Year-Round Fodder Technology Interventions for Sustainable Livestock Production in North-western Himalayan region

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Introduction

The livestock sector is vital for nutritional security and the national economy, contributing 4.1% to the national GDP and 25.6% to agricultural GDP. However, livestock productivity in India remains below the global average due to improper nutrition, inadequate healthcare, and poor management. Limited cultivable land for fodder production, prioritizing human nutrition, further aggravates this issue. The problem is more severe in the Himalayan region, where only about 1% of cultivated land is devoted to fodder crops, making the region heavily dependent on the plains for livestock feed. Nationally, there is a deficit of 11.24–32% in green fodder, 23.40–40% in dry fodder, and 28.90–44% in concentrates, with the Himalayan region facing even higher shortages. Animal keepers spend 60–70% of their expenses on feed, highlighting the need for sufficient and balanced nutrition to improve livestock productivity and profitability. Green fodder, being a critical component, should ideally be available year-round. This can be achieved through advanced fodder production and conservation technologies. This article discusses key technologies that can address feed and nutritional security, thereby enhancing the productivity and profitability of animal husbandry in the temperate Himalayan region.

Fodder production technologies:

Annual fodder crops:

Annual forages are grown for a single season, typically sown in autumn (October-November) or spring/summer (April-June). They establish quickly, filling feed gaps, controlling weeds, and serving as emergency or rotational crops. These forages complement inconsistent perennial supplies and respond well to moisture, fertility, and temperature, ensuring feed availability during droughts or periods of low perennial productivity. When cut and stored as greenfeed, they provide supplemental feed during harsh winters.

Although annual forages require yearly seeding and higher inputs like fertilizer, making them costlier than perennials, they offer flexibility in mixed farming operations with short-term land commitments. They can be grown alone for hay or silage, as a companion crop with perennials, or to extend grazing in rotational systems. While they grow in dryland, assured irrigation boosts productivity. Major annual fodder crops for cultivation include fodder maize, sorghum, cowpea, soybean, rice bean, and guar for kharif season and oat, rye grass, barley, berseem, shaftal for rabi season.

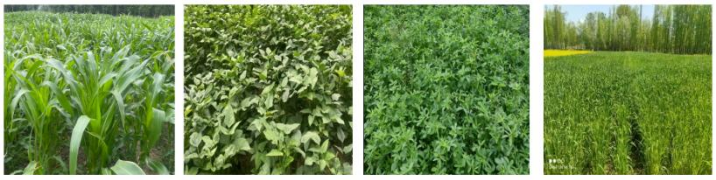


Fig. 1. Annual Fodder Crops

Perennial fodder crops:

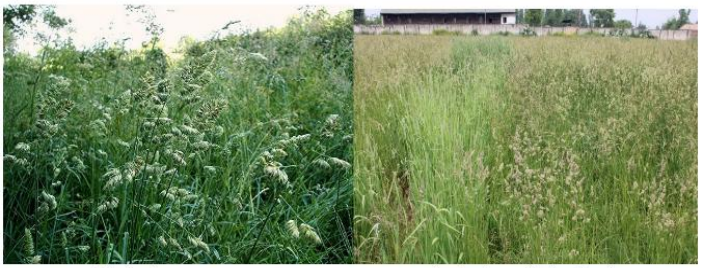


Fig.2. Perennial Fodder crops

Unlike annual crops, perennial forage crops can persist for several years, regrowing after each harvest, thus making them a more sustainable and long-term source of feed for livestock. Perennial forage includes a wide range of grasses and legumes. Forage grasses are used by livestock producers for a variety of reasons—from hay and greenfeed to summer pasture to winter grazing to stockpiled forage**.** Perennial forages come with a wide variety of characteristics. Some forage crops are tolerant to grazing (Creeping Red Fescue, Orchardgrass, Kura Clover) while others are easily eaten by livestock as hay or greenfeed (Sainfoin, Smooth bromegrass). When perennial legumes are included in the grass based systems, forage and soil quality both are improved. The major perennial fodder crops suitable for temperate climate are harding grass, orchard grass,

fescues, timothy, bromus among grasses and red clover, white clover, sainfoin, vetch and lucerne among legumes.

System approach

In most parts of the country, it is common to observe farming systems integrated with forage crops and livestock production. Undoubtedly, it is the best alternative to increasing the area and production of forage crops, as there are constraints to bringing more land under forage crops (Thomas, 2003). Some of the prominent farming systems with forage crops like intercropping, sequential cropping and agroforestry, may be useful (Thomas and Thomas, 2019).

Intercropping and sequential cropping

Dominant multiple-cropping systems have been practiced in the tropics. The main objective of intercropping is to intensify production in time and space dimensions. Important fodder crops suitable for intercropping are maize, sorghum, oat, perennial grasses, cowpea, soybean and berseem. A system of growing two or more crops in the same field per year, one after the other, is called sequential cropping. A very common example of sequential cropping is growing fodder maize/sorghum/cowpea in kharif followed by oat/rye grass/berseem/vetch in rabi season.

Fig.3. Forage based cropping sequences

Fodder Trees: Fodder tree leaves alone contribute 76.8% to UT's fodder resources**.** The fodder trees can be grown in bund areas of field for getting supplemental fodder production. The composition of tree and shrub foliage reveals wide variation in the CP content, which ranges from 10.3% (*Malus sylvestrus*) to 21.3% (*Morus multicaulis*). The CP content of *Morus, Ailanthus, Robinia, Salix, Populus, Ulmus and Elaeganus* species is higher than 17% and comparable to common legume fodders like lucerene, berseem and cowpea. The above-mentioned tree leaves in general have more than 40% NFE, which indicates a high level of soluble carbohydrate. Hence, these tree leaves besides protein sources, can also be considered as a good source of energy.

Diversified fodder production system for round the year fodder availability

Sole cultivation of a fodder crop provides fodder of only one kind. However, in order to meet the nutritional requirements, it is advised to grow fodder crops of differing nature. Cultivation of leguminous and non-leguminous fodder crops together is the best strategy to provide a balanced feed rich in energy and protein. Various round the year fodder production models based on diversity of fodder crops have been developed by Indian Grassland and Fodder Research Institute, Jhansi as per the rainfall availability; for the sub-tropical and tropical regions of the country. On similar lines, fodder production models can be adopted in the temperate regions:

Round the year fodder production system (Irrigated situation)

The system comprises of raising seasonal legumes (cowpea/berseem) inter-planted with annual (maize / sorghum) and perennial fodder grasses (harding grass, orchard grass, rye grass, tall fescue, bromus). These annual and perennial cropping systems can assure round the year green fodder availability.

Round the year fodder production system (Rainfed situation)

Almond/mulberry + orchard grass/tall fescue + red clover/sainfoin based fodder production systems may be recommended for temperate conditions with least irrigation facilities. In this system, dwarf varieties of almond/mulberry may be planted at 4 m x 4 m spacing. The space between tree alleys may be utilized for fodder production sown at a row spacing of 30 cm. In a study at IGFRI, RRS, Srinagar, orchard grass + cowpea-oat system recorded GFY of 308.69 q/ha and DMY of 70.07 q/ha.

Fodder on Field boundary/ Bunds/ Channels/ Non-competitive land

Among different perennial grasses, orchard grass, tall fescue, red fescue and rye grass are suitable for bunds/field boundaries of crop fields. Tree species like *Celtis australis, Robinia pseudoacacia, Salix alba, Aesculus indica, Ulmus wallichiana, Morus spp., Populus spp and shrubs like Zizyphus jujube, Indigofera heterentha, Rosa spp., Berberis lyceum, Rubus spp.* can also be planted on bunds and non-competitive field areas for harvesting additional fodder.

6. Silvo-pasture and horti-pasture based fodder production systems:

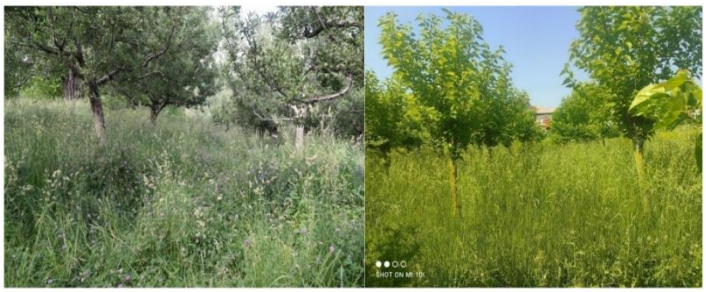
Any land use system that includes both trees and agricultural crops on the same piece of land is called an agro-forestry system. It is divided into subsystems, including the agrisilvicultural system, horti-pastural, silvi-pastoral and the agri-silvi-pastoral systems.

Horti-pastoral systems combine fruit trees with pasture, while silvi-pastoral systems integrate trees with forage crops, offering sustainable land management options. Hortipastoral systems improve orchard floor management, enhance soil quality, and provide high-quality forage. Successful combinations include *Phalaris* grass with almond and orchard grass with red clover, adaptable across various rainfall regimes in the North-Western Himalayas. These systems deliver ecosystem benefits such as flood control, carbon storage, and nutrient cycling. For example, in the context of Jammu & Kashmir that has 3.57 lakh hectares under horticulture, with 0.86 lakh hectares under grass cover. If 50% of the remaining 2.7 lakh hectares is utilized for perennial grasses and legumes under a hortipastoral scheme, an additional 206.4 crore kilograms of quality fodder could support 7 lakh animals annually.

Silvipasture models (forest trees + fodder) and horti-pasture systems (fruit trees + fodder) yield higher forage year-round compared to open pastures. Understory areas of forest trees such as Celtis australis, Robinia pseudoacacia, and Morus spp., or fruit trees like apple, almond, and pear, can be intercropped with grasses (orchard grass, tall fescue) and legumes (red clover, sainfoin). A study at IGFRI, Srinagar, demonstrated the effectiveness of a mulberry-based silvi-pastoral system. Phalaris + orchard grass + sainfoin + mulberry produced maximum green fodder (73.42 t/ha), dry fodder (19.09 t/ha), and crude protein (3.26 q/ha), achieving a 225.16% yield increase over control. This highlights the potential of integrated systems to boost fodder availability sustainably.

7. Fodder conservation technologies:

Year-round fodder production in sufficient and balanced quantities is challenging due to seasonal and weather variations. At times, fodder production may exceed demand, and in such cases, conserving the surplus is recommended to ensure availability during lean periods. Various fodder conservation technologies are developed which are as following:



Orchard grass + Red clover in an apple orchard Mulberry + Tall fescue

Fig. 4. Horti/silvi-pasture systems

Hay: Haymaking is the process of drying forage crops to preserve their nutrients and store them for later use. During hay making process, the loss of leaves from the plants during handling and transportation of fodder crops should be minimal. Thin stemmed crops which dry easily are most suitable for hay making e.g. natural grasses, cowpea, berseem, lucerne, soybean, rice bean etc. 130 kg of hay with 90 % DM is equivalent to 600 kg of GF with 15 % DM. For hay making, crops should be cut preferably at flowering stage and can be stored after reducing the moisture content up to 15-20 percent. Hay making involves cutting at proper stage (generally at flowering stage), drying for 2-3 days to reduce the moisture content below 15 %, raking i.e. turning hay to dry it and prepare it for baling, hay baling i.e. the process of compacting the hay for subsequent storage as animal feed. The bales can be square or round, and are bound together with twine, netting, strapping, or wire. Rope making is a common practice of hay making on smaller farms.

Silage: Silage is the fodder which is conserved by reducing pH through natural anaerobic fermentation and is used for feeding during scarcity period, drought or floods and for utilizing surplus forage (Borreani, 2018). The suitable crops are starch rich or thick stemmed crops like sorghum, maize and oat etc. During lean period silage acts as a green fodder and maintains livestock productivity.

Process of silage making

Selection of forage crops and their maturity stage

The optimum dry matter for crop harvesting for silage depends on the stage of crop harvesting. Most of crops are harvested at 50% flowering to dough stage when the moisture content varies between 80-90%. After overnight wilting the dry matter content reaches a favourable 30-35% range.

Steps in silage making

Silage making involves following steps:

1. Pit making

Firstly, a silage pit has to be dug for storing silage. The chaffed fodder should be pressed such that one cubic feet of pit should contain about 16 kg of ensiling material. A pit with a dimension of 1 cubic metre can store 550 kilograms of silage. The location of pit should be free from water stagnation. The pit should be surrounded on all sides with thick plastic sheet. Pit can also be constructed using bricks and cement or silage bags can also be used for making silage.

2. Preparation of fermentation mixture

For preparing 1 ton of silage, the following materials are required:

- ✓ Jaggery or Molasses - 1 Kg
- ✓ Common salt - 1 Kg
- ✓ Mineral Mixture - 1 Kg
- ✓ DCP (Di-Calcium Phosphate) - 1 Kg
- ✓ LAB (Lactic Acid Bacteria)
- ✓ Urea - 1 Kg
- ✓ Mix all of the above into a drum by adding water

3. Chaffing

Forage has to be chaffed into small pieces preferably 1.5-2 cm length using a chaff cutter. This improves the packing density which favours the growth of lactic acid bacteria, naturally present in crops. Add the fermentation mixture in small quantities as the fodder is loaded to chaff cutter.

4. Filling of silo and compaction

Chaffed material should be spread evenly over entire surface of silo (the structure) and then compacted through trampling (in case of small silo). In case of large silo (trenches) the compaction can be done using tractor. It helps in rapid evacuation of air from the silo, thus checks the aerobic respiration and nutrient loss.

5. Properly sealing and covering of silo pit

It should be done in such a way that neither air enters into the silo nor the gas comes out from the silo. The silage will be ready in 45 to 60 days, depending on the types of material used. Ideal silage is golden yellowish green colour with good aroma and is free from butyric acid, mold, sliminess, has pH in 3.5-4.2 range, 1%-2% lactic acid and ammonical nitrogen less than 10 % of total nitrogen.

Conclusion

Fodder scarcity is a major challenge in sustaining the livestock sector, especially in the temperate Himalayas, where limited land availability for fodder cultivation further aggravates the problem. Considering the embezzled scenario of Indian animal husbandry, utmost care whilst crop planning is needed to allocate a significant proportion of cultivable land to fodder crops since, importance of green fodder based balanced animal nutrition can't be disdained. Hence, adoption of innovative and diversified fodder technologies, including annual and perennial crops, fodder trees, intercropping, silvo-pastoral systems, and conservation techniques like silage and haymaking, can significantly enhance year-round fodder availability.

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