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Crop residues management and nutritional improvement practices

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1. Introduction

Crop residues are the second most important feed source for livestock next to grazing lands in the crop-livestock mixed production system in Ethiopia. However, their contribution to livestock feed in pastoral and agropastoral areas is insignificant. The major crop residues are cereals, namely, maize, teff, sorghum, wheat and barley, which account for more than 80% of the total acreage and production of the major food crops in the country. In the last three decades, crop residue production has sharply increased as farmers use more land to grow cereals and use improved technologies. However, the adoption of crop residues as feed for livestock to improve productivity is low because of its poor quality. It is known that crop residues are low in protein and energy content, and high in fibre.

Many countries, however, have successfully used crop residues as feed for livestock. The application of different physical, chemical and biological techniques has been used to improve the feed value of the residues in terms of digestibility and crude protein. Improving the quality of crop residues for better and efficient utilization of this important feed resource for livestock by smallholder farmers in Ethiopia is an essential and crucial intervention. This brief presents an overview of the available crop residues in Ethiopia and explains procedures for improving crop residues quality that can be used by Ethiopian farmers

2. Main crop residues in Ethiopia

Ethiopia has a diverse agro-ecology and produces different types of crops. The main crop residues are cereals (straws – teff, wheat barley, oats, finger millet, and stover – maize, sorghum and pearl millet), haulms (chickpea, lentil, beans, grass pea and field pea), oil crops (groundnut leaves), others (vegetable residues and enset leaves). The estimated grain yield and residues yields of the major crops are summarized in Table 1. Crop residues have diverse functions among the smallholder farmers. Their primary use is as feed for livestock, but depending on the local circumstances, crop residues are also used as fire fuel, construction materials for houses and thatching traditional houses.

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Table 1. Estimated grain and residue yield of main cereals in Ethiopia

No	Crop	2017/2018		2020/2021	
		Grain yield	Residue yield	Grain yield	Residue yield
		(tons)	(tons)	(tons)	(tons)
1	Maize	83,959	167,918	105,571	211,142
2	Sorghum	51,693	129,231	45,174	112,935
3	Teff	52,834	79,251	55,100	82,650
4	Wheat	46,430	69,644	57,801	86,702
5	Barley	20,530	30,795	23,391	35,087
6	Finger millet	10,308	12,370	12,030	14,436
7	Rice	1,510	1,963	2,682	3,487
	Total	267,263	491,173	301,749	546,438

Table 2: Nutrient composition (%), digestibility (%) and metabolizable energy (mcal/kg DM) of commonly found crop residues in Ethiopia

No	Crop residue	CP	IVDMD	ME
1	Barley straw	3.4	53.5	2
2	Maize stover	2.8	58	2.1
3	Oats straw	3.2	62.7	2.27
4	Teff straw	4.2	53.2	1.94
5	Wheat straw	4.4	53.6	2.01
6	Finger millet stover	4.1	55.5	1.97
7	Bean straw	7.6	54.1	1.99
8	Chickpea straw	4.4	51.8	1.91
9	Faba bean straw	8.8	55.6	1.97
10	Field pea straw	5.6	49.4	1.85
11	Groundnut haulm	10	64	2.15
12	Lentil straw	8	55	2.03
13	Linseed straw	5.2	48.8	1.82

3. Crop residues improvement methods

Crop varieties differ in their biomass productivity and most often breeders select varieties with the highest grain yield and early maturity. However, smallholder farmers prefer varieties with higher grain, biomass yield and that stay green for a long time. This reveals that in addition to improving the total production and quality of crop residues there is a need to select the appropriate varieties of a given crop to achieve the higher grain and biomass yield that different user require. In addition, agronomic practices such as application of fertilizer, affect the quality and quantity of the crop residues. Crops also need to be harvested promptly at grain maturity to protect against over maturity, exposure to direct sunlight, heat and moisture to ensure residues of

high-quality. Once the crop is harvested it must be threshed in time. The residues should also be collected and stored timely in a proper manner (Photo 1) and stored correctly. There are physical, chemical, and biological techniques to improve the nutritional quality of the crop residues.

Photo 1. The main crop residues in the mid and highlands areas of Ethiopia (teff, wheat and barley). *Photo credit: ILRI/Getnet Assefa*

Feeding value improvement methods of crop residues

a) Physical treatment of crop residues

Chopping:
Chopping is the most common physical treatment of crop residues widely used by smallholder farmers. It is primarily important for crop residues with thick stems like maize, sorghum, and pearl millet. The advantages of chopping roughages like crop residues and hay are that it minimizes wastage of feed, avoids selective feeding and maximizes their utilization. Animals usually select the most nutritious parts like leaves compared to stems. Chopping also increases intake of roughages, and improves the overall feed use efficiency to increase animal productivity.

Grinding:
Grinding uses grinding machines to crush and sieve residues into small sizes of 0.6 to 0.8 mm, which can be mixed with other feeds that are given to animals directly or made into pellets.

Generally, chopping and grinding increase crop residues intake by animals by more than 25%. It has also been reported that these practices increase feed passage rate and overall efficiency of feed utilization. Farmers mix chopped /threshed straws or stover with legume haulms to improve intake and quality.

b) Biological treatment of crop residues

Urea treatment of crop residues:
To improve feeding values of cereal crop residues, different chemical treatments have been developed, including urea treatment, which has been utilized for many years in different countries to improves the nitrogen (crude protein) content and digestibility of cereal crop residues.

Urea treatment is suitable in many developing country contexts due to its ease of access and use. The main benefits for smallholder farmers are that the urea treatment procedures are simple.Urea is readily available in many areas and its use does not have negative health effects both in animals and humans.

The inputs and facilities required for treatment of crop residues are 1) chopped (2-4 cm length) cereal straws and stover or poor-quality hay, 2) plastic sheets for mixing, 3) fertilizer grade urea, 4) molasses (optional), 5) clean water, 6) silos of different types or other containers like plastic bags, plastic barrels and sealing materials such as airtight plastic sheets, and 7) watering cans and weighing balance machines.

Procedures for urea treatment of crop residues:
Prepare a pit silo, silage bags, or large volume plastic barrels and the chopped and weighed crop residues to be treated. Prepare 5 kg of fertilizer grade urea to treat 100 kg of crop residue. To improve palatability and digestibility of treated crop residues it is advisable to add about 10 kg of molasses for 100 kg of crop residue (but this is optional). The recommended moisture content of the treated product is about 30%. Based on this, depending on the level of moisture in the crop residue and weather conditions, 60– 80 litres of water is enough to treat 100 kg of crop residue. Mix the 5 kg of urea with 60–80 litres of water and then add 10 kgs of molasses and stir to mix uniformly. Spread the 100 kg chopped crop residue on a plastic sheet and spray with the mixed solution. Spray the solution uniformly. For uniform distribution, spray slowly with a watering can and turn up the residues continuously while spraying (Photo 2).

The uniformly sprayed crop residues should then be filled into a silo, plastic bag or any airtight container. The filling need to be done slowly and should be compacted to take out the air inside the silo or container to create an anaerobic environment. The top should be covered and sealed with an airtight plastic sheet or similar material. In addition, it is recommended to place heavy materials like stones, old tyres or any similar heavy object on top to help to take out the remaining air inside the silo or storage container.

Urease is an enzyme produced by ureolytic bacteria that is found naturally on crop residues. In the presence of water, sufficiently warm ambient temperature and under anaerobic conditions, it hydrolyses into gaseous ammonia and carbonic gas. The ammonia thus generated creates an alkaline reaction, which gradually spreads and treats the mass of crop residue. Practical conditions affecting successful treatment urea include the presence of urease, the application rate of urea, moisture content, ambient temperature, and the treatment period, the degree of sealing (anerobic environment condition) and the quality of crop residue.

The sealed material should be kept for 21 days before use. The treated crop residue will have a pungent smell when it is opened. The treated crop residue should be taken out and ventilated by spreading it on a plastic sheet or canvas overnight before it is fed to animals.

Photo 2. Urea effective microbes. *Photo credit: ILRI/Getnet Assefa*

c) Effective microorganisms (EM) of crop residues

Among other biological treatments of crop residues, use of effective microbes (EM) is the most widely used. Effective microbes are a mixture of lactic acid bacteria, yeast and photosynthetic bacteria. They help to increase digestibility of fibrous feeds like crop residues by directly producing enzymes, organic acids, amino acids, hormones, and other chemicals inside the digestive system of the animals. In Ethiopia, effective microbes are commercially available from Weljeje, a local manufacturer, as effective microbes solution one (EM-1) in Debre Zeit. EM-1 is brewed to effective microbes solution two (EM-2) which is used in treating crop residues and other feeds sources this.

Procedures for preparing the EM-2 solution:
Mix 1 litre of molasses (if molasses is not available use 30 to 50 g of sugar) with 18 litres of warm water (35–40oC). Stir until it is completely dissolved. In this solution add 1 litre of EM-1 solution and stir so that the solution is properly mixed. The solution will have a total of 20 litres volume and will be poured in to a 20-litre jerrican and tightly closed or sealed to create anaerobic conditions. The sealed solution should be put in a warm shed/room to ferment for 10– 14 days. Occasionally remove the gas by slowly loosening the cap for short time and closing it again tightly..

Ways of using effective microbes to improve feeding values of crop residues including the following:

- Directly spraying the EM-2 solution on crop residues at the rate of 20 litres EM-2 solution per about 15 kg crop residues and keeping it for about 4 hours before feeding it to animals.
- Treating crop residues using the EM solution to make a silage. One can use EM-1 solutions and EM-2 solutions to treat crop residues as silage. The procedures are described in detail below. After the treatment, the silage will be ready for use in 4–6 weeks.
- EM can also be included in drinking water of ruminant animals. The EM-2 solution should be added at 0.2% (100 ml solution to 50 litres of water). Properly mix and allow animals to drink ad libitum.
- EM can also be used to treat concentrate feeds like wheat, rice and maize bran, poultry litter and other organic concentrates feeds. The treated cereal bran are called Bokashe.
- Effective Microbes are also used to avoid or reduce bad oduor of barns and poultry houses when sprayed on barn floors.

Procedures of treating crop residues with EM:
The inputs and facilities required for treatment of crop residues using EM are 1) chopped (2-4 cm length) cereal straws and stover or poor-quality hay, 2) plastic sheets for mixing, 3) EM-1 or EM-2 solutions, 4) molasses (or sugar), 5) clean water, 6) silos of different types or other containers like plastic bags, plastic barrels and sealing materials such as airtight plastic sheets, 7) watering cans and balances.

Prepare an ensiling facility either a pit silo, or large volume plastic barrels, plastic bags or other similar materials. Weigh and prepare the chopped cropped residue

or poor-quality hay. Prepare either EM-1 solution or EM-2 solution. If making the EM-1 solution add 1 litre of molasses (or 30 to 50 g of sugar) to 18 litres of warm water (about 35oC) and stir it to mix. Add the EM-1 solution and stir to mix properly. This solution is ready to treat the crop residues to be ensiled. If using the EM-2 solution, prepare 20 litres the solution. This amount of solution (both EM-1 and EM2) is enough to treat 50–70 kg of dry crop residues to make silage.

The crop residues to be treated with EM should be rinsed well with clean water and kept overnight. Use 2 litres of water for 1 kg of crop residues. Put the rinsed crop residue into the silo or barrel to a thickness of about 20 cm and spray the EM-solution, fill again the rinsed crop residue for about 20 cm and spray the EM solution. Continue like this until the crop residue is finished. Please try to estimate uniform distribution of the EM solution to the total crop residue. Another option is also to spread the water-rinsed straw on a large plastic sheet and spray the EM solution uniformly and put it into the silo or ensiling container. When filling the silo or a container / bag the treated crop residue, compact it to remove any air inside to create anaerobic conditions. At the end, seal the EM-treated crop residue with plastic sheet to make it airtight and put heavy things on it and leave for 4–6 weeks. The EM treated straw will be ready to be used as feed for ruminant animals after 4 weeks in warmer areas and about 6 weeks in cooler areas. EM-treated crop residues have a pleasant smell, a light yellow to light brown colour and no decay or fungus on it. The freshly treated straw can be fed directly to animals.

4. Improved use of crop residues through supplementation

Supplementing crop residues with high protein and energy feeds is one of the best methods of maximizing the efficiency of their utilization. Crop residues (even treated crop residues) need to be supplemented with high-quality feeds such as green fodder or concentrate feeds. The level of supplementation, however, is lower for treated straws relative to the untreated crop residues. Many smallholder farmers may have limitations to afford concentrate feeds. Under such condition cultivation of forages, especially those with high crude protein content and higher biomass yields such as alfalfa, vetches, cowpea, lablab, tree lucerne and elephant grass are alternative options.

Summary

- Proper selection of crop species and varieties, appropriate agronomic practices, harvesting at the right stage and time of grain maturity, and proper storage ensure high-quality and high crop residue yield.
- Physical processing of crop residues by chopping and grinding improves their nutritional value, intake, digestibility and efficient utilization.
- Urea treatment of cereal crop residues primarily improves crude protein content. It also improves intake, digestibility and efficient utilization.
- Effective microbes produce different enzymes, hormones, and other chemicals, which help to improve the flavour, intake, digestibility, and overall nutritional value of crop residues.
- Crop residues even after treatment, are not usually nutritionally adequate to feed productive animals. Therefore, depending on the level and type of production (milk or meat) crop residue basal diets need to be supplemented with quality green forages or concentrate feeds.

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Resources

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