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Demonstration of Urea Treatment Technology in Selected Kebeles of the Western Zone of Tigray

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ABSTRACT

The study aimed to demonstrate the effect of urea treatment on the utilization of sorghum stover and farmers' perception. It was conducted in four kebeles of Kafta Humera district with one farmer group per kebele. Farmers and agents trained on urea treatment procedures before the experiment. The participating farmers were provided with urea, heavy plastic sheets, and guiding manuals for urea treatment preparation. Weekly meetings were held with group members to address issues and propose solutions. During field visits, data on feed intake, milk yield of cows, and farmers' perception were collected. The results showed that urea treatment technology significantly increased the average daily milk yield of milking cows from 2.39 to 3.85 liters, with an average daily increment of 1.46 liters (61.1%). The analysis indicated that each additional unit of one birr per cow's cost increment resulted in a 1.84 birr benefit from feeding urea-treated sorghum stover as a supplement. Urea treatment also increased sorghum stover intake, reduced wastage, and improved the milk yield and body conditions of lactating local cows. Therefore, it is recommended to introduce urea treatment technology, along with affordable improved feed choppers, to wider areas for further popularization and scaling up of the technology.

Keywords: Milk yield; Feed intake; Sorghum stover; Perception; Body condition; Farmers' perception.

1. Introduction

Cereal crop residues, also known as stover or straw, refer to the remaining parts of the plant after harvesting the grain crop, including leaves and stems. These residues can be collected, chopped, and stored for animal feed when grazing is unavailable. In addition to being used as feed, crop residues have various other uses such as building materials, roofing, fencing, fuel, and fertilizer or surface mulch for crops.

In Ethiopia, crop residues play a crucial role in feed resources, especially during the dry season. The availability of crop residues for livestock feed depends on the agro-ecology and farming system in a particular area. In low and medium land areas, maize and sorghum residues are dominant, while teff, barley, and wheat straws are major crop residues in medium and highland areas, contributing to year-round feed resources [1].

Currently, there is an increasing demand for crop residues as livestock feed due to the expansion of crop production to meet the needs of a rapidly growing human population. However, the size of grazing areas is decreasing, leading to overgrazing and a serious feed shortage problem. This shortage is a major bottleneck that hampers the productive and reproductive performance of animals.

Crop residues are typically low in crude protein content but high in cell wall and cell wall constituents. Their crude protein content falls below the threshold required to maintain a positive nitrogen balance in animals [1]. Consequently, digestibility, rate of passage, and voluntary feed intake are limited. However, the nutritive value, intake, and digestibility of crop residues can be effectively improved through chopping, chemical treatments, or supplementation with concentrates, molasses, or other energy and protein-rich feeds [2], [3], [4]. Unfortunately, these options are either unavailable or expensive in the area.

Sorghum stover is the most commonly used ruminant feed in the western zone of Tigray. However, due to its low digestible crude protein content, animals fed solely on this forage do not perform well. Supplementing poor-quality forages like sorghum and sesame stover with high-protein and high-energy feeds improve the utilization of stover and the performance of animals [5].

Crop residues can be chopped and mixed with molasses or treated with urea to enhance their palatability, digestibility, and feed value. Treating cereal straws with urea or mixing them with molasses before feeding animals can help them gain weight [6]. Therefore, this study aimed to demonstrate the effect of urea treatment in enhancing the feeding value and utilization of sorghum stover, as well as to investigate farmers' perception of the technology in improving the milk yield of their lactating cows.

2. Materials and Methods

2.1. Description of the Study Areas

The demonstration of urea treatment was carried out in four selected lowland kebeles of Kafta Humera Wereda in the western zone of Tigray, namely Adebay, Rawian, Maykadra, and Bereket (Figure 1). The district is located 585 km from Mekelle, the capital city of Tigray region, Ethiopia. Kafta Humera accounts for 49.13% of the total area coverage of the Western zone of Tigray (HuARC, Unpublished). The Wereda consists of two agro-ecological zones (midland and lowland), with Kolla (lowland) representing 85.7% and Weynadega (midland) accounting for 14.3% of the land coverage of the district.

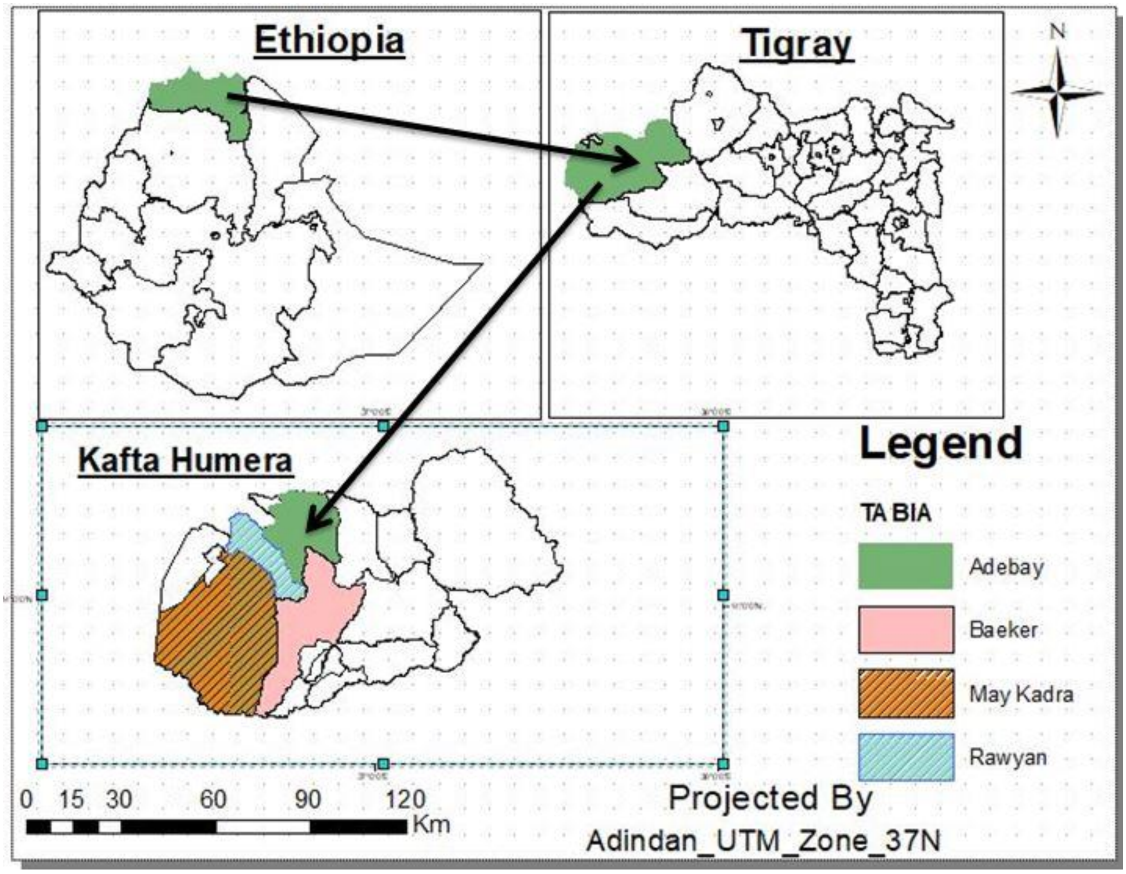

Figure 1. Map of study Kebeles

The geographic location of the district lies within the coordinates of 13^0 40'- 14^0 27' north latitude and 36^0 27'-37^0 32' east longitude. The agro-ecology of the zone is hot to warm semi-arid lowland plains characterized by hot temperatures, erratic rainfall, vast areas of plain lowlands suitable for large-scale and subsistence agriculture, including crops and livestock. It has a unimodal rainfall pattern, and the annual rainfall is 448.8.5 mm. The mean annual temperature of the area ranges from 25°C to 27.5°C [7]. The altitude of the district ranges from 500-1850 m.a.s.l. The district shares borders with Tsegede in the south, Sudan in the west, and then the Tekeze River, which separates Kafta Humera from Eritrea in the north, and Sheraro in the east, and Welkait in the southeast. The study area represents a remote tropical climate where extensive agriculture is performed manually by large numbers of migrant laborers.

2.2. Farmers' selection and training

Four farmers' groups, consisting of interested member farmers, were established in four selected kebeles of Kafta Humera (Adebay, Rawian, Baeker, and Maykadra) Wereda in the western zone of Tigray. There was one farmers' group in each selected kebeles. Each group had a total of four members, with one member elected as the team leader to facilitate effective communication between researchers and community members. Before conducting the experiment, training on urea treatment preparation procedures was provided to the members of the farmers' groups and the development agents of each selected kebeles, which lasted for about two days. All necessary input materials (urea and heavy plastic sheet) and guiding manuals for urea treatment preparation were provided, and the farmers were encouraged to collaborate with researchers in designing and implementing the experiment. Technical advice was given to team leaders and group members during field visits, as well as through training sessions and regular meetings. Weekly meetings were held to discuss problems and suggest solutions with group members. In most cases, extension workers played a facilitating role, while the actual implementation and routine work were carried out by the farmers themselves.

2.3. Procedures for the preparation of urea-treated stover

Step 1: A pit measuring 1m x 1m x 2m (length, width, and height) was manually prepared using a hoe.

Step 2: The sorghum stover was manually chopped into 2-3 cm lengths using an axe.

Step 3: A layer of chopped stover was spread on a large, thick plastic sheet and sprinkled with a mixture of urea and water.

Step 4: Another layer of stover was added and sprinkled with more urea and water. This process was repeated for several layers. For every 100kg of straw, you would need 50 liters of water and 4kg of urea.

Step 5: The plastic sheet was wrapped over the top and sides of the pile to seal it completely. A stone was placed on top to keep it airtight.

Step 6: The stover was sealed for two weeks (14 days).

Step 7: Before feeding, the sheet was opened and enough treated stover for a day was taken out. The rest of the stack was covered again with the plastic sheet.

Step 8: The stover that had been taken out from the pit was left for about 20 minutes until the ammonia smell disappeared, and then it was offered to the animals.

2.4. Experimental animals and feeding management

Experimental animals: A total of fifteen lactating Begait cows from interested farmers (one per farmer) at mid-lactation (5-8 weeks after calving) were purposively selected for the demonstration feeding trial based on the farmers' willingness. The selected cows were in their second parity and were dewormed against internal and external parasites prior to the start of the demonstration.

Experimental feeds and feeding: The feeding regime consisted of grazing, ad libitum untreated sorghum stover, and 6 kg of treated stover. The level of urea-treated stover supplementation for the lactating Begait cows was determined based on recommendations from the Ethiopia Sheep and Goat Productivity Improvement Program [8]. The selected cows were offered 3 kg of treated stover mixed with untreated stover at 2 hours in the morning before grazing, and another 3 kg of treated stover mixed with untreated stover at 12 hours in the evening before resting. Each lactating cow was supplemented with urea-treated stover for a consecutive sixty (60) days.

2.5. Data Collection

The data collected during the demonstration included:

2.5.1. Farmers' perception

The farmers' attitude towards the urea treatment technology was assessed using a prepared checklist at the end of the demonstration.

2.5.2. Milk yield

The initial daily milk yield of the selected lactating Begait cows before they were supplemented with urea-treated sorghum stover was recorded for approximately 20 consecutive days. Similarly, the final daily milk yield of the lactating Begait cows after they were supplemented with urea-treated sorghum stover was recorded for 60 consecutive days.

2.5.3. Body condition

The body condition of the lactating cows before and after they were fed urea-treated sorghum stover was visually observed based on changes in skin and hair smoothness.

2.5.4. Feed intake

A measured amount of feed (both untreated and treated sorghum stover) was offered twice a day at 8:00 am in the morning before the lactating Begait cows were allowed to graze, and at 6:00 pm in the evening before they were allowed to rest. For each selected lactating cow, the feed offered and the amounts refused were recorded. The amount of feed consumed was determined as the difference between the feed offered and the amount refused on a dry matter basis.

2.5.5. Partial Budget Analysis

The partial budget analysis was conducted to evaluate the economic advantages of the urea treatment using the procedures outlined by CIMMYT [9]. The analysis involved calculating the variable costs and the benefits obtained

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from the results. At the beginning of the demonstration, the purchase prices of urea treatment materials (heavy plastic, urea, water) were recorded. Throughout the entire demonstration period, the milk production of each lactating Begait cow and the selling price of milk per head were recorded. The partial budget analysis method measures profits or losses, which are the net benefits or differences between gains and losses for the proposed change, and includes calculating the net return (NR), which is the amount of money left when total variable costs (TVC) are subtracted from the total returns (TR).

$$\text{NR (Birr)} = \text{TR} - \text{TVC} \qquad (1)$$

Total variable costs include the costs of all inputs that change as a result of the change in production technology. The change in net return (ΔNR) was calculated as the difference between the change in total return (ΔTR) and the change in total variable cost (ΔTVC). This calculation served as a reference criterion for making decisions regarding the adoption of a new technology.

$$\Delta\text{NR} = \Delta\text{TR} - \Delta\text{TVC} \qquad (2)$$

The marginal rate of return (MRR) measures the increase in net income (ΔNR) associated with each additional unit of expenditure (ΔTVC) and is expressed as a percentage.

$$\text{MRR (\%)} = \frac{\Delta\text{NR}}{\Delta\text{TVC}} \text{x}100 \qquad (3)$$

2.5.6. Duration, Monitoring, and Data Recording

The data were recorded over a period of 60 days, following an adaptation period of fourteen days. Field visits were conducted once per a week to monitor the feed intake and milk yield of the lactating cows. Changes in the body condition of the lactating cows were visually assessed based on alterations in skin and hair smoothness. The farmers themselves recorded the intake of untreated and treated sorghum stover, as well as the daily milk yield, on a data recording sheet prepared in the local language (*Tigrigna*).

2.6. Statistical Analysis

A paired t-test using SPSS 22 was employed to analyze the change in milk yield and feed intake of the sorghum stover before and after the cows were fed urea-treated stover [10].

3. Results and Discussions

3.1. Response of lactating cows to urea-treated sorghum stover

3.1.1. Milk yield

The results of the demonstration indicate that urea treatment technology significantly ($P < 0.0001$) increased the average daily milk yield of the milking cows of FRG members from 2.39±1.30 liters to 3.85±1.02 liters with an average daily increment of 1.46±0.54 liters (61.1%) (Table 1). This positive effect of urea treatment on the milk yield of lactating cows supports previous studies [11], [12], [13], [14], [15]. The milk yield of Begait lactating cows supplemented with urea-treated sorghum stover was higher than that reported by Teshome [11], and Lemma and Endalew [14] on Fogera cows supplemented with urea-treated rice straw in Ethiopia but lower than those reported by Wanapat *et al*. [16], Gunnum *et al*. [12], and Gelane [13] on Holstein crossbred dairy cows supplemented with urea-treated rice straw in Australia, Thailand, and Ethiopia, respectively. Tesfaye *et al*. [17] also reported a significant increase in the daily milk yield of crossbred dairy cows when supplementing with urea-treated maize stover.

Ahmad *et al*. [15] discovered that using molasses and urea in the treatment of corn stover silage resulted in higher levels of carbohydrates and nitrogen. This ultimately led to increased volatile fatty acids, which improved the milk and milk fat content of Sahiwal lactating cows. The researchers also found that using corn stover ensiled with molasses or molasses plus urea as a substitute for corn silage was successful in maintaining sustainable milk yield in lactating Sahiwal cows and can help to reduce the wastage of valuable biomass. The variation in the milk yield of lactating dairy cows supplemented with urea-treated crop residues in different areas might be due to variations in the type of crop residue used, lactation stage and parity, breeds of the dairy cows used, study time, and other factors.

Table 1. Average milk yield of Begait dairy cows (liter/day) at mid lactation before and after they fed urea treated sorghum stover

Name of FRG member	No of Cows involved per member	Milk yield (liter/day)			P-value
		Before they fed urea treated stover	After they fed urea treated stover	Difference (%)	
ZeferMahari	1	0.5	1.875	1.375 (275%)	
GebruLibelo	1	2	4	2 (100%)	
GebremedihinYaylew	1	1	3.25	2.25 (225%)	
Gebru Zbelo	1	1.5	3	1.5 (100%)	
Almaz Eijigu	1	3	4.9	1.9 (63.3%)	
Fisseha Tadesse	1	4	5	1 (25%)	
Teweldebrhan G/Medihin	1	1.5	2.75	1.25 (83.3%)	
Ademas Assefa	1	0.5	2.6	2.1 (420%)	
Birawaberas Derese	1	2	4.15	2.15 (107.5%)	
Mebrahtu Welense	1	4	5	1 (25%)	
Mekonnen G/Hiwet	1	3	4.15	1.15 (38.3%)	
Adane	1	4	4.5	0.5 (12.5%)	
G/Tsadik	2	4	5	1 (25%)	
Desta Belay	1	2.5	3.75	1.25 (50%)	
Mean ±SD		**2.39±1.30**	**3.85±1.02**	**1.46±0.54**	**0.000 ***

* Significant at P <0.0001; FRG= Farmers Research Group.

3.1.2. Feed intake

The dry matter intake of lactating Begait cows supplemented with urea-treated sorghum stover is presented in Table 2. The daily dry matter intake of treated sorghum stover with urea was significantly ($P < 0.05$) higher than untreated sorghum stover. The dry matter intake of sorghum stover in the current study somewhat agrees with the findings of Parnich [18], who reported that the daily feed intake of treated and untreated rice straw in lactating cows was 5.65 kg and 4.91 kg, respectively. However, the intake of sorghum stover in the demonstration was significantly higher than the intake of maize stover in crossbreed heifers by Sekhonyana and Fulpagare [19], but lower than the intake of rice straw reported by Wanapat *et al.* [16] and Lemma and Endalew [14], as well as the intake of teff straw by Dejene *et al*. [20]. The variation in the feed intake of urea-treated crop residues in different areas might be due to variations in the type of crop residue used, lactation stage and parity, breeds of the dairy cows used, study time, and other factors. Moreover, in Ethiopia, it was also found that urea treatment was more effective in improving the chemical composition (crude protein and mineral matter) and degradability of sorghum stover [21]. Esheta *et al*. [22] discovered that the nutritive values and digestibility of wheat straw, sorghum, and maize stover were enhanced through urea treatment in the Somalia region. Similarly, Katoch and Tripathi [23] observed improvements in the feeding value, feed intake, and digestibility of wheat and rice straws, Sorghum Sudan grass, and Guria grass hays with urea treatment. Previous studies by Tesfaye *et al*. [17] and Katoch *et al.* [24] also indicated that urea treatment increased the nutritive value, feed intake, and digestibility of maize stover. Urea has received considerable attention in ruminant nutrition because it improves the palatability of the treated crop residue by solubilizing the hemicellulose fractions, thus improving DM digestibility and daily DM intake [25], [26], [27].

Table 2. Feed intake of untreated and treated sorghum stover (Kg DM/cow/day) (Mean±SEM)

Stover type	**DMI (Kg/cow/day)**
Untreated Stover	4.42±0.1
Treated stover	5.75±0.1

3.1.3. Farmers' perception

Farmers involved in this experiment (FRG members) appreciated the technology. They responded that it had great advantages because it resulted in promising milk yield, reduced feed wastage by improving the palatability of the stover, and brought visible changes in the body conditions of the experimental cows and their calves (Table 2). Some FRG members also compared the milk yield obtained while supplementing sesame seed cake and urea-treated sorghum stover, and found them to be similar. Moreover, they expressed a high interest in preparing urea-treated stover themselves, using their own urea and heavy plastic sheets, throughout the dry season every year if they can afford an improved chopper. In their concluding remarks, they also mentioned their eagerness to purchase affordable improved choppers, either individually or cooperatively, whenever choppers are available.

3.1.4. Experience sharing

Experience sharing on urea treatment was carried out in collaboration with the extension workers of the study kebeles. During the experience sharing, all participants appreciated the technology. They mentioned that they had

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no prior knowledge about this technology and expressed a strong interest in practicing it to maximize milk yield from their dairy cows and utilize sorghum stover, provided that the technology is a complete package. According to the participants, a complete package technology includes the urea treatment technology along with an improved chopper to minimize the time and labor required for manually chopping the sorghum stover during the preparation of urea-treated stover. The farmers also concluded that urea treatment technology without a chopper is only half of the technology, as it is labor-intensive and time-consuming to manually chop the sorghum stover.

Table 3. Farmers' perception towards urea treatment N (%)

Attributes	**Animal preferences, N (%)**		
	Less preferred	**Moderately preferred**	**Highly preferred**
Untreated Stover	30(100%)	-	-
Treated Stover before they adapted	30(100%)	-	-
Treated Stover after they adapted	-	2(6.7%)	28(93.3%)
	Palatability, N (%)		
	Less palatable	Moderately palatable	Highly palatable
Untreated Stover	30(100%)	-	-
Treated Stover before they adapted	30(100%)	-	-
Treated Stover after they adapted	-	2(6.7%)	28(93.3%)
Change in body condition of cows after they fed treated stover	No change		Improved
Cows	-		30(100%)
Calves	4(13.3%)		26(86.7%)
Change in the feed intake of sorghum stover after they fed treated stover	No change		Increased
	-		30(100%)
Sorghum Stover wastage while cows feeding treated stover	No change		Reduced
	5(16.7%)		25(83.3%)

3.2. Partial budget analysis

The partial budget analysis of the urea treatment technology is presented in Table 3. The results suggest that supplementing cows with urea-treated sorghum stover is more profitable than supplementing with untreated sorghum stover. There is a higher net return and change in net return observed in cows fed urea-treated sorghum stover, which could be attributed to the improvement in the nutrient content of the stover. Feeding urea-treated sorghum stover as a supplement is more expensive compared to the corresponding costs for untreated sorghum stover. The costs involved in sorghum stover urea treatment are mainly pit preparation, urea purchasing, and chopping.

The marginal rate of return measures the increase in net income and the effects of additional investment in a new technology on additional net return. The partial budget analysis indicates that urea-treated stover has a higher MRR compared to the untreated stover, which is due to the improvement in milk yields of the cows. Based on the MRR analysis, each additional unit of one birr per cow's cost increment results in a 1.84 birr benefit for feeding urea-treated sorghum stover as a supplement. This indicates that cows fed with urea-treated sorghum stover perform well, have higher milk yields, can be sold at a premium price, and earn better net returns.

Table 4. Partial Budget Analyses of Urea Treatment Technology

Variables	**Untreated**	**Treated**
Number of cows	15	15
Purchase price of sorghum stover (ETB/head)	0	0
Total sorghum stover intake (kg)	1500	1500
Total urea intake (kg)	0	4
Cost of sorghum stover (ETB/head)	0	0
Cost of labor (ETB/head)	0	200
Cost of urea (ETB/head)	0	40
Cost of water	0	30
Total variable cost (ETB/head)	0	274
Δ TVC	0	274
Total milk produced (liter)	1075.5	1732.5
Milk production (liter/head)	71.7	115.5
Selling price of milk (ETB/head)	1720.8	2772
Total Rate of return (TRR)	1720.8	2498
ΔTRR	0	777.2
Net return (NR) (ETB/head)	1720.8	2224
ΔNR	0	503.2
Marginal rate of return (MRR %)	0	183.65

4. Conclusion and Recommendation

Based on the improvements in milk yield and body condition due to urea treatment technology, and the positive perception of farmers, urea treatment increases voluntary sorghum stover intake and palatability, reduces sorghum stover wastage, and improves the milk yield and body conditions of lactating local cows. Therefore, it is recommended that urea treatment, together with affordable improved choppers, should be introduced to wider areas for further popularization and scaling up and out of the technology. It is practically more applicable in the dry season (January to mid-June) when there is a shortage of quality feed. The dry season is a critical time for feeding urea-treated sorghum stover to lactating cows and any ruminant animals to ensure sustainable improved ruminant production.

Based on the MRR analysis, each additional unit of one birr per cow's cost increment resulted in a 1.84 birr benefit for feeding urea-treated sorghum stover as a supplement. This indicates that cows fed with urea-treated sorghum stover perform well, have higher milk yields, can be sold at a premium price, and earn better net returns.

Further research on optimal urea treatment dosage for sorghum stover is recommended to maximize feeding intake and milk yield in dairy cows. Investigating long-term effects on cow health and productivity will provide valuable insights into potential benefits and risks. Exploring urea treatment feasibility for other forage crops and residues can enhance overall feed efficiency in dairy farming. Evaluating urea treatment's economic viability compared to other methods is vital for determining cost-effectiveness. Assessing potential environmental impacts of urea treatment on soil health and nutrient cycling contributes to sustainable farming practices and minimize negative environmental consequences.

Declarations

Source of Funding

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Competing Interests Statement

The authors declare that there are no competing interests.

Consent for Publication

The authors declare that they consented to the publication of their original research work. The manuscript has been submitted for publication with due consent of authorities of their institute.

Ethical Statement and Conflict of Interest

In our research, we followed Ethiopia's ethical guidelines for accessing genetic resources and community knowledge, as well as benefit sharing [28]. We also adhered to the genetic resource transfer and management conventions established by the Directorate Institute of Biodiversity Conservation. We obtained a supporting letter from the Tigray Agricultural Research Institute and permission from relevant administrative bodies in the study zone to conduct our research. Every participating farmers have provided written informed consent for their involvement in the research.

Authors' Contributions

All authors took part in data collection, literature review, analysis, and manuscript writing equally.

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References

[1] Seyoum, B. (1997). Livestock Feed Potential of Crop Residues in Ethiopia: Opportunities and Challenges. Utilization of Crop residues. Angaw Tsigie, Bayeh Mulatu and Getachew Agegnehu (Eds.), Ethiopian Institute of Agricultural Research, Addis Ababa, Ethiopia, Pages 75–78.

[2] Kategile, J.A., Said, A.N., & Sundstol, F. (Eds). (1981). Utilization of low quality roughages in Africa. Proceedings of a work shop held at Arusha. Tanzania, 18-22 January 1981.

[3] Kifle Wahid, B., Potts, G.R., & Dry S date, R.M. (Eds). (1983). By-product utilization for animal production. Proceedings of a workshop held at Nairobi, 26-30 September 1982.

[4] Wanapat, M., & Devendra (Eds.). (1985). Relevance of Crop residues as animal feeds in developing countries. Proceedings of an international workshop held at Khonkoen, Thailand, Funny Press, Bangkok, Thailand.

[5] Mohammed, A.A., AEEL-Taye, B., Homeida, A.M., & Mohammed, T.A. (1992). Effects of supplementing a low quality forage with concentrates on performance and sexual development of Dairy Heifers. The complementarity of feed resources for animal production in Africa. Abdullah N said, Jackson Akategile & John Es stares (eds.) AFRN, ILCA (International Livestock Center for Africa), Ethiopia, Page 300.

[6] Gashew, G., & Getachew, F. (2005). Managing Livestock and Fodder. Managing Land: A practical guide book for development agents in Ethiopia. Technical hand book N0 36. Anna Klindguist, Paul Mundy, Berhanu Mekonnen, Yetagesu Mergia and Sandra Limley (Eds.). Regional Land Management Unit (RELMA), World Agro forestry Center and Ministry of Agriculture and Rural Development of Ethiopia, Eastern and Central Africa Regional Programme, Dubai Printing Press and Publishing Ltd Kenya, Page 219.

[7] EARO (Ethiopia Agricultural research Organization) (2002). National Pastoral and Agro-Pastoral Research Document. Addis Ababa, Ethiopia, Page 51.

[8] Alemu, Y. (2008). Nutrition and Feeding of Sheep and Goats. In Sheep and Goat Production Handbook for Ethiopia. Alemu, Y. and R.C. Merkel (Eds.), Pages 110–167.

[9] CIMMYT (1988). From agronomic data to farmer recommendations: an economics training manual. Completely Revised Edition, Mexico.

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Volume 7, Issue 4, Pages 42-54, October-December 2023

[10] SPSS (Statistical Package for Social Sciences) (2013). SPSS for windows. User's guide: Statistics version 22., Inc. Cary, NC.

[11] Teshome, D.A. (2009). On-farm evaluation of urea treated rice straw and rice bran supplementation on feed intake, milk yield and composition of Fogera Cows, North western Ethiopia, Bahirdar University, Bahirdar, Ethiopia. https://cgspace.cgiar.org/handle/10568/722.

[12] Gunnum, P., Wanaput, M., & Anantasook, N. (2013). Effects of physical Form and urea treatment of rice straw on rumen fermentation, microbial protein synthesis and nutrient digestibility in dairy steers. Asian Australas. J. Anim. Sci., 26(12): 1689–1697. https://doi.org/10.5713/ajas.2013.13190.

[13] Gelane, K. (2017). On-farm evaluation and demonstration of Urea treated straw and urea–molasses block supplementation to cross bred dairy cows at Lume District, East Shoa zone. MSc. Thesis submitted to Postgraduate Program Directorate School of animal and range Science, Haramaya University, Haramaya, Ethiopia. https://cgspace.cgiar.org/handle/10568/90442.

[14] Lemma, G., & Endalew, W. (2017). Evaluation of milk production performance of Lactating Fogera cows fed with Urea and effective micro-organisms treated rice straw as basal diet. International Journal of Scientific and Research Publications, 7(5): 45–50. doi: 10.5958/2277-940X.2017.00001.8.

[15] Ahmad, F., Tauqir, N.A., Faraz, A., Asghar, l., Wadood, F., Tahir, M.N., & Mujahid, M.N. (2021). Performance of Lactating Sahiwal Cows Fed Corn Stovers Ensiled with Molasses, Urea and Lime Solution. Iranian Journal of Applied Animal Science, 11(1): 59–66. https://ijas.rasht.iau.ir/article_680321_88fbf7df52c3db288b10976779f61f46.pdf.

[16] Wanapat, M., Kang, S., Hankla, N., & Phesatcha, K. (2013). Effect of rice straw treatment on feed intake, rumen fermentation and milk production in lactating dairy cows. African Journal of Agricultural Research, 8(17): 1677–1678. doi: 10.5897/AJAR2013.6732.

[17] Tesfaye, M., Habtamu, A., & Dereje, B. (2018). Effect of Maize Stover treated with urea on feed intake, milk yield and composition of crossbred dairy cows. Basic Research Journal of Agricultural Science and Review, 6(5): 39–43.

[18] Parnich, T. (1983). Urea–ensiled rice straw as a feed for cattle in Thailand. S Afr J Anim Sci., 13(3): 203–205.

[19] Sekhonyana, T.E., & Fulpagare, Y.G. (2015). Effects of urea treated maize stover silage on growth performance of cross bred heifers. Journal of Agriculture and Veterinary Science, 8(5): 58–62.

[20] Dejene, M., Bediye, S., Kehaliw, A., Kitaw, G., & Nesha, K. (2009). On-farm evaluation of lactating crossbred (*Bos taurus* x *Bos indicus*) dairy cows fed a basal diet of urea treated teff (*Eragrostis teff*) straw supplemented with escape protein source during the dry season in crop-livestock production system of north Shoa, Ethiopia. Livestock Research for Rural Development, 21(61). http://www.lrrd.org/lrrd21/5/deje21061.htm.

[21] Daniel, T., Mengistu, U., Gebeyehu, G., & Zemelak, G. (2017). Insacco dry matter degradability of urea and effective microorganism treated sorghum stover. Advances in Biological Research, 11(1): 41–50.

[22] Esheta, D.S., & Tesfamariam (2022). On-station evaluation of straws and stovers with urea to increase utilization in Somalia Region. African Journal of Agricultural Research, 8(9): 776–782. https://doi.org/10.5897/AJAR2022.16030.

[23] Katoch, R., & Tripathi, A. (2020). Improving nutritive value and digestibility of hay and crop residues. Forage Research, 46(2): 157–162.

[24] Katoch, R., Apoorva, Tripathi, A., & Manoj, N.V. (2021). Effect of pre-treatments on quality of maize (*zea mays* l.) stover. Forage Research, 46(4): 356–362.

[25] Mir, Z., Jan, E.Z., Robertson, J.A., McCarteney, D.H., & Mir, P.S. (1991). Effects of ammonization of brome-alfalfa and alfalfa hay stored as large round baler on preservation and feed quality. Can. J. anim. Sci., 75: 755–765. https://cdnsciencepub.com/doi/pdf/10.4141/cjas91-090.

[26] Jabbar, M.A., Muzafar, H., khottak, F.M., Pasha, T.N., & khalique, A. (2009). Simplification of urea treatment method of wheat straw for its better adoption by the farmers. S. Afri. J. Anim. Sci., 39(1): 58–61.

[27] Ali, I., Fontenot, J.P., & Allen, V.G. (2012). Effects of feeding corn stover treated with different nitrogen sources on palatability and dry matter intake in sheep. J. Vet. Anim. Sci., 2(1): 11–15.

[28] Genetic Resources Transfer and Regulation Directorate Institute of Biodiversity Conservation (2012). A guide to Access to Genetic Resources and Community Knowledge and Benefit Sharing in Ethiopia, Addis Ababa.