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TREE FODDER FOR NUTRITIONAL SECURITY AND SUSTAINABLE FEEDING OF LIVESTOCK- A REVIEW

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SUMMARY

The sustainable supply of adequate and nutritious feed and fodder is essential for the development of livestock sector. The area under fodder production is continually reducing indicating high pressure for cash crops production. The estimated fodder scarcity in India by 2050 reveals a net deficit of 35.6 % green fodder and 10.9 % dry crop residue, which calls for development and adoption of land use based interventions. Though, quality fodder availability in India is low due to low or non availability of suitable varietal wealth, more emphasis on food grain and cash crops. The area under fodder production is continually reducing indicating high pressure for cash crops production. There is a dire need felt to explore new feed resources. Fodder tree leaves may supplement the existing feed resources for small as well as large ruminant and can help to bridge the wider gap between demand and supply of nutrients. Tree leaves may become a rich source of supplementary protein, vitamins and minerals and their use in ruminant to enhance microbial growth and digestion. Thus, fodder trees pave the way for forage security besides their role in climate change mitigation and societal well being. The objective of this review is to explore the potentials of using fodder trees and shrub as a feed resource for livestock feeding and nutritional security especially in drylands.

Keywords : Fodder tree, livestock, nutritional value, sustainable, drylands

Agriculture and livestock are complimentary enterprises for each other. Both play an important role in strengthening food and nutritional security, and improve rural livelihood through income options and employment generation. The estimated doubling of demand for meat and milk in developing countries in the next two decades offers significant opportunities to poor livestock producers to increase their income from livestock farming (Hall *et al*. 2007). Livestock had a contribution of 29.35% in total gross value added (GVA) of agriculture and allied sector and 4.35% in total GVA as per Economic Survey 2021-22 (Annon, 2022). The livestock population in the country witnessed 5.3% increase in 2019 compared to 2012 (Livestock Census, 2019). Due to the observed trend and emerging demand of milk, the present availability of feed and fodder is lagging behind and the existing shortage may get widened to fulfill the fodder demand due expected increase in livestock population. The scarcity of quality fodder, high cost of commercial feeds and seasonal fluctuation in forage availability are the major barriers that limit profitable livestock production in India. Currently, as per IGFRI Vision (2050), the country faces a net deficit of 35.6% green fodder, 10.95% dry fodder and 44% concentrate feed ingredients. The demand for green and dry fodder will reach to 1012 and 631 million tones, respectively by 2050. Therefore, to meet out this deficit, fodder supply has to grow at 1.69% annually to sustain livestock husbandry. Since last two decades, static area under cultivated fodder is only 8.4 m ha (less than 5%), which warrants immediate intervention. This gap in demand and supply may further rise due to consistent growth of livestock population in the coming years.

The problem of acute shortage of livestock fodder is comparatively more notable in dryland areas. These areas are characterized by low rainfall, harsh and unfavorable environment conditions coupled with poor soils make the agricultural production systems a gamble. Nevertheless, livestock is a major source of revenue and stability for the residents of such regions rely heavily on their livestock for their livelihoods. In drylands, only single cropping system is the viable option and grain crops are given more attention than fodder crops (Priya *et al.,* 2022). Therefore, availability of quality fodder remains a limited resource round the year (Chandran and Athulya, 2021; Zam *et*

al., 2022) leading to the supplementation of livestock with minimum and low-quality feed thus reducing their produc-tivity and affecting their growth (Sasi *et al.,* 2021). In this situation, tree fodders provide viable option to supplement the feed of livestock sustainably. Fodder trees, with their nutrient rich leaves, constitute a potential source of quality green fodder to livestock especially during lean periods. The majority grass vegetation available in the dry season is poor in digestibility, protein as well as in overall nutrient content. Hence, introducing fodder trees in existing cropping systems is one of the promising ways for enhancing production of protein and nutrient rich fodder round the year, thereby saving farmer's expenses on purchased feeds. Tree fodders could be a good option to meet the fodder demand of livestock in areas having a perennial shortage of green fodder (Kumar *et al.,* 2019). Tree fodders provide a cheap source of protein and micro-nutrients. Research efforts have confirmed the potentiality of browsing plants to provide alternate source of nutrition for ruminants. There are number of such indigenous browse trees and shrubs with potential use as fodder. In addition to fodder production, the integration of fodder trees in cropping systems offers ecosystem services like enhanced carbon storage and associated climate change mitigation (Rocha et al., 2017).

Significance of fodder trees in livestock feeding

Fodder trees and fodder shrubs play a significant role in feeding domestic animals. In fact, trees and shrubs are increasingly recognized as important components of animal feeding, as suppliers of protein especially under harsh environmental conditions. Cultivation of fodder trees has several benefits compared to seasonal fodder crops. The foremost is their adaptability to harsh agro-climatic conditions. Fodder trees utilize limited quantities of water while remaining productive for longer periods. As they require minimum management after establishment, the cost of production is low (Deb Roy *et al.,* 1989). Flexibility in harvesting fodder from woody perennials is an added advantage; tree fodder is only used when other fodder resources are exhausted. Trees require less management and care, and give consistent yield for a prolonged period.

In a comparative study with various fodder legume trees and shrubs in Ghana, *Desmanthus virgatus* was among the low-yielding species and much less productive than *Gliricidia sepium*, *Calliandra calothyrsus* or *Cajanus cajan* (Barnes 1999). The growth pattern of various crops over two-year period reveals that trees require care during the establishment phase and once it is established, they show more persistence and the yield increases over the passage of time. However, herbaceous/shrub legumes require more careful tending throughout the crop growing period and yield declines with subsequent cutting over years. Fodder trees are considerably less affected by dry conditions as they have deep root systems which enables in extraction of water and nutrients from soil even during dry season (Teferi *et al*. 2008). This characteristic enables these plants to retain fresh foliage into the dry season. Moreover, the hot and wet climate of humid tropical zone favours luxuriant growth of fodder trees. The cultivation of trees has been recognized as one of the effective means for enhancing the production of quality forage for livestock, especially during the lean period (Gutteridge and Shelton 1994). The greatest value of fodder trees lies in their role as diet supplements rich in protein, energy, minerals and vitamins. Fodder trees have almost double the amount of protein (18 to 25%) and high levels of essential elements such as calcium, sodium and sulphur as well as critical micronutrients such as iron and zinc when compared to fodder grass species, which can save farmers expenses on purchased concentrate feeds (Moleele, 1998). Tree leaves are a rich source of supplementary protein, vitamins and minerals and their use in ruminants helps to enhance microbial growth and digestion (Cheema *et al.,* 2011). Leguminous tree species are favoured than non-leguminous because of their high foliar protein content and ability to fix nitrogen (Gutteridge and Shelton 1994), which in turn enrich the soil nutrient content. Jamala *et al.* (2013) claimed that leguminous species contain 25 to 50% more crude protein than non-leguminous plants. As per Mathukia *et al.* (2016) about 25% of the total annual diet of livestock is composed of trees and shrubs. Moreover, while integrating with existing cropping systems, maintaining fodder trees as hedges also regulates the possible competition to the main crop and facilitates easy harvesting of fodder (Raj *et al*. 2019). The process of integrating trees, forage, and the grazing of domesticated animals in a mutually beneficial fashion is known as silvi-pastoral farming. By establishing adequate silvi-pasture models, it was possible to raise land productivity from 0.5–1.5t $ha^{-1}yr^{-1}$ to > 15 t $ha^{-1}yr^{-1}$ (Ramteke *et al.,* 2021). The increased forage supply provided by such systems is projected to lessen grazing pressure, resulting in significant environmental benefits.

Status of tree fodders in India

In greater parts of India, animals' feed on tree or shrub leaves, usually rich in protein therefore, used as a supplement for low-protein fodders. Not all types of fodder trees and shrubs perform well in each area of the country. Different types of trees and shrubs are suited to different climates (depending on temperature and amount of rainfall), altitudes and soil types (Kumar et al., 2019). Therefore, it is important to select those types, which are suitable for the area. Species, which are most suited to the local climate, are trees and shrubs, which originated from the area. They are called indigenous species. But exotic species can also do well in certain areas under favourable conditions. The value of trees for feeding animals necessitates the planting of multipurpose fodder trees, which are, otherwise, primarily grown for fuel and timber purpose. In India, several exotic and indigenous trees including fodder trees were introduced during 1950s, to the Central Arid Zone Research Institute (CAZRI), Jodhpur, Rajasthan. Amongst exotic fodder trees and shrubs, most promising one includes *Acacia tortilis*, *Cellophospermum mopane*, *Prosopis juliflora*, *Dichrostachys mutans, Brasilettia mollis, Pittosporum phillyraesides, Schirueus mole, Atriplex spp.*, and *Zizyphus spinacristi w*hile, successful indigenous introductions were *Ailanthus excelsa, Albizia amara, Cardio roti, Albizia lebbek, Acacia nilotica, Hardwickia binata, Azardirachta indica, A. excelsa, and Prosopis cineraria* (Raghavan, 1989). The leaves of most of these trees are rich in nutrients. This type of fodder becomes more relevant during drought period, when there is scarcity of fodder. Exotic and indigenous fodder trees were introduced either due to lack of availability of such useful trees or their slow growth and inability to meet feed requirements of the area (Patil et. al., 1983). However, most of the areas and vegetations, which could serve as fodder for animals, are mainly found in semi-arid regions of the country (Raghavan, 1989). The suitable fodder trees for humid tropical regions include *Leucaena leucocephala*, *Calliandra calothyrsus*, *Gliricidia sepium*, *Morus indica*, *Moringa oleifera*, *Sesbania grandiflora, e*rythrina, *Neolamarckia cadamba*, *Cratylia argentea, Flemingia macrophylla* etc. (Sanchez, 2006, Ghimire *et al*. 2013, Raj *et al*. 2019, Patrick, 2019). They can be grown in close hedge rows and can be harvested frequently to yield quality forage.

Tree fodders in dryland

In drylands, livestock rearing is a predomi-nant occupation of people and is important in safeguarding their livelihood and protecting them from ill-effects of crop failure. Nearly 60% of the small ruminants' entire feed requirement is contributed by top feeds in dry areas (Aganga and Tshwenyane, 2003). Tree fodder can be integrated into dryland agriculture through alley-cropping/agroforestry system and its various types such as hedge row cropping wherein the fodder trees are placed along the boundaries or between main crops in long rows. Unlike grass and herbs vegetation, tree fodder continues to be available even at times of drought making it appropriate for fodder source in arid and semi-arid regions (Manuvanthra *et al.,* 2022). The following are some of the commonly found fodder trees around the world.

Potential fodder trees for drylands

Drylands farmers have fed tree foliage to their livestock for centuries, using wild browse or trees that grow naturally. The following fodder trees need more attention to meet the gap between demand and supply of livestock fodder.

Khejri (*Prosopis cineraria*)

Prosopis cineraria (L.) Druce commonly known as Jandi or Khejri belonging to family *Leguminosae*, holds an important place in the arid ecosystem (Shankarnarayan et al., 1987; Khatri *et al.,* 2010). In drylands, khejri grows very well in areas having sandy soils deficient in nutrients and in rainfall ranging from 100 to 600 mm annually with long dry season. It is being regarded as 'King of desert', 'Golden Tree of Desert', 'Love Tree', and 'Pride of the Desert', because every plant part of this versatile tree is utilized. This tree is so important in arid region that their number forms the major criterion for the value of land (Singh *et al.,* 1998). It is the true multipurpose species and often referred to in ancient literature as the 'Kalpvriksha' of the desert (Mahoney, 1990). It provides nutritive fodder, fuelwood, small timber, medicines, gum and tannins and also helps in improving the soil fertility and sand dune stabilization (Singh *et al.,* 1998). The fodder from its leaves, commonly known as 'loong' is very nutritious, protein

rich (12- 18% crude protein) and palatable to the animals (Bhandari *et al.,* 1979). It is a tree with great potential for agroforestry systems as it is highly compatible with agricultural crops (Puri *et al.,* 1994) due to its deep root system, monolayer canopy, nitrogen fixing ability and high efficiency of recharging the soil with organic matter (Toky and Bisht, 1992). Khejri based agro-forestry systems recorded 1500 Kg ha^{-1} forage yield and fodder palatability up to 74.8% (Roy et al., 2011). Its dried pods locally known as '*Kho kha'* contains 11.9% crude protein (Khan et al., 2006). Its leaves, significantly improves the growth rate (46 g/day) of goat kids when supplied at the rate of 672 g/ day (Singh and Bhatia, 1982), which may be attributed high palatability, protein and other nutrient contents (Bhandari et al., 1979). The farmers lopped the khejri for fodder during the winter months (October and November). The annual dry fodder production ranges from 1 to 1.5 t h^{-1} in a good rainfall year. Moderate lopping (2/3 of the foliage) on alternate year or at an interval of three years (Bangarwa and Hooda 2007) have been recommended to get maximum benefits on a sustainable basis. In contrast, Singh and Bishoni (2014) recorded more fodder yield from annual lopping. Pods of khejri are eaten by cattle, sheep, horses, mules, donkeys, goats, camel and other wildlife in the desert especially blackbuck and chinkara in western Rajasthan have survived by eating pods and leaves of this tree (Arshad *et al.,* 2006). Thus, Khejri which is the lifeline of the hot desert would provide fodder for the rising population of livestock on the long term basis contributing to resilience and system' sustainability (Kumar et al., 1992). Higher fodder biomass was reported under khejri tree canopy (Aggarwal *et al.,* 1976) may be due to higher soil fertility under the tree. Khejri provides utilizable biomass of 19.96 t ha^{-1} (208 tree ha^{-1}) including leaf fodder of 0.85 t ha^{-1} at 12 year age (Singh and Bishnoi, 2014).

Moringa (*Moringa oleifera*)

Moringa oleifera L. commonly known as 'Moringa' or 'Drumstick tree' or 'Sahjan 'leaves contain a good amount of beta-carotene, protein, vitamin C, calcium, magnesium and iron. Its leaves are rich in protein, so can be used as a supplemental fodder for milch animals. Rather, its leaves contain much higher protein than conventional protein supplements like coconut meal, cotton seed cake, ground nut cake, sesame cake, sunflower cake etc. Besides these, the leaves posses antioxidant and antimicrobial properties against several fungal species. Moringa can withstand both severe drought and mild frost conditions and hence widely cultivated across the world (Gopalakrishnan, et. al., 2016). It is a drought tolerant plant that can be grown in diverse soils, except those that are waterlogged. Slightly alkaline clay and sandy loam soils are considered the best media for this species due to their good drainage (Ramchandran *et al.,* 1980). It does not grow properly under waterlogged conditions as its roots get rotten. In nursery, moringa is easily propagated through seed using different containers (root trainer filled with vermiculite and coir compost) and polythene filled the sand, soil and FYM mixture in equal proportion. After it grows to about 30 cm, it can be transplanted in field. However, utmost care has to be taken while transplanting as the tap roots are tender and tend to get affected. The clonal plants can be raised using cuttings with 1 m length and 4–5 cm in diameter, but these plants may not have a good deep root system (Khan *et al.,*2016). Such plants tend to be sensitive to drought and winds. Moringa can be successfully grown in agroforestry at different spacings (Rout *et al.,* 2021). In recent years, its leaves have been widely used as substitutes for traditional protein feeds for monogastric animals (e.g., pig, rabbit, chicken), ruminants (e.g., cattle and sheep), and aquatic animals (Mahfuz and Piao, 2019). In recent years, *M. oleifera* has increasingly attracted the attention of researchers in animal husbandry because of its comprehensive nutritional, antioxidative, and medicative attributes (Makkar and Becker, 1997). Moreover, the consumption of *its* leaf strengthens neural response, enhances immune functions, and improves health because of the large amounts of microelements and polyphenol antioxidants (Bamishaiye *et al.,* 2011). Aside from promoting animal productivity and favorably influencing lipid composition, the potent antioxidant in *its* leaf prevents meat products from deterioration (Falowo *et al.,* 2014). Several researchers (Richter *et al.,* 2003; Sanchez *et al.,* 2006; Mendieta-Araica *et al.,* 2011) have explored moringa cultivation practices and its utilization as livestock fodder and in fish diet. They have shown that this species has potential as livestock fodder.

Mahaneem (*Ailanthus excelsa*)

Ailanthus excelsa Roxb. commonly known as 'Mahaneem', 'Ardu', 'Maharukh' and 'Tree of Heaven' and it is an important member of family

Simaroubaceae. It thrives well in the arid and semi-moist regions and figures in the list of important fodder trees with multiple uses. It can be utilized as leaf fodder, mulch, timber, fuelwood, charcol and in human and animal medicine. It is relatively a fast growing tree. An average full grown tree yields about 5- 7 quintals of green leaves lopped twice a year in the month of November-December and May-June (Arif et al., 2021). Leaf fodder from mahaneem is an important fodder with high palatability and nutritious for sheep and goats. In arid ecosystem sheep and goats are essentially dependent on pastures and also it is the cheapest source of feeding but it may not provide a perfect diet for these animals especially during extreme climate. Pastures of perennial fodder trees like mahaneem produces feed more quickly and provide feeding even during drought condition also. Its leaves are rated as highly palatable and protein rich nutritious fodder for sheep and goats and believed to augment milk production. In green leaves of mahaneem crude protein varies 16.25-19.87%, ether extract, 3- 3.96%, crude fiber 12.82-21.85%, N-free extract 41.43-19.96% calcium 1.48-2.42% (Jat *et al.,* 2011). Although, nutritive value of leaves may vary with age and stage of plant, season, lopping or pollarding. Realizing its multiple uses, its cultivation in various systems extended and came out to be as profitable venture in case of agroforestry and silvi-pastoral system (Mann, 1994).

Babool (*Acacia nilotica*)

Acacia nilotica (L.) Willd. ex Del commonly known as babul, kikar or Indian gum Arabic tree, has been recognized worldwide as a multipurpose fodder tree. It is widely distributed throughout arid and semi-arid zones of the world. *It* survives well in areas receiving 400-500 mm rainfall per annum. It grows in light and deep soils (Sabareeshwari et al., 2021). The pods (approx. 130kg) and green fodder of the tree are suitable for feeding the livestock. The leaves of the trees also possess fodder of very high quality. This tree species is an important fodder source in India, Ethiopia, West Africa and Somalia (Greiller *et al.,* 2012). The fruits of the tree are ground and stall-fed to animals. The species has crude protein content of 18% and digestibility coeffi-cient of 46.2% (Chandran, and Athulya, 2021).

Mulberry (*Morus alba*)

Morus alba grown over a wide range of climatic regions and edaphic conditions. In the agroforestry systems, for foliage fodder purpose, it can be recommended for plantation on black and low lands as well (Mathukia *et. al.,* 2016). It produces about 25-30 t ha^{-1} $year^{-1}$ fresh leaves biomass of high protein content (18-25% in DM) and about 75-85%, *in vitro* DM digestibility (Ba *et al.,* 2005). Besides, its leaves are also rich in proteins, minerals, especially in calcium (Ca) and phosphorous (P), and metabolizable energy (Srivastava et al., 2006). Mulberry plant produces more fodder in terms of digestible nutrients compare to most of the traditional forages (Sanchez, 2000). It was reported that its foliage is comparable to alfalfa hay mix in terms of digestible energy and crude protein values. Mulberry leaves are protein rich forage supplements and can be used fresh or dried in compound feeds of high yielding animals. When used as supplement feed, it has significant effect on protein as well as fat content, besides improving total quantity of milk in cow and goat (Venkatesh et al., 2015). In several parts of the world it is also used as a substitute to concentrate feed for cattle. Moreover, its leaves can be used as main feed for sheep and, goats (Bakshi and Wadhwa, 2007).

CONCLUSION

Importance of forage production in maintaining food security as well as nutritional security has been felt since long. The overall scene of forage production is very alarming and corrective measures have to be taken to improve this problem. Tree fodders serve as a livelihood support to farmers in drylands with their regular supply of nutritive green fodder throughout the year, their rugged-ness to survive in harsh climates, and faster growth rates. The livestock which remains as a lifeline for people including farmers and landless labourers are benefitted in terms of quantity as well as quality of feed by integration of tree fodder in dryland agriculture. In future, owing to its rich nutritional properties and increased palatability, fodder trees have the potential to expand in areas where only traditional fodder has been utilized. The future prospect lies in creating awareness regarding the importance of tree fodder in dryland areas and further research on fodder tree improvement programmes for higher leaf fodder need to be initiated.

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