicchiarico, 2002). In nature, these elements of the growing environment do not exist in a proportion that is required for potential productivity of the crop plants. Plant growth and development are connected to the environment via a combination of liner and non-liner responses. In some cases, as much as 80% of the variability of agricultural production is due to variations in the weather, especially under rain fed conditions (Peter, 1991; Fageria, 1992; Hoogenboom, 2000). Agro-metrological variables such as rainfall, soil and air temperatures, wind, relative humidity or dew point temperature and solar radiation have major impacts on plants, pests and diseases (Hoogenboom, 2000). In turn, these influence crop growth and development and are some of the primary determinant of yield (Dapaah, 1997). Individual legume species or cultivars often require specific ecological niches for maximum production (Masaya and White, 1991), which should not be ignored when considering site suitability weather local, national or international (Valentine and Matthew, 1999; Rahman, 2002). In crop production, one of the first requirements is a site which is compatible with the day length, temperature and radiation requirements of the species or cultivar to be grown. A sound knowledge of the developmental and environmental factors contributing to yield and quality variation is
therefore required to maximize yield of agricultural crops. A quantitative understanding of phenological development in response to environmental factors is required to adequately predict forage yield. Of the environmental factors that affect growth, DM accumulation and its partitioning, soil and the atmospheric environment are the most important. In a production system, stresses such as drought, water logging, high and low temperatures affect crop growth and production. These are further influenced by biotic factors and management (Huda and Maiti, 1997). In most regions where temperature is appropriate for plant growth, water is among the most limiting factors for plant production and growth rates are proportional to water availability (Pugnaire et al., 1994). Plant growth is the result of cell division and enlargement and water stress directly reduces growth by decreasing CO₂ assimilation and reducing cell division and expansion (Pugnaire et al., 1994). Singh (1995) showed that in dry common beans, water stress during flowering and pod filling reduced yield and seed weight and accelerated crop maturity. In the same crop, water stress reduced the number of trifoliate leaves, stem height, the total number of main branches and the number of main stem nodes (Boutraa and Sanders, 2001). Growth responses are enhanced by certain diurnal temperature regimes compared with other regimes with the same mean temperature (Masaya and White, 1991). Temperature effects on assimilate partitioning to leaves and roots may reflect effects on the rate of water uptake by roots, which cause shifts in the balance between root and shoot growth (Masaya and White, 1991). Cool temperatures markedly reduce root growth and restricted the rate of water uptake (Masaya and White, 1991). Symbiotic nitrogen fixation is a process in which root nodule bacteria are able to reduce atmospheric nitrogen into ammonia (Giller and Wilson, 1991). Root nodule bacteria (RNB), generally known as rhizobium, are microsymbionts that infect roots of some legumes and transform atmospheric nitrogen into ammonia by the process of biological nitrogen fixation (BNF). Ammonia is further converted by oxidation or reduction to the forms NO₃⁻N and NH₄⁺N respectively, which are available to plants (Zahran, 1999). The plant furnishes the necessary energy that enables the bacteria to fix gaseous N₂ from the atmosphere and pass it on to the plant for use in producing protein. BNF by legumes is a key process in Low External Input Agriculture (LEIA) technologies as it potentially results in a net addition of N to the system. Forage legumes such as alfalfa (M. sativa) are nodulated by fast growing rhizobia of S. meliloti, vetch (V. dasycarpa) and trifolium species are induced by R. leguminosarum (biovar viceae and trifolii) respectively; whereas forage legumes like desmodium, cowpea and lablab are all nodulated and fix nitrogen by a slow growing ‘Bradyrhizobium’ species generally known as the cowpea miscellany (Giller and Wilson, 1991). Climatic factors like extreme temperatures, excessive soil moisture and moisture stress and edaphic factors like soil acidity, existence of mineral nitrogen in the soil and deficiencies of phosphorus, calcium, molybdenum, copper, cobalt, zinc and boron may cause poor nitrogen fixation (Pearson et al., 1995; Serraj et al., 2004; Pimratch et al., 2008). Toxicity by heavy metals was also found to reduce symbiotic nitrogen fixation which is compounded by acidity
Legumes normally require more phosphorus than nitrogen non-fixing crops (Serraj et al., 2004) as phosphorus is important in ATP synthesis for nitrogen fixation (Muhammad et al., 2004; Bucher, 2006; Qiao et al., 2007). Molybdenum is also considered an important constituent of the nitrogenase enzyme (Pearson et al., 1995).

Adoption of Forage Legumes in Mixed Farming Systems

Biological resources are fundamental to human well-being: in agriculture, livestock, export earning, economic output and for their ecological services and functions (Alemayehu, 2001). The complex topography coupled with environmental heterogeneity offers suitable environments for a wide range of life forms. However, the threat of genetic erosion of herbaceous legumes is serious due to the fact that they are palatable and easily affected by overgrazing (Getnet et al., 2003). The species and varieties of forage legumes are many in number and adapted to wide environmental conditions compared to food legumes. They have also different characteristics in terms of growth habit (erect, creeping, and climbing), life cycle (annual and perennial), climatic adaptation (tropical and temperate). These characteristics of legumes determine the utilization, production and the various management practices. Breeding of forage legumes has received little attention in the world, where the selection is usually made at species level based on high biomass yield, good nutritional quality, and high animal intake. Only few species, accessions and varieties are evaluated by mass selection but, advanced forms of breeding such as pure line selection and crossing are virtually not practiced (Getnet et al., 2003). Yield improvement in legumes is so difficult compared to cereals due to nitrogen fixation, which is an additional sink or demand for energy in legumes that the plant must confront. According to Steve et al., (2003), while all seeds producing plants remobilize leaf nitrogen to seed to form proteins as a mechanism of N nutrition for the following generation, the intensity of N remobilization in legumes is higher than in cereals, due to higher level of protein in seed. As seeds fills and protein is deposited, this result in a drain on leaf N, and early stress on the rate of net photosynthesis and this is a likely cause of lower yield potential of legumes, and might well contribute to frequently observe negative correlations between yield and seed protein or N concentration (Steve et al., 2003).

Reviews of the uptake of tropical forage legumes around the world have revealed that the original promise of legume technology has not been fully realized (Thomas and Sumberg, 1995; Peters and Lascano, 2003). There is an emerging view in developing countries that grasses are being adapted more quickly and more strongly than legumes. Legumes were regarded as less resilient than grasses under cutting or grazing, benefits were largely long-term in nature, and grass/legume systems were more complex to manage (Peters and Lascano, 2003). In many instances, lack of adoption could be related to failure of the technology for technical or socio-economic reasons, i.e. the technology did not live up to
expectations and/or was not targeted at the appropriate production system. Legumes did not persist under grazing was another significant disadvantage. This lead to widespread disappointment among farmers, extension workers and consultants. Lack of persistence was also cited as a reason for lack of adoption of forage legumes in Africa (Boonman, 1993). Socioeconomic factors contributed to the lack of adoption of legumes intercropping in communal grazing. Attempts to promote intercropping of maize with legumes in East Africa failed due to the high cost of technology, variable rainfall and lack of interest in innovation by older farmers. Legume adoption in West Africa was constrained by lack of extension information, credit and seed, high cost of fencing, shortage of labor, insecurity of land tenure and land scarcity, livestock diseases, invasion by weeds, and fire damage. The analysis indicated that success could be achieved when the technology led to profitability, on-farm environmental benefits such as fertility improvement or weed control, and other multipurpose benefits—often there was a combination of several benefits. However, most successful examples of adoption of forage legumes were unambiguously profitable for the adopter. Farmers normally choose profit, food and income security, before environmental protection. However, many scientists and government development personnel continue to justify the extension of forage legume technology by promoting natural resources management benefits, including off-farm benefits such as carbon sequestration and watershed management. The fundamental need for the legume technology to be firstly profitable and then afford delivery of on-farm environmental services as a secondary priority, cannot be emphasized strongly enough.

**Nutritional Qualities of Forage Legumes**

Moisture, temperature and the amount of sunlight influence forage quality. Rain damage is very destructive to forage quality. Temperature is among the environmental factors that have a direct influence on forage quality. A rise in temperature increases cell wall constituents, increase lignifications, decrease soluble carbohydrates concentration and decrease digestibility (Pearson and Ison, 1997). It also reduces the leaf to stem ratio of the forage, which directly affects the digestibility of the forage dry matter because of the lower digestibility of the stems in relation to the leaf (Buxton et al., 1995). The digestibility of forages decreases by about 0.5 to 7 percentage units per $1^\circ$C increase in temperature. This means that forages grown in cooler regions or seasons are of higher quality than forages grown in warmer climates. Similarly, the concentration of mineral elements in forages is dependent upon the interaction of a number of factors including soil, plant species, stage of maturity, yield, pasture management and climate (McDowell, 2003). Soil fertility affects forage yield much more than it does quality. While it is possible to produce high quality forage on poor unproductive soils, it is generally very difficult to produce high yields of high quality forage with an unproductive soil resource. Proper soil phosphorus (P) and potassium (K) levels help to keep desirable legumes in a mixed seeding and also reduce weed problems. It
is necessary to balance soil fertility to avoid mineral imbalances in ruminants. Low soil fertility, as well as very high fertility has resulted in reduced forage quality. After decades of breeding forages for yield and persistence, attention has recently been focused on developing or identifying varieties with improved quality. Several lesser factors also can influence forage quality. Weeds can negatively affect quality, especially in the case of noxious weeds. Insect pests can lower forage quality, particularly if they cause significant leaf loss. Plant diseases can affect quality when they result in a shift in the species present in the field and when they promote leaf senescence. Insects and diseases generally have their greatest impact on forage quality and persistence of forages.

Animal performance including milk production and growth rate depends on the quality of feeds, especially the forage available to the animal. The main determinants of forage quality are nutrient concentrations (crude protein and fibers), intake, digestibility and partitioning of metabolized products within animals (Juiler et al., 2001). Most of these attributes are shown to be strongly affected by plant species, plant morphological fractions, environmental factors and stage of maturity (Papachristou and Papanastasis, 1994). Forage quality is never static; plants continually change in forage quality as they mature. Maturity is the most important factor affecting forage quality. As plant cell wall content increases, indigestible lignin accumulates. In fact, forage plant maturity changes so rapidly that it is possible to measure significant declines in forage quality every two or three days. Maturity influences forage quality more than any other single factor, but plant environment and agronomic factors modify the impact of maturity on forage quality and cause year to year, seasonal and geographical location effects on forage quality even when harvested at the same stage of development. All forage plants are composed of cells having fibrous cell walls for support and protection. Since cell wall material is the primary constituent of forages, one of the main objectives of forage analysis is to characterize the cell wall fiber. Higher concentration of cell wall constituents was related to reduced intake and low digestibility (Sarwar et al., 1991) in ruminants. Plant fiber has three major components: lignin, cellulose and hemicellulose. Research on forage fiber has shown that each part of the cell wall has a specific digestibility. The lignin component comprises 0% to 20% of digestible material. The cellulose has digestible material in the 50% to 90% range, with hemicelluloses being 20% to 80% digestible (Linn and Martin, 1999). Riday et al., (2002) argue that the genetic variation of fiber content is one of the main reasons of forage quality variation. Variation in lucerne forage digestibility and forage intake is correlated with the variation in the cell wall content.

Both grasses and legumes have two main plant parts, leaf and stem. As a structural component of the plant, stems typically contain more fiber for support. Leaves, on the other hand, provide a means for capture and utilization of energy from sunlight and tend to be lower in fiber content than stems. Given the large difference between the digestible fiber of stems and leaves, the proportion of leaf to stem in given
Forage plant relates directly to its forage quality. Increased leaf contribution to yield leads to an increase in lucerne quality due to a higher crude protein content and greater digestibility and hence results in an increased nutritional value of the crop (Julier et al., 2001; Rotili et al., 2001). The variation in morphological characteristics such as leaf, stem, pod and flower fractions of forages accounts for parts of the difference in feed quality (Gezahagn et al., 2014). This variation in morphological characteristic is important in the selection of forage crops, which are agronomically suitable and used for various purposes such as hay, silage and grazing (Getnet and Ledin, 2001). The proportion of leaves in dry matter yield also depends on genetic factors, i.e. variety (Katic et al., 2005), as well as on stand density and the phenological stage of plant development (Lamb et al., 2006). Differences in forage quality between grasses and legumes can be very large. Since legumes are rich in protein (15-23%), especially in the leaves (over 25%), they are the most important source of crude protein in roughage (Vasiljevic et al., 2005). In contrast to the grasses, the fibers of which are less lignified and hence more digestible, forage legumes have fibers that are characterized by high levels of soluble nutrients. This compensates for the somewhat lower digestibility of their fiber resulting in an increased nutritive value. In addition, it has been established that legume fibers ferment more rapidly in the rumen (Hinders, 1995), that is why ruminants can consume larger amounts of legumes than grasses. Fresh, dried or preserved forage legumes are highly suitable for use as roughage in the animal diet because of their richness in protein, vitamins and mineral matter. As roughage, they are also characterized by increased fiber content (over 18% crude cellulose). The proportion of available (digestible) energy per unit weight or volume is lower in these feeds than in the concentrate and most of the energy is in the form of cellulose or hemi cellulose (Grubić and Adamović, 2003).

**Forage and Food Crops Compatibility in the Integration Systems**

There are various strategies to integrate forage legumes into crop-livestock farming system. The method of integration used for a specific farming system mainly depends on the type of forage crops, food crops, soil type, rainfall pattern, and other social and economic factors. Differences in phenological and morphological characteristics of crop species in mixture may lead to an increased capture of growth limiting resources (Silwana and Locus, 2002) leading to greater potential to acquire higher total yields than when crops are grown separately on the same area of land (Rao and Mathuva, 2000; Olufemi et al., 2001; Dapaah et al., 2003). It is commonly known that intercropping reduces weed infestation and in one of the integrated weed management strategies with less effect on the environment than the use of chemical herbicides. Ferguson and Rathimssbapathi, (2003) defined allelopathy as the beneficial or harmful effect that is caused by one plant or another thus releasing chemicals from plant parts by leaching, root exudates, volatilization, residue decomposition and other processes in both natural and
agricultural systems. Allelopathy also plays an important role in suppressing the growth of weed species (Regosa et al., 2000; Patil et al., 2002; Chung et al., 2003). When species are grown as sole crops it attracts many pests and diseases which might show less damage when intercropped compared to monoculture (Trenbath, 1993). This may be related to microenvironment effects of associated crops in intercropping compared to sole cropping (Letourneau, 1990). Maize stem borer was found to be more severe under sole cropping than intercropping with lablab [Lablab purpureus (L.)] (Maluleke et al., 2005). In many parts of Ethiopia, soil is nitrogen deficient and often limits the productivity of the crop. Among the plant nutrients, nitrogen plays a very important role in crop productivity and its deficiency is one of the major yield limiting factors for cereal production. Integrated nutrient management adopts a holistic approach to plant nutrient management by considering the totality of the farm resources that can be used as plant nutrients. Vesterager et al., (2008) found maize and cowpea intercropping is beneficial on nitrogen poor soils. Maize-cowpea intercropping increases the amount of nitrogen, phosphorous and potassium contents compared to mono crop of maize (Dahmardeh et al., 2010). Intercrops have been identified to conserve water largely because of early high leaf area index and higher leaf area (Ogindo and Walker, 2005). Various root systems in the soil reduces water loss, increases water uptake and increases transpiration, leads to create microclimate cooler than surroundings (Innis, 1997). Morris and Garrity, (1993) mentioned that water capture by intercrops is higher by about 7% compared to mono crop. Maize-cowpea intercropping, cowpea acts as best cover crop and reduced soil erosion (Kariaga, 2004). Reddy and Reddi (2007) mentioned taller crops act as wind barrier for short crops. Compatibility of forage legumes with food crops depends on the morphology and physiological characteristics of the integrated crops in combination with the response of each to management imposed and the climate, soil and biotic conditions under which the crop is growing. Silwana and Lucas (2002) found intercropping affects vegetative growth of component crops; therefore have to consider the spatial, temporal and physical resources. Economically viable intercropping largely depends on adaptation of planting pattern and selection of compatible crops (Seran and Brintha, 2009). The choice of compatible crops for an intercropping system depends on plant growth habit, land, light, water and fertilizer utilization (Brintha and Seran, 2009). There are some socio economic, biological and ecological advantages in intercropping over mono-cropping (Ali et al., 2000; Langat et al., 2006; Hugar and Palled, 2008). Silwana and Lucas (2002) reported different crop species in mixtures increased capture of growth limiting resources and reduce the competition. The biggest complementary effects and thus biggest yield advantages seen to occur when the component crops have different growing periods so make their major demands on resources at different times. Selecting crops or varieties with different maturity time can also assist staggered harvesting and separation of grain commodities. By this, the time of peak nutrient demands of component crops should be differed. Crops which mature at different times thereby
separating their periods of maximum demand to nutrient, moisture, aerial space and light could be suitably intercropped. Choosing of the crop combination plays vital role in intercropping. Plant competition could be minimized not only by spatial arrangement, but also by choosing those crops best able to exploit soil nutrients. In tropics, maize-cowpea intercropping is often practiced (M pangane et al., 2004). Yield is taken as primary consideration in the assessment of the potential of intercropping practices (Anil et al., 1998). In legume and non-legume intercropping, yield of non-legume increased in intercropping as compared with monocropping (Brintha and Seran, 2008). Mashingaidze (2004) found that by intercropping land was effectively utilized and yield was improved. Land Equivalent Ratio (LER) is the most common index adopted in intercropping to measure the land productivity. It is often used as an indicator to determine the efficacy of intercropping (Seran and Brintha, 2009). LER greater than one indicates greater efficiency of land utilization in intercropping system. Tsubo et al., (2005) stated legume-cereal intercropping is generally more productive than monocrop. Intercropping gives a greater stability of yield over monoculture and intercropping was more productivity than sole crop grown on the same area of land (Anil et al., 1998).

Crop rotation is an integral part of the crop production system. A well planned cropping sequence will reduce insect, pest, diseases, ameliorate soil structure, improve organic matter levels, prevents proliferation of weeds and consequently increase the crop yield. The general purpose of rotations are to improve or maintain soil fertility, reduce erosion, reduce the risk of weather damage, reduce reliance on agricultural chemicals and increase net profits (Bauman et al., 2000). Legumes in the rotation are used to increase the available soil nitrogen because legumes are a large, diverse and agriculturally important family of plants. According to Peoples and Craswell (1992) and Giller (2001), legumes can fix substantial amounts of atmospheric N₂, which allows them to be grown in N-Impoverished soils without fertilizer or N inputs. The fixed nitrogen leads to a higher protein concentration in its various plant parts which in turn enhances diet and can also be recycled into the environment as a form of fertilizer. It is argued that a system of land use involving periods of bare fallow is unsustainable because fallow is a destructive element in land use, contributing to wind, water and biological erosion of soils. There is also significant evidence that bare fallow contributes to the loss of organic matter from soil (Sule and Menov, 2004). Thus, falling could be an advantage to grow crops such as annual and perennial legumes to produce forage and at the same time to improve soil fertility and reduce erosion during falling periods.

Alley cropping is another way of intercropping and is done by planting alternating strips of crop and forage. On-farm study done by the Ethiopian Institute of agricultural research near Nazareth, Ethiopia, when alley cropping of Cajanus cajan and Sesbania sesban with sorghum, maize or haricot beans, the trees produce 2.8-3.0 ton of dry matter/ha⁻¹ without affecting the yield of the food crops (Mulatu et al., 1990). In the Ethiopian highlands, green fodder is scarce during the dry season and the inclusion of tree
legumes in the mixed crop-livestock system could help alleviate the fodder shortage. Among other species tagasaste and sesbania are performing well in terms of adaptation and fodder production. An alley cropping experiment of tagasaste in barely crop at Holetta, Ethiopia showed that, allaying of tagasaste did not reduce grain and straw yield of barely in fact a higher amount of green fodder was produced which could be used either for livestock feed or as a mulching for the next crop (HARC, 1998).

Over-sowing forage legumes in the natural pasture improve its botanical composition, forage yield, forage quality and the soil fertility. The natural pasture is estimated to contribute about 50 to 60% of the total feed supply, mainly in the upper highlands of Ethiopia. However, most of the pasture lands in the highlands are waterlogged bottom lands and land interrupted by gullies and rocks, and degraded steep slopes. Low productivity and degradation of these lands calls for an immediate intervention. Alemu (1990) reported that Desmodium uncinatum, Stylosanthes guianesis and Macroptilium atropureum fairly established and gave substantial herbage yield when over-sown in burned native pasture in the mid-altitude areas of Ethiopia. Among legumes, vicia species established well, when over-sown in natural pasture in the central highlands of Ethiopia. Sequential or relay cropping is another method of integrating forage crops in to the farming system in different agro-ecologies. This is when two crops are grown in a year one after the other. In areas where there is short rain forage crops could be grown in the short rains and cereals could follow during the main rainy season. On the other hand forage crops could be grown during the early parts of the main rainy season and food crops which usually grow with residual moisture like chickpea and Lathyrus will follow towards the ends of the main rainy season. Oats/vetch mixture could be planned as first crop to produce higher quality feed and chickpea followed as second crop without grain yield reduction due to the effect of the first crop. In the second year, wheat was planted on fields that were either Oats-vetch or fallowed land followed by chickpea. The study showed that, sequential cropping had a positive effect on wheat yield in the second year (Abate et al., 1996).

Conclusion
Forage legumes not only provide high quality and quantity feed for livestock but by fixing nitrogen they could maintain and improve soil fertility and reduce the cost of chemical fertilizers, in which prices are increased rapidly in recent years and their use will be limited in the long term. Mixed farming systems involving complementary interactions between crops and livestock such as using animal traction and manure for cropping and feeding crop residues to livestock are increasing in importance. Mixed farming also minimizes production risk due to the combination of crop and livestock enterprises. Compatibility of forage legumes with grasses depends on the morphology and physiological characteristics of the legume and grass, in combination with the response of each to management imposed and the climate, and soil and biotic conditions under which the crop is growing. The advantages of integration of forage legumes with
cereals are the possibility of N accretion from the legume to the cereal, maintenance of continuity of feed supply during the dry season, more efficient utilization of low quality cereals thorough the addition of high protein forages, return of manure from livestock to the field, increased crop productivity and greater dependability of return compared sole cropping. Generally forage legumes have various advantages to improve crop-livestock production systems so integration of the forage legumes in crop production system is very important for sustainable production.

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