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Technical manual for growing lablab and cowpea for animal feed in Sidama region

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Manual



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Cover photo: Lablab forage. Photo credit: Aberra Adie/ILRI

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Introduction

Livestock production in the Sidama Region is highly constrained by the shortage of quality animal feed, particularly during the dry season. Feed shortages negatively affect milk production, animal growth, reproductive performance, and overall livestock productivity. Traditionally, forage development efforts in Ethiopia focused mainly on forage quantity rather than forage quality (Turner & Duncan, 2020) However, current livestock production systems require greater emphasis on nutrient-rich forage production to improve land-use efficiency and animal productivity. Improved forage production strategies such as intercropping strengthen the integration between crop and livestock production systems. They also support soil and water conservation, enhance soil fertility, and improve sustainable land management (Mekonnen et al., 2022).

The International Livestock Research Institute (ILRI), in partnership with the Sidama Agricultural Research Institute (SIRARI), has been promoting integrated intensification practices in maize-growing woredas (districts) of the Sidama Region in Ethiopia's Central Rift Valley through research-for-development projects implemented in 2024 and 2025. In 2024, ILRI and SIRARI engaged 99 farmers from three kebeles in Hawassa Zuria Woreda in demonstrations of forage intercropping with maize. In 2025, they expanded the demonstrations to Boricha, Lok Abaya, and Bilate woredas, reaching an additional 312 farmers.

In the maize belt areas of Sidama Region, cowpea and lablab are best produced through intercropping between maize rows to maximize land utilization, improve soil fertility, increase total biomass production, soil moisture retention and suppress the growth of unwanted weeds.

Cowpea (Vigna unguiculata) and lablab (Lablab purpureus) are important leguminous forage crops that can contribute to increased forage availability and productivity in mixed crop-livestock production systems (Tesfaye et al., 2021). These crops provide high-quality forage rich in protein and digestible nutrients, while improving soil health through nitrogen fixation (Feedipedia, n.d.; Skerman et al., 1988). Improving access to quality forage throughout the year can increase milk and meat production at reduced feed costs, improve animal health and reproduction performance, and reduce greenhouse gas emissions per unit of livestock product (African Union, 2020; Herrero et al., 2009).

Building on these benefits and the field demonstrations conducted in the Sidama Region, there is a need to strengthen farmers' and development agents' / extension experts' knowledge and skills in producing forage legumes through intercropping with maize. Appropriate guidance on land preparation, planting methods, spacing, crop management, harvesting, and forage utilization can help farmers improve forage availability and quality while making efficient use of available land. This manual therefore provides practical, farm-level guidance on improved forage production, with particular emphasis on intercropping cowpea and lablab with maize under the farming conditions of the Sidama Region.

Objectives of the manual

The general objective of this manual is to provide practical and technical guidance for farmers, development agents, and livestock experts on improved forage production in general and inter-cropping of forage legumes with maize in particular under farm conditions to enhance food and nutritional security, diversify income generation opportunities and improve soil health

The specific objectives are to:

- Improve forage production at farmer level
- Improve livestock feed availability and quality
- Enhance farmers' knowledge of forage agronomic practices and seed production
- Understand the characteristics of the forage legumes to be intercropped with maize

Characteristics of the forage legumes (cowpea and lablab) intercropped with maize

Cowpea





Photo 1: Cowpea forage. Photo credit: Aberra Adie/ILRI Photo 2: Cowpea seed. Photo credit: Ozgu Coskun.

General characteristics

Description: Cowpea (*Vigna unguiculata* (L.) Walp.) is a member of the family Fabaceae and is an herbaceous legume exhibiting erect, trailing, or climbing growth forms. Its leaves are alternately arranged and trifoliate. The inflorescences are racemose, and the flowers vary in colour from white or yellowish white to violet or purple. Pods and seeds show considerable morphological variation, with seeds ranging from oblong to reniform and displaying various colours (Royal Botanic Gardens, Kew, n.d.; World Flora Online, 2026).

Uses: Cowpea (*Vigna unguiculata* (L.) Walp.) is a dual-purpose legume that provides food for humans and feed for livestock. Its seeds, pods, and succulent leaves are consumed as human food, while the forage can be used for grazing, hay or silage. Cowpea provides nutritious feed for livestock and is suitable for both cattle and sheep fattening as well as feeding dairy cows. In addition, cowpea can contribute to soil fertility through biological nitrogen fixation and can be incorporated into the soil as green manure or used in crop rotation systems (Habte et al., 2023).

Nutritive value: Cowpea (*Vigna unguiculata*) is a nutritionally valuable forage legume. Its nutritive value varies according to factors such as plant part, maturity stage, variety and growing conditions. Cowpea leaf sample collected in Ethiopia at flowering in ILRI's Sub-Saharan Africa Feed Composition Database contained 27.25% crude protein, 22.21% neutral detergent fibre, 14.24% acid detergent fibre and 2.62% acid detergent lignin (ILRI, 2021).

Adaptation: Cowpea (Vigna unguiculata (L.) Walp.) grows in a wide range of soils, from sandy soils to heavy, well-drained clays. However, lighter soil is preferred because it promotes root development. The crop is moderately tolerant of drought and heat but sensitive to frost, prolonged flooding, and salinity. Major pests include the legume pod borer (Maruca vitrata), pod-sucking bugs, thrips, and the postharvest cowpea weevil (Callosobruchus maculatus) (Habte et al., 2023).

Establishment: Cowpea (*Vigna unguiculata* (L.) Walp.) can be grown as a sole crop or intercropped with cereals such as maize. Research conducted at Adami Tulu and Dugda districts in Ethiopia demonstrated that maize–cowpea intercropping can provide additional forage biomass, with appropriate cowpea seeding ratios and planting times improving the productivity of the system (Aredo et al., 2023). Cowpea is a nitrogen-fixing legume and therefore contributes to soil fertility. On soils with low fertility, fertilizer application at establishment may be beneficial. However, recommendations for seed rate, spacing, and fertilizer application should be adapted to the variety, production objective, and local growing conditions.

Inter-cropping cow pea with maize: Cowpea (*Vigna unguiculata* (L.) Walp.) is well suited to intercropping with cereal crops such as maize. In Ethiopia, cowpea has been evaluated under maize at different seeding ratios and planting times. Planting time significantly influenced cowpea forage biomass and maize grain yield. A 75% cowpea seeding ratio planted 10 days after maize produced 1.78 t/ha of cowpea forage biomass without significantly reducing maize grain yield under the conditions of the study (Aredo et al., 2023).

Field management: Cowpea is susceptible to various diseases and pests. Therefore, proper field management, follow-up, and treatment are essential at field level and at post-harvest seed management stage. Early weeding and keeping the plot clean reduces competition for water and nutrients and at the same time it is good to minimize pest and disease infestations.

Harvesting: Cowpea (*Vigna unguiculata* (L.) Walp.) can be harvested at different stages depending on its intended use. For forage production, harvesting stages should be selected to balance forage yield and quality, with flowering and maturity being important indicators for determining harvest time. Cowpea can be utilized either as green forage or conserved as dry fodder. In southern Ethiopia, significant differences in days to 50% flowering and forage dry-matter yield have been reported among cowpea accessions (Atumo, 2018).

Feed conservation and utilization: Cowpea (*Vigna unguiculata* (L.) Walp.) forage can be utilized as green fodder or conserved as hay and provides a valuable protein-rich feed resource for livestock. Studies conducted in Ethiopia have demonstrated appreciable crude protein content and digestibility in cowpea forage, indicating its potential to supplement lower-quality basal feeds (Gebreyowhans & Gebremeskel, 2014).

Hay making: Good-quality hay can be produced from cowpea (*Vigna unguiculata*) forage. Forage harvested around the flowering to early pod-development stage can be conserved as hay for livestock feeding. The harvesting must be done in good weather so that wilting of the forage is done in rain free or bright sunny weather. It is important to maintain the greenness of the forage while extracting the moisture by thinly spreading harvested material in a well-ventilated, dry and shaded surface where any dropped leaves could also be collected and heaped in a well-protected storage for use in time of need. When intercropped with other food crops, cow pea can be harvested with the residue of the main crop after the grain of the main crop has been harvested. The harvested residue/forage mixture can be chopped either using traditional tools or a forage chopper machine to break down the sizes to a size easily consumed by the animals (small ruminants and large ruminants). The chopped material can be fed to the animals at any time of the day or can be stored for future use after the legume is wilted.

Forage yields: Cowpea (Vigna unguiculata) can produce substantial amounts of forage (up to 10 DMT/ha forage), although dry-matter yield varies with variety, environment, and management. After grain harvest, cowpea can provide approximately 3–10 t DM/ha of crop residues for livestock feeding (International Livestock Research Institute [ILRI], 2013).

Contribution of cow pea forage to livestock production:

Cowpea forage is a valuable protein source for growing ruminants and can be incorporated into balanced diets to support nutrient intake, digestibility, and animal growth. However, supplementation rates should be determined according to the animal's live weight, physiological status, forage quality, and composition of the basal diet.

Cowpea (*Vigna unguiculata*) forage is an important feed resource for ruminants because of its potential to provide nutritious fodder alongside grain production. Singh et al. (2003) examined the production and utilization of cowpea as both food and fodder, emphasizing its dual-purpose role. Mediksa et al. (2016) demonstrated that cowpea hay could replace up to 50% of a formulated concentrate mixture in diets of lactating Horro cows fed natural grass hay without a significant reduction in milk yield or live weight. The 50% replacement treatment also recorded the highest dry-matter and crude-protein intake among the treatments (Mediksa et al., 2016).

Seed production

Establishment and farm management: When establishing cowpea for seed production, special care must be taken with site selection and seedbed preparation. Agroecological conditions, including elevation, rainfall, soil type, etc., where cowpea is adapted must be checked before deciding on the site. Seed for seed production must come from a credible source, with clear variety identification and certification from the regulatory body. Proper isolation distance from other cowpea plots must be maintained to reduce the risk of cross-pollination. At the farm level, an isolation distance of 10–20 m may be adequate for maintaining seed for own use, while 20–50 m may be used when producing certified seed. Alternatively, different varieties may be planted at different times, with a 2–3-week interval between planting dates (Sinkala et al., 2022).

Seeding rate and fertilizer application for seed production must be lower than when planted for forage production. Timely weeding and pest control is mandatory for clean seed production.

Seed harvesting: Seed harvesting should be done before the crop is too dry and is suggested to be done when most of the pods turn yellow. This will reduce loss of seeds by shattering if overdried in the field. The harvested pods must be left under shed for further drying until the pods are brittle and the seeds are too hard to dent with a fingernail.

Threshing and cleaning: Threshing can be carried out manually by beating with sticks, trampling by animals or with the help of machines. In any case, care must be taken to minimize seed damage as cow pea seeds are easily breakable. Seed cleaning can be done traditionally by winnowing and sieving or with the help of machines.

Seed storage: Cowpea (*Vigna unguiculata* (L.) Walp.) seed should be adequately dried before storage because seed moisture content is an important determinant of storage longevity and subsequent germination. Cowpea seeds stored at 10% moisture content maintained higher viability and vigour than seeds stored at higher moisture levels (Awosanmi et al., 2020). Properly dried cowpea can also be stored in tightly sealed or hermetic containers to protect the grain during storage.

Seed quality: Cowpea seed intended for planting should meet the minimum quality requirements specified in the Ethiopian cowpea seed standard, including requirements for germination, physical and varietal purity, and other relevant seed-quality parameters (Quality and Standards Authority of Ethiopia [QSAE], 2000)

Seed yield: Cowpea (*Vigna unguiculata* (L.) Walp.) grain yield varies considerably depending on variety, environmental conditions, and crop management. Under Ethiopian experimental conditions, improved varieties have produced grain yields exceeding 1,200 kg/ha, with some varieties achieving approximately 1,525 kg/ha (Asrat et al., 2021)

Table 1. Improved cowpea (Vigna unguiculata (L.) Walp.) varieties released in Ethiopia

No.	Variety	Year released/registered	Releasing/Breeding research center
1	Black Eye Bean	1976	Melkassa Agricultural Research Center
2	White Wonder Trailing	1976	Melkassa Agricultural Research Center
3	TVU 1977OD-1	1978	Melkassa Agricultural Research Center
4	Bekur	2001	Sirinka Agricultural Research Center
5	Asrat	2001	Sirinka Agricultural Research Center
6	Bole	2006	Melkassa Agricultural Research Center
7	Asebot	2008	Melkassa Agricultural Research Center
8	Sewunet	2009	Pawe Agricultural Research Center
9	Kenketi	2012	Melkassa Agricultural Research Center
10	Temesgen	2014	Humera Agricultural Research Center
11	Melka	2018	Melkassa Agricultural Research Center
12	Adulala	2018	Melkassa Agricultural Research Center
13	White Wonder	Not specified	Melkassa Agricultural Research Center
14	ILRI-IT83D-442*	2022	Bako Agricultural Research Center
15	ILRI-11114*	2022	Bako Agricultural Research Center

Source: Adapted from Urgesa (2023) and Ethiopian crop-variety information

Lablab



Photo 3: Lablab forage. Photo credit: Aberra Adie/ILRI

General characteristics

Description: Lablab (*Lablab purpureus* (L.) Sweet; family Fabaceae) is a vigorous herbaceous legume with climbing or, in some cultivated forms, erect growth habits. It may occur as an annual or perennial and can attain a stem length of up to 6 m. Its leaves are trifoliate, and the flowers may be white,

cream, crimson, or purple. The pods are approximately 3.5–14 cm long and generally contain 2–5 seeds. Seeds vary considerably in colour, ranging from white and red to black, and are typically oblong and compressed (Royal Botanic Gardens, Kew, n.d.). World Flora Online similarly describes lablab as a twining herb with stems reaching 6 m, trifoliate leaves, white or purple flowers, pods approximately 5–7 cm long, and usually 3–5 seeds that vary from white to purple-black.

Uses: Though there are varieties which are edible by humans, most of the varieties promoted in the Ethiopian context are forage types which are used for livestock feeding. As lablab is one of the nutrient–rich forages it is used as supplemental feeding rather than sole feed. It can be utilized by green harvesting (cutting, wilting and mixing with other feed resources), hay making and crop residue (after grain harvest). Lablab (*Lablab purpureus* (L.) Sweet) is a versatile forage legume that can be utilized through grazing or conserved as hay or silage. It is commonly used as a supplementary livestock feed and can also be incorporated into cropping systems as a green-manure or break crop. As a forage legume, lablab can contribute to the restoration of soil fertility and support the sustainable intensification of mixed crop-livestock production systems (Teshome et al., 2024).

Nutritive value: Lablab (*Lablab purpureus*) is a nutritious forage legume with relatively high protein content and digestibility, although its nutritive value varies with plant part, maturity and other factors. Ethiopia-specific records in ILRI's Sub-Saharan Africa Feed Composition Database show that aerial lablab forage harvested at late flowering contained 18.13–23.94% crude protein, 31.47–43.53% NDF and 62.31–74.46% in vitro dry matter disappearance, with metabolizable energy ranging from 9.04 to 9.75 MJ/kg. Lablab leaves may have considerably higher protein concentrations; one ILRI Addis Ababa sample contained 31.19% crude protein (ILRI, 2021)

Adaptation: Lablab (*Lablab purpureus* (L.) Sweet) is adapted to a relatively wide range of tropical and subtropical environments and has been evaluated successfully under different agroecological conditions in Ethiopia (Faji et al., 2020). It performs best at elevations up to about 2,000 m and can survive under annual rainfall ranging from approximately 400 to 2,500 mm. It is drought tolerant once established and grows on soils ranging from sandy loams to heavy clays, provided drainage is adequate. Reported suitable soil pH ranges include approximately 5.0–7.5, while optimum temperature recommendations are around 18–30°C. Lablab has low tolerance to salinity and prolonged waterlogging and is susceptible to frost. [idosi.org]

Diseases and pests: Lablab (*Lablab purpureus* (L.) Sweet) can be affected by a range of diseases and insect pests during crop growth and seed production. Leaf-spot diseases have been documented in lablab, including infections caused by *Alternaria* species, while pods and seeds may also be damaged by pod-feeding and boring insects (Singh et al., 2025; Tropical Forages, n.d.). Regular monitoring of the crop is therefore important so that pest and disease problems can be identified early and appropriate management measures can be selected with relevant plant-health or agricultural-extension advice.

Establishment: Lablab (*Lablab purpureus* (L.) Sweet) can be established as a sole forage crop or intercropped with cereal crops. In Ethiopia, lablab has been successfully under sown with maize, demonstrating its potential to increase forage biomass and improve the quality of maize stover(Wana et al., 2020). For establishment, seed rates of approximately 25–30 kg/ha for pure stands have been reported, with seed generally placed about 2–3 cm deep in adequately drained soil. As a forage legume, lablab can contribute to biological nitrogen fixation, and lablab-based cereal intercrops have been associated with improved soil nitrogen and crop productivity.

Intercropping lablab with maize Lablab (*Lablab purpureus*) is a valuable forage legume that can be successfully intercropped with cereal crops such as maize and sorghum, providing additional high-

quality forage within mixed crop–livestock production systems (Mpairwe et al., 2002; Redae & Tekle, 2020).

It can be planted during the first weeding of the main crop which usually occurs within a month after planting the main crop or can be planted after grain filling stage of the main crop. In the latter case, competition for moisture and nutrients is relatively low and hence less negative impact on the grain yield of the main crop. Seed rate can be reduced to half of the normal rate of sole cropping while intercropping and seeds can be drilled between the rows (50 – 80cm) of the main crop in 30-50 cm interval between plants.

Field management: Early hand weeding of the plots is always important for best establishment of the crop. Lablab can suppress weeds after the first weeding. Adequate follow up of the field for disease or pest incidence and taking timely preventive and combatant action is always mandatory.



Photo 4: Maize-legume intercropping. Photo credit: Amare Argaw

Harvesting: Depending on the purpose, lablab can be harvested at various stages of plant growth. If it is intended for green fodder or hay making, the ideal time for harvest is at about 50% flowering to early podding of the plot. If the original plan is for seed and residue harvest, it can be harvested when most of the pods have matured (more details on seed harvest are discussed in the seed production part below). If the lablab is intercropped with cereal crops, the forage is harvested together with the crop residue once the grain of the main crop has been collected.

Feed conservation and utilization: Lablab forage can be fed to livestock as green supplement, hay or crop residue. When feeding as green fodder, lablab should be harvested at 50% flowering stage in a portion sufficient for the number of animals to be fed and wilted in sunlight for about 2-3 hours and can be chopped and mixed with roughage feed (crop residues or grass hay) in a proportion of 3:1 (roughage: lablab forage).

Hay making: Lablab (*Lablab purpureus*) can be conserved as hay and used as a valuable forage supplement, particularly during periods of feed scarcity (Madzonga & Mogotsi, 2014).

The harvesting must be done in good weather so that wilting of the forage is done in rain-free or bright sunny weather. It is important to maintain the greenness of the forage while extracting the moisture by thinly spreading the harvested material in a well-ventilated and shaded dry surface, where any dropped leaves could also be collected and heaped in a well-protected storage for use in time of need.

When intercropped with other food crops, lablab can be harvested with the residue of the main crop after the grain of the main crop has been harvested. The harvested residue/forage mixture can be chopped either using traditional tools or a forage chopper machine to break down the sizes to a level easily consumed by the animals (small ruminants and large ruminants). The chopped material can be fed to the animals at any time of the day or can be stored for future use after the legume is wilted.

Forage yields: Lablab (*Lablab purpureus* (L.) Sweet) is a high-yielding forage legume capable of producing approximately 6–9 t DM/ha annually, although forage yield varies with genotype,

environmental conditions, crop management, and stage of harvest (Teshome et al., 2024). The crop may be managed for additional forage production after cutting where sufficient regrowth occurs, but regrowth performance depends on growing conditions and management.

Contribution of lablab forage to livestock production

Lablab is a nutritious, protein-rich forage that can be used to supplement poor-quality feeds, especially during the dry season. Supplementing animals with lablab can improve productive performance, including milk production and live-weight gain (Mpairwe, 2003; Duguma et al., 2020). Lablab hay can be combined with other roughages, such as grass hay or straw, rather than being fed alone.

Seed production

Establishment and farm management: When lablab is established for seed production, especial care must be taken during site selection and seed bed preparation. Agroecological conditions including elevation, rainfall, soil type, etc. where lablab is adapted must be checked before deciding on the site. The source of seed for seed production must be from a credible source with clear identification for varieties and certification from the regulatory body.

To maintain varietal purity during lablab seed production, seed plots should be adequately isolated from other lablab varieties to minimize the risk of cross-pollination. Isolation may be achieved spatially by maintaining an appropriate distance between varieties or temporally by staggering planting dates so that flowering periods do not overlap.

Seeding rate and fertilizer application for seed production must be lower than when planted for forage production. Timely weeding and pest control is mandatory for clean seed production.

Seed harvesting: Lablab pods begin to dry around the base of the pod rather than the top, and seed should be collected (hand-picked) before the upper pod matures to protect from weather and insect damage. This will reduce loss of seeds by shattering if over-dried in the field. Then another round of collection can follow when lately matured seeds are ready for harvest. The harvested pods must be left under shed for further drying until the pods are dry and the seeds are too hard to dent with a fingernail.

Threshing and cleaning: Threshing can be carried out manually by beating with sticks, trampling by animals or with the help of machines. In any case care must be taken to minimize seed damage of the seeds. Seed cleaning can be done traditionally by windowing and sieving or with the help of machines.

Seed storage: Lablab seeds should be adequately dried before storage to maintain seed viability and quality. A moisture content of about 10% is suitable for safe storage, while refrigerated storage at ≤5°C helps maintain germination and seed quality during prolonged storage (Yahaya et al., 2022).

Seed quality: The quality of lablab seed should be assessed based on key parameters such as germination percentage, physical purity, and seed moisture content, specified in the Ethiopian seed standard, including requirements for germination, physical and varietal purity, and other relevant seed-quality parameters following applicable seed-quality and certification standards.

Seed yield: Depending on genotype, location, and management conditions, lablab seed yield can vary considerably; under lowland conditions of southwestern Ethiopia, an average seed yield of about 9.4 qt/ha has been reported (Aleme et al., n.d.).

Table 2: Lablab varieties released in Ethiopia

Variety name	Accession no.	Year of release	Institute released
Bechi	ILRI-11613	2022	EIAR/TNSRC
Doli-II	ILRI-147	2019	EIAR/MARC
Doli-I	ILRI-11640	2019	EIAR/HARC
Beresa-55	ILRI-14455	2016	EIAR/BARC
Gebis-17	ILRI-14417	2016	EIAR/BARC
Foyesa	ILRI-14490	2024	EIAR/FARC

EIAR -Ethiopian Agricultural Research Institute; TNSRC – Tepi National Spice Research Center; MARC – Melkasa Agricultural Research Center; HARC – Holeta Agricultural Research Center; BARC – Bako Agricultural Research Center; FARC – Fedis Agricultural Research Center

Source: Ethiopian Ministry of Agriculture crop variety registration information and published Ethiopian forage-variety research. The 2024 release of Foyesa (ILRI-14490) is documented by Fikadu et al. (2024)

On-farm demonstration of intercropping lablab and cow pea with maize in Hawassa Zuria woreda, Sidama region

Background

As explained in the introduction part of this document, ILRI, through its various research for development projects, has been partnering with Sidama Agricultural Research Institute and other partners to demonstrate its research outputs to the farmers. Sidama region is one the maize belts in Ethiopia which is characterized by limited agricultural lands associated with high population density. Introducing forage legumes which are compatible with the existing farming system and the crops grown has been deemed necessary to alleviate the ever-increasing feed shortage both in terms of quality and quantity.

Methods

Project sensitization, farmer selection and training: Project sensitization workshops have been conducted with various stakeholders from Sidama region and national institutions to discuss the need, opportunities and potential gaps to introduce forage legumes into the maize-growing woredas of Sidama region. Following the workshop, which paved the way for the intervention, selection of kebeles and volunteer farmers has been carried out by the Hawassa woreda livestock and fisheries office with the help of staff from SIRARI. The selected farmers along with the extension workers (DAs and experts) were given awareness creation and project sensitization followed by technical training on the inter-cropping of maize with forage crops like cow pea and lablab.

Two accessions of each of cowpea (Vigna unguiculata -accessions ILRI 9334 and ILRI 12688) and lablab (Lablab purpureus – accessions ILRI 11609 and ILRI 147) have been used for farm level demonstration of maize-legume intercropping. The seeds have been sourced from ILRI forage seed unit. Each of the farmers in the three kebeles have put aside 500m2 of land voluntarily from their maize plots. Each farmer was entitled to take one accession of lablab and one accession of cowpea to intercrop each accession in the 500m2 within maize field. The legumes were planted at a rate of 15-20 kg/ha between the maize rows (row spacing of 75-80cm) at the knee height stage of the maize crop which has been planted earlier. Forage and maize biomass sampling has been made from seven farms in two kebeles (Makbasa Korke and Sama Ijersa) to estimate maize grain yield and forage biomass (maize stover and intercropped legumes).

Measurements

Feed biomass (maize stover and intercropped legumes) and maize grain have been measured from sample farms intercropped with forage legumes and from the adjacent maize farms which were not intercropped (control) to determine the total productivity of the plots with and without forage intercropping after the grain harvest of the maize. In addition, samples of the forages and maize stover from all treatments have been analyzed for major nutritional values at ILRI nutrition laboratory in Addis Ababa.

Maize legume intercropping at farmer's field

Table 3. Description of treatment arrangements used for the on-farm sampling

SN	Location	Farmer	Maize-legume intercropping (Treatments)
1	M.Korka	Mara Dingam	M_C12688, M_C9334, M_L11609, M_L147 and M_weed
2	M.Korka	Kebede Burisa	M_C12688, M_C9334, M_L11609, M_L147 and M_weed
3	M.Korka	Beria Bekele	M_C9334, M_L11609 and M_weed
4	M.Korka	Sergi Sanja	M_C12688, M_L147 and M_weed
5	Sama Ejersa	Desta Alaso	M_C9333, M_L147 and M_weed
6	Sama Ejersa	Netsnet Letamo	M_C9334, M_L147 and M_weed
7	Sama Ejersa	Abayenesh Tukulo	M_C9334, M_L147 and M_weed

M_C 12688 = Cow pea accession 12688 intercropped with maize
M_C9334 = Cow pea accession 9334 intercropped with maize
M_C9333 = Cow pea accession 9333 intercropped with maize
M_L11609 = Lablab accession 11609 intercropped with maize
M_L147 = Lablab accession 147 intercropped with maize

Statistical Analysis

Data were analyzed using a linear mixed-effects model to account for the unbalanced on-farm experimental structure. Treatments were considered as fixed effects, while farmer fields were treated as random effects to capture variability among individual experimental fields within locations. A unique farmer field identifier was created by nesting farmers within locations. The statistical model used was:
$Y = \mu + Ti + Fj + \varepsilon ij$

where Y is the observed response variable (total feed yield or grain yield), μ is the overall mean, Ti is the fixed effect of the i^{th} treatment, Fj is the random effect of the j^{th} farmer field, and εij is the residual error term. The mixed model was fitted using the lmer function in the **lme4** package in R. The significance of treatment effects was tested using likelihood ratio tests by comparing the full model with a reduced model without the treatment term. Estimated marginal means (EMMs) for treatments were calculated using the **emmeans** package, and treatment means were separated using an LSD-type grouping procedure based on pairwise comparisons without adjustment. Bar graphs of treatment means with standard error bars and grouping letters were generated to visually illustrate treatment performance.

Summary of results

Mixed-model analysis revealed that treatments significantly influenced total feed yield (LR $\chi^2 = 14.31$, df = 5, P = 0.0138). The estimated marginal means of total feed yield ranged from 4.35 to 10.48 t ha^{-1} among treatments. The highest total feed was recorded for treatment M_C9333 (10.48 ± 2.41 t ha^{-1}), followed by M_L11609 (8.11 ± 1.04 t ha^{-1}) and M_C9334 (7.35 ± 0.83 t ha^{-1}). The lowest yield was observed for the weedy control treatment (4.35 ± 0.68 t ha^{-1}). Mean separation indicated that

treatment M_C9333 formed the highest statistical group, whereas the weedy control showed the lowest performance. Treatments M_C12688 and M_weed formed intermediate statistical groups, while the remaining treatments did not differ significantly from the highest-yielding treatment. The bar graph illustrates the treatment means with standard error bars and grouping letters obtained from mean separation analysis (Figure 2).

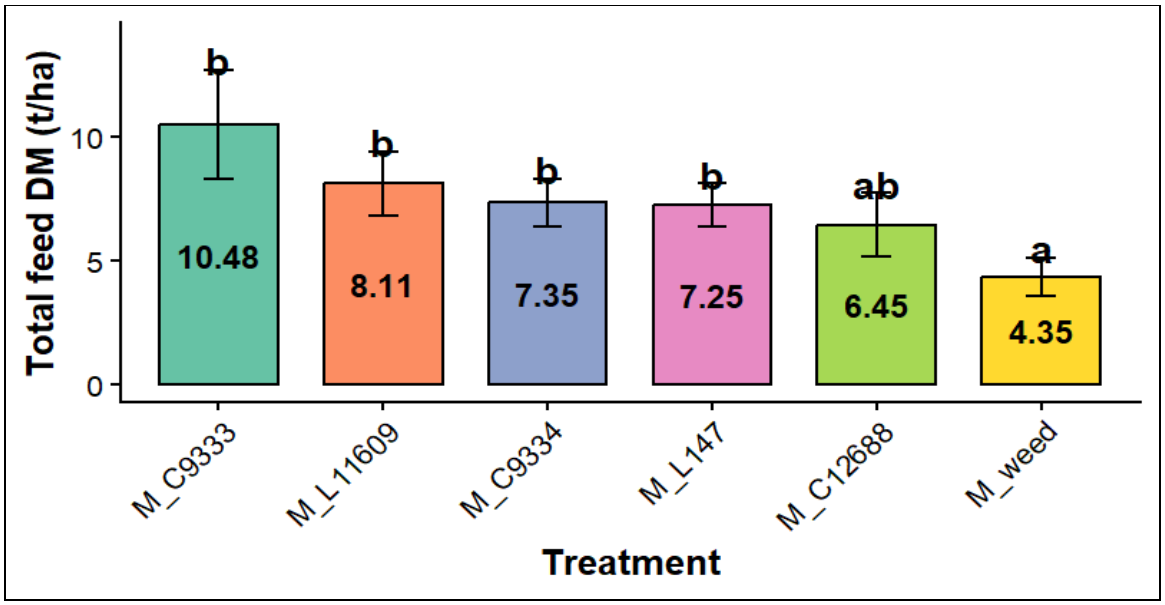


Figure 1. *Effect of maize-legume intercropping on total feed yield (t/ha). Treatments sharing the same letter are not significantly different according to LSD test at P ≤ 0.05.*

In contrast to total feed yield, mixed-model analysis indicated that treatment effects on grain yield were not statistically significant (LR χ^2 = 5.58, df = 5, P = 0.3489). Estimated marginal means of grain yield varied from 4.32 to 7.25 t ha^{-1} across treatments. Treatment M_C9333 produced the highest estimated grain yield (7.25 ± 2.06 t ha^{-1}), followed by M_L11609 (7.04 ± 1.13 t ha^{-1}) and M_C9334 (6.05 ± 0.91 t ha^{-1}). The lowest grain yield was obtained from treatment M_C12688 (4.32 ± 1.14 t ha^{-1}). The grain yield performance of the treatments follows a similar trend with that of the total feed except the maize-weedy control (4.88 t ha^{-1}) out yielded M_C12688 (4.57 t ha^{-1}). However, because the treatment effect was not significant, mean separation analysis indicated that all treatments belonged to the same statistical group at the 5% probability level (Figure 4).

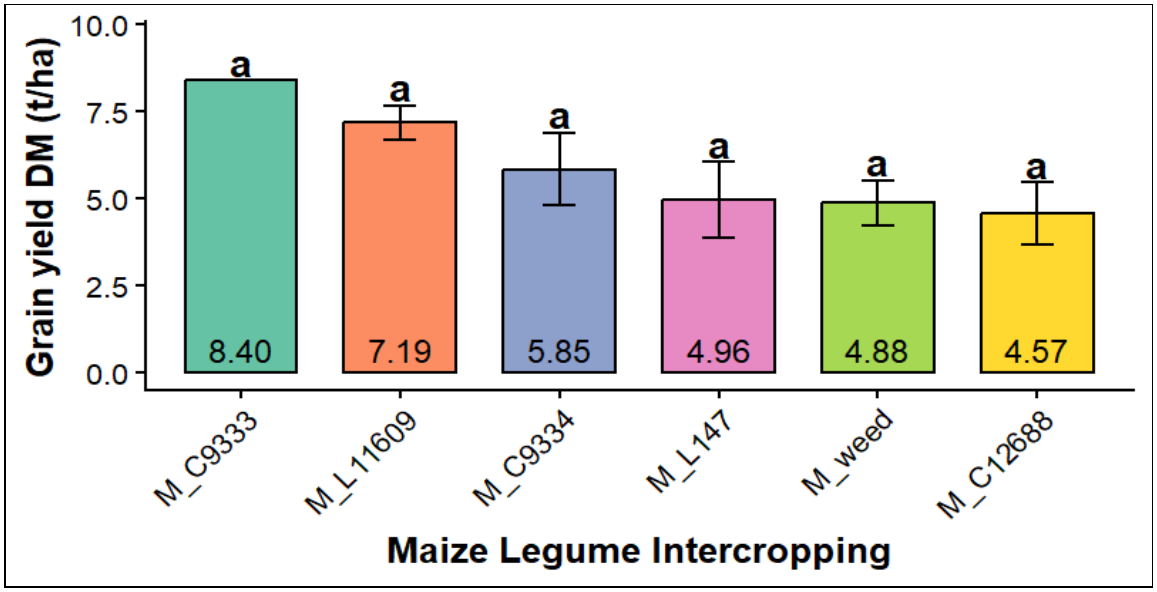


Figure 2. *Effect of maize-legume intercropping on grain dry matter yield (t/ha). Bars represent treatment means with standard errors.*

Conclusion and recommendations

The mixed-model analysis showed that treatments significantly affected total feed but did not significantly influence grain yield. Based on the findings of this study, maize–legume intercropping can be considered a promising strategy for improving biomass production without negatively affecting maize grain yield under farmer field conditions. Among the evaluated treatments M_C9333 (10.48 t ha^{-1}), M_L11609 (8.11 t ha^{-1}) and M_C9334 (7.35t ha^{-1}) showed the highest total feed and therefore appears to be a particularly suitable option for enhancing forage availability in mixed crop–livestock production systems. Although grain yield differences among treatments were not statistically significant, the overall performance of the intercropping treatments suggests that integrating legumes with maize can contribute to improved system productivity.

Nutritional analyses reported by the ILRI's laboratory confirmed that legume forages have far superior crude protein (21–22%) and digestibility compared to maize stover (6.9% CP). These findings agree with farmer testimonies of increased milk production, improved animal condition, and reduced reliance on purchased feed, which was expressed during the field day experience sharing events around the intervention.

Feed conservation and utilization

Traditional methods of conserving and utilizing maize stover and other crop residues in the Sidama Region, as in many parts of Ethiopia, can result in considerable feed wastage and contamination. These practices may reduce feed intake and digestibility and consequently limit livestock productivity. To address these challenges, ILRI procured a multipurpose electric forage chopper that can chop crop residues and other feeds to appropriate particle sizes, helping to reduce wastage, improve feed utilization, and facilitate mixing with other feed ingredients. The chopper is particularly relevant for market-oriented livestock producers seeking to improve feed preparation and utilization. During field demonstrations, farmers expressed interest in accessing the chopper through cooperatives or organized service-provision groups, provided that appropriate institutional support and access mechanisms are established.



Photo 5: Forage chopper demo. Photo credit: Haimanot Seifu

Key lessons from the maize-forage intercropping and feed processing demonstrations in Sidama region

Land shortage, especially in the mixed crop-livestock system of Ethiopia, prompted by competition for crop production, urbanization and infrastructure development, has triggered feed shortage and decreased livestock productivity. Intercropping forages with food crops with careful selection of compatible varieties, is beneficial to maximize plot productivity, increase feed production and consequently increase livestock production and improve livelihoods.

Demonstration of intercropping and feed processing and conservation technologies has won interest of farmers who witnessed improved production from their plots and better ways of conservation and utilization of their scarce feed resources

Increased arousal of interest of farmers from neighboring villages and woredas for the improved technologies pave the way for further scaling of the technologies

Farmers should be assisted to use healthy (disease-free) and adaptable seeds from known sources both for maize and the intercropped forages. They must also be encouraged to exercise proper management practices from land preparation and planting to harvesting and conservation of the feeds to maximize the use of the scarce resources from their limited sizes of land.

Summary

Land scarcity in Ethiopia's mixed crop-livestock systems, driven by expanding crop cultivation, urbanization, and infrastructure development, has reduced grazing areas, leading to feed shortages and lower livestock productivity. Intercropping forage species with food crops offers an effective solution by increasing land-use efficiency, enhancing feed availability, and improving livestock production and household livelihoods. Demonstrations of intercropping, feed processing, and conservation technologies have generated strong farmer interest due to their visible benefits in forage production, feed conservation, and utilization. The growing demand for these technologies among farmers in neighboring villages and districts indicates significant potential for wider scaling and adoption.

Conclusion

Intercropping forage crops with food crops and adopting improved feed processing and conservation technologies can help address feed shortages and enhance livestock productivity in land-constrained mixed crop–livestock farming systems (Mekonnen et al., 2021).

Cowpea (*Vigna unguiculata*) and lablab (*Lablab purpureus*) are protein-rich forage legumes that can improve the nutritional quality of diets based on low-quality roughages and consequently support improved animal productivity. Though the current study did not directly assess the effects of feed from maize–forage legume intercrops on animal productivity, evidence from Ethiopia demonstrates substantial improvements in live-weight gain when these forages are used as supplements. In Black Head sheep, supplementation with lablab and cowpea resulted in average daily weight gains of 88.13 and 73.02 g/day, respectively, compared with 26.68 g/day for sheep receiving the control diet (Kumsa et al., 2023). Lablab also has potential as a protein supplement in dairy-cow diets and has been associated with improved milk-production potential. However, animal responses depend on forage quality, variety, inclusion level, basal diet, animal type and production conditions. Hence, the observed increase in biomass production and improvement in feed quality suggest potential benefits for livestock productivity, such as increased milk yield and live-weight gain. In addition, the integration of forage legumes into maize-based cropping systems may provide complementary benefits through improved soil fertility.

To maximize benefits, farmers should be supported with access to high-quality, disease-free, and locally adaptable seed sources and encouraged to apply appropriate management practices throughout the production and conservation cycle. Continued dissemination and scaling of these technologies will contribute to more sustainable livestock production and improved rural livelihoods.

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