

Challenges of the forage crops in northwestern Ethiopia

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Research Article

Keywords: Agroecology, Constraint, Forage Crop

Posted Date: March 31st, 2023

DOI: <https://doi.org/10.21203/rs.3.rs-2745885/v1>

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Abstract

*Inadequate quality and quantity of animal feed are major factors influencing livestock production in Ethiopia. The primary feed sources (crop residue and natural pasture) were insufficient to meet even the annual maintenance requirement for livestock feed. To address this disparity, the production of cultivated forage is essential. Identifying the constraints and opportunities for improved forage production is critical for developing forage crops and intervention options for forage and livestock production. However, due to various constraints, the production and utilization of forage crops for animal feed are low in Ethiopia's highlands. Therefore, the purpose of this study was to identify the types, strategies, and constraints of forage crop production in three agroecologies (high, mid, and lowland agroecologies) of the east Gojjam zone. Two districts were chosen at random from all agroecologies. A total of 12 peasant associations from six districts (two from each district) were chosen using a simple random sampling system. A total of 360 respondents were taken from all agroecologies using a simple random sampling system. The data was collected through focus group discussions and individual interviews, and it was analyzed using SPSS. According to the findings, only 51% of respondents developed forage crops, due mainly to factors such as land scarcity (60.4%), a lack of awareness (24.0%), a lack of seed (14.6%), a lack of water (8.3%), and a fear of farmers birds setting on forage (3.1%). *Chamaecytisus palmensis* (tree lucerne) was the only forage in the highland agroecologies, whereas *Sesbania sesban* was the dominant species in the midland agroecologies. The dominant improved forage development strategy in all agroecologies was backyard, which did not compete with food crop production.*

1. Introduction

Ethiopia is Africa's largest livestock producer [1]. However, due to insufficient feed quality and quantity, livestock production and productivity are extremely low [2–4]; i.e., the average daily milk production for local cows and camels is approximately 1.4 and 3.6 liters, respectively, while the average number of eggs/hens/periods is 12, 35, and 137 for indigenous, cross, and exotic breeds, respectively [3]. The majority of feed in the Ethiopian highlands comes from crop residue and natural pasture (Belay and Geert, 2021), both of which vary in quantity and quality throughout the year. Natural pastures are in short supply due to rainfall fluctuations and have been reduced as a result of Ethiopia's rapid population growth and increased land available for crop production. Due to poor grazing and soil fertility reduction, the remaining pasture land produced minimal feed [5]. Overgrazing and poor management practices encourage the spread of invasive plant species, resulting in a shift in the plant composition of pastoral grazing and a reduction in livestock carrying capacity [5, 6]. Currently, crop residues are the primary feed source for animals, owing to their low digestibility and high fiber content; as a result, livestock production and productivity have decreased [5, 7, 8], resulting in poor productive and reproductive performance of livestock.

Thus, the production and utilization of improved forages can help to mitigate livestock feed shortages, reduce pressure on natural pastures, substantially support systems, and enhance natural assets and system reliance [8]. Moreover, improved forage maintains continuous feed supply during feed scarcity

and makes low-quality crop residues more efficient by adding more protein to forages [9]. However, the utilization of forage crops for animal feed is low; it represents < 1% of the total feed offered to livestock in 2021 as reported due to the highly increasing rate of the human population, which results in a shortage of land and awareness and skill gaps for farmers [5, 8].

Despite the introduction of various forages into the country, they have not been widely used in Ethiopia's highlands. The knowledge of the constraints and opportunities for improved forage is essential for developing forage development strategies and intervention options for forage and livestock production. However, there was insufficient information on opportunities and constraints for forage crop production in the study area. As a result, this study was initiated with the goals of 1) identifying forage crops, 2) assessing forage crop development strategies 3) identifying the challenges of forage crops in the study areas.

2. Materials And Methods

2.1. Description of the Study Areas

The investigation was carried out in the east Gojjam zone of Ethiopia's Amhara region. The zone is located in Ethiopia's northwestern highlands at 10° 1' 46" and 10° 35' 12" N latitude and 37° 55' 52" E longitude, respectively, and is 305 and 251 kilometers from Addis Abeba and Bahir Dar. East Gojjam has highland, midland, and lowland agroecologies. According to reports from east Gojjam agricultural offices, the altitude of districts ranges from 1500 to 3577 meters above sea level. The average annual rainfall ranged from 900 to 2000 millimeters, and the average minimum and maximum temperatures ranged from 7 to 15 degrees Celsius and 22 to 25 degrees Celsius, respectively.

2.2. Sampling Techniques and Sample Size

The east Gojjam zone was divided into highland, midland, and lowland agro-ecologies, with two districts from each agro-ecology chosen to represent the zone's highland, midland, and lowland agro-ecologies, respectively: Sinan and Machakel, Aneded and Enemay, and Debre-Elias and Basoliben. A total of 12 peasant associations from six districts (two from each district) were chosen using a simple random sampling method to represent corresponding agroecologies. In each peasant association, 30 farmers (households) were selected using the simple random sampling method, and thus, a total of 360 farmers were selected randomly for individual interviews.

2.3. Data Collection

During the survey, information was primarily gathered through focus group discussions (FGDs) and individual interviews. The FGD captured data on the opportunities and constraints of forage production and utilization in the study areas. The individual farmer was interviewed using questionnaires designed to capture land size, livestock holdings, household characteristics, strategies, and constraints of improved forage production. In addition, key informant interviews and discussions with district and peasant

associations were conducted to confirm the information obtained from group discussions and individual interviews.

2.4. Data Analysis

The data were summarized and analyzed by SPSS (version 25) software. The General Liner Model procedure was used to analyze the effect of agroecology on constraints on forage production. The following model was used for analysis:- $y_{ij} = \mu + A_i + e_{ij}$, where y_{ij} = response variable; μ = overall mean; A_i = agroecological effect; and e_{ij} = random error. Significant difference comparisons between means were tested using the least significant difference (LSD).

3. Results And Discussion

3.1. Sources of Major Livestock Feed

The major feed resources in the study areas were natural pasture, crop residue, stubble grazing, agricultural byproducts, and forage crops, in descending order as ranked by respondents (Table 1), which is consistent with the reports of [10–12]. Natural pasture and crop residues were the primary and secondary sources of feed for livestock in all agroecologies (Table 1), as was the case in the majority of developing countries [13]. Furthermore, respondents and key informants reported that locally brewed byproducts were also used as a supplementary feed resource in the area.

Table 1
Ranked feed resources by Henry ranking methods

Agroecology		Feed resources				
		Natural pasture	Crop residues	Stubble grazing	Agro-industrial byproduct	Forage crops
Highland	Score	85.0	76.8	68.0	14.8	60.0
	Rank	1	2	3	5	4
Midland	Score	82.3	79.5	68.0	62.0	60.0
	Rank	1	2	3	4	5
Lowland	Score	85.0	82.3	68.0	63.0	59.0
	Rank	1	2	3	4	5
Overall	Score	85.0	74.0	68.0	63.0	59.0
	Rank	1	2	3	4	5

3.2. Grazing Lands Owned by Individuals

The percentage of households with private grazing lands was 44.2%, which was significantly higher in highland than midland and lowland agroecologies. This could be due to the lower forage production and smaller size of communal grazing land in highland agroecologies. According to Table 2, the total percentage of respondents who managed private grazing land was low. Nobody introduced improved forage in all agroecologies on private grazing lands, indicating a lack of farmer awareness of the benefits of improved forage and a limited supply of skilled extension services in the study areas. However, manure and fertilizer application, as well as invasive weed control, performed much better than other private grazing land management practices across all agroecologies (Table 2), despite no significant ($p > 0.05$) differences in private grazing land management practices across agroecologies.

Table 2
Private grazing land management techniques

Agroecology	Highland	Midland	Lowland	Overall	P value
Respondents (%) had private grazing land	21.1 ^a	16.8 ^b	6.3 ^c	44.2	0.006
Manure Application	6.3 ^a	8.4 ^a	3.2 ^a	17.9	0.556
Weed control	6.3 ^a	7.4 ^a	3.2 ^a	16.8	0.613
Improved forages	0.0 ^a	0.0 ^a	0.0 ^a	0.0	0.00
Fertilizer application	8.4 ^a	5.3 ^a	2.1 ^a	15.8	0.207
Irrigation	1.1 ^a	0.0 ^a	0.0 ^a	1.1	0.387

Superscript letters with different values within the same rows are significantly different ($P < 0.05$ among agroecologies)

3.3. Forage Crop Species

Chamaecytisus palmensis, *Sesbania sesban*, *Vicia da scarpa*, *Pennisetum purpureum*, *Avena sativa*, *Chloris Guyana*, and *Pennisetum pedicellatum* are among the forage crops that have been introduced (Table 3). These improved forage crops are widely used in various parts of the Amhara region [10, 14, 15]. According to respondents and direct observations, *Chamaecytisus palmensis* (tree lucerne) was the only forage in the highland areas, and it was significantly ($P < 0.05$) higher than in the midland and lowland agroecologies, which was consistent with the report [14]. This could be due to the lack of other improved species that have adapted to cold environmental conditions.

The diversity of forage crops was greater in the midlands than in highland and lowland agroecologies (Table 3). This could be due to a lack of forage species adapted to high moisture and high temperatures in highlands and lowlands agroecologies [16]. Furthermore, in highland and midland agroecologies, the percentage of respondents with *Vicia dasycarpa* and *Sesbainia sesban* was significantly lower ($p < 0.05$). Thus, the intervention of forage species that adapt to highland and lowland areas may necessarily

require an increase in livestock production. The proportion of respondents with *Pennisetum purpureum*, *Avena sativa*, *Chloris Guyana*, and *Pennisetum pedicellatum* did not differ significantly ($p > 0.05$) across agroecologies.

Table 3
Percentage of respondents who had forage crops

	AgroEcology				P value
	Highland	Midland	Lowland	Overall	
Farmers (%) sown/planted improved forage	17.7 ^a	27.1 ^a	4.2 ^b	49.0	0.000
Types of improved forages					
<i>Chamaecytisus palmensis</i>	17.7 ^a	1.0 ^b	0.0 ^b	18.8	0.000
<i>Sesbania sesban</i>	0.0 ^b	25.0 ^a	3.1 ^b	28.1	0.000
<i>Pennisetum purpureum</i>	0.0 ^a	1.0 ^a	2.1 ^a	3.1	0.237
<i>Chloris gayana</i>	0.0 ^a	4.2 ^a	2.1 ^a	6.3	0.165
<i>Avena sativa</i>	0.0 ^a	2.1 ^a	0.0 ^a	2.1	0.196
<i>Vicia dasycarpa</i>	0.0 ^b	5.2 ^a	0.0 ^b	5.2	0.015
<i>Pennisetum pedicellatum</i>	0.0 ^a	2.1 ^a	0.0 ^a	2.1	0.196

Means within the same row with different superscripts are significantly varied ($P < 0.05$) among agroecologies

3.4. Strategies for Forage Crop Development in the Study Areas

Backyard development was the most common forage crop strategy across all agroecologies, and it was significantly more common ($P < 0.05$) in highland and midland than lowland agroecologies, which was consistent with the observations [15]. This might be the case because backyard methods only required a limited amount of land around the homestead areas and did not compete with the production of food crops. However, none of the respondents in all agroecologies sowed or planted improved forage crops with food crops (Table 4). This indicated farmers' poor level of understanding of the value of improved forage strategies and the lack of knowledgeable extension services in the study areas. Farmers can increase the availability of high-quality animal feed, strengthen the important relationship between livestock and crop production, improve water and soil conservation, and reduce the amount of barren grazing lands by developing forage crops [7].

Table 4
Percent of respondents implementing forage crop production strategies

Agroecologies	Improved forage development strategies				
	Backyard	Intercrop/under sowing	Forage strips	Stock exclusion	Alley cropping
Highland	16.7 ^a	0.0 ^a	0.0 ^a	0.0 ^a	0.0 ^a
Midland	25.0 ^a	0.0 ^a	3.1 ^a	1.0 ^a	0.0 ^a
Lowland	3.1 ^b	0.0 ^a	0.0 ^a	0.00 ^a	2.1 ^a
Overall	44.8	0.0	3.1	1.0	2.1
p value	0.000	0.000	0.085	0.447	0.064

Means within the same column with different superscripts are significantly varied ($P < 0.05$) among agroecologies

3.5. Challenges to Forage Crop Production

In line with the reports of [14], the findings revealed that the majority (51.0%) of respondents in the study areas did not participate in the production of forage crops. This was caused by a lack of land, awareness of the problem, a lack of seeds, and farmers' concern as a result of birds being fed by farmers' crops as feeders (Table 5), which is consistent with the findings of previous studies[14, 17]. The lack of available land was the primary impediment to the cultivation of forage crops, and it was significantly ($P < 0.05$) higher in highland agroecologies than in midland and lowland agroecologies, supporting reports from the Hadiya zone [2, 14, 17, 18]. The reason for this could be that farmers prioritized growing food crops on the available areas rather than raising animal feed. This poor practice of forage development might be challenged by information and technology limitations. As concluded from group discussions, farmers in the study area prefer to grow food crops rather than feed on land because there are no comparative findings on the profitability of crop production and livestock production per unit of land.

The respondents also mentioned farmer awareness as an obstacle to the cultivation of improved forages, and there was no difference in agroecologies that was statistically significant ($P > 0.05$). In line with the findings of studies by [14, 18], farmers in the study areas lacked a thorough understanding of the systems for producing and utilizing enhanced forage crops. Due to a lack of awareness, farmers did not sow forage crops under terraces, borders, or intercropping. A lack of seeds and planting materials for suitable forage crop species also hampered forage crop production (Table 5), which was consistent with the findings of [14, 17]. The lack of forage species that are adaptive, particularly for highland agroecologies, is a significant limiting issue in the production of improved forages, according to the development agents and farmers who were interviewed. Because of the lack of farmers and organizations in various regions producing improved forage seeds, there is a restricted supply of seed and planting materials appropriate for the various agroecologies and development strategies. However,

according to respondents, the peasant association, and district experts, the opportunities for the production of forage crops were rising consumer demand for animal products, expensive feed, crop-dominated areas for intercropping, seasonal fallow land, suitable agroecologies, increased soil erosion, and protection from climate change.

Table 5
Challenges of forage crop production in the study areas

Constraints of forage production						
Agroecologies	Land shortage	Lack of awareness	lack of seed and planting materials	Fear of farmers birds set on forages	water shortage	Lack of capital to purchase seeds
Highland	26.0 ^a	8.3 ^a	5.2 ^a	3.1 ^a	2.1 ^a	2.1 ^a
Midland	16.7 ^b	7.0 ^a	4.2 ^a	0.0 ^a	2.1 ^a	1.0 ^a
Lowland	17.7 ^b	12.5 ^a	5.2 ^a	0.0 ^a	4.2 ^a	0.0 ^a
Total	60.4	24.0	14.6	3.1	8.3	3.1
p value	0.018	0.062	0.643	0.052	0.312	0.407

Percentages within the same column with different superscript letters are significantly varied ($P < 0.05$) across Agroecologies

Conclusions

According to the findings, only 51% of respondents developed forage crops, due mainly to factors such as land scarcity (60.4%), a lack of awareness (24.0%), a lack of seed (14.6%), a lack of water (8.3%), and a fear of farmers birds setting on forage (3.1%). *Avena sativa*, *Chamaecytisus palmensis*, *Sesbania sesban*, *Pennisetum purpureum*, *Chloris Guyana*, and *Pennisetum pedicellatum* were among the improved forage crop varieties that were introduced in the east Gojjam zone. *Chamaecytisus palmensis* (tree lucerne) was the only forage in the highland agroecologies, whereas *Sesbania sesban* was the dominant species in the midland agroecologies. The dominant improved forage development strategy in all agroecologies was backyard, which did not compete with food crop production. Thus, adoption of forage crop production in the study areas can be achieved through forage production awareness, the use of fallow land for forage production, and the planting or sowing of forage crops with food crops in contour strip areas and homestead areas.

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