



Mulberry (*Morus* spp.) for mitigating enteric methane emissions and ensuring sustainable livestock feeding systems in India

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Abstract

Mulberry (*Morus* species; Family: *Moraceae*) leaves are source of highly palatable as well as digestible fodder during summer season and are rich in crude protein content (14.0–34.2%) and macro as well as micro nutrients. These leaves are rich in secondary metabolites known to enhance livestock production including the flavonoids present in mulberry leaves are known to show efficacy in managing fatal livestock diseases such as neonatal calf diarrhea and reducing enteric methane production. Moreover, mulberry species is easy to propagate, and produces high leaf biomass yield and can be grown under vast climatic conditions from arid, semi arid, tropical, subtropical to temperate conditions. Further, mulberry species can be managed as a tree, shrub or hedge and has been found to be compatible to be grown under agro-forestry systems, as high density plantations, as boundary plantations and bund plantations etc. Thus, given the pressing issues of declining livestock productivity, increasing enteric methane emissions, and the prevalence of livestock diseases, harnessing the potential of mulberry species emerges as a sustainable solution which needs promoting cultivation of mulberry species ensuring sustainable livestock feeding systems in India. For cultivation, identification of elite germplasm that are well suited to the various climatic conditions along with higher and uniform leaf biomass yield, high protein as well as nutritional profile, nutraceutical potential (flavanoid rich) and methane reduction potential is required which can be promoted for cultivation among farmers. Thus, there is an urgent need to initiate screening of mulberry species germplasm for identification of superior genotypes of mulberry for ensuring economically viable way to reduce enteric methane emissions and ensuring sustainable livestock feeding systems in India under various agro-climatic zones.

Introduction

In India, livestock plays a key role in sustaining rural economy and nutritional requirements of the rural people. Besides this, livestock sector also contributes 4.11% and 25.6% respectively to total GDP and agriculture GDP of India. The average milk productivity of milk animals in India is significantly lower than in developed countries such as the USA and UK (Intodia, 2017). Sustaining livestock production is crucial for bolstering the rural economy in India, where the livestock population stands at 535.78 million, according to the 20th Livestock Census (2019), reflecting a 4.43% increase since the 2012 census (Singh, 2020). However, low productivity is primarily attributed to a persistent shortage of quality fodder. The rising livestock population exacerbates this demand-supply gap, emphasizing the urgent need for strategies to enhance fodder availability and ensure sustainable livestock

production. According to reports, India faces a deficit of 11.24% for green fodder and 23% for dry fodder (Roy et al. 2019). Moreover, feedstuff and fodder that is fed to our livestock is of poor quality especially feed/fodder stuff that is fed during the dry/lean period is poor in crude protein content, digestible nutrients, metabolizable energy, vitamins and macro as well as micro mineral content (Devendra 2011, Simbaya 2020). Because of poor quality of feed, digestibility as well as utilization of nutrients gets reduced and it leads to increased enteric methane emission from livestock, the lesser body weight gain and reduced milk production (Devendra 2011, Simbaya 2020). Therefore, ensuring round the year quality nutritious fodder supply and improving protein availability for livestock during lean period is need of the hour to ensure fodder security, reduce enteric methane emission from livestock via inhibiting the growth of methanogenic bacteria and ciliates inside gut and sustain livestock productivity. Under such case, tree fodder leaves are sustainable option for ensuring round the year quality fodder supply and to address dry season protein and nutrients deficiency for livestock and reduce enteric methane emissions (Jetana et al. 2010, Chibinga et al. 2012). Therefore a literature review was carried out to shortlist important fodder tree species to identify tree species that are easy to grow as well as widely distributed; protein, macro micro nutrient as well as secondary metabolite rich to ensure round the year quality fodder supply, reduce enteric methane emissions and enhance livestock productivity.

Methods

Literature review was carried out using relevant sources, including peer-reviewed journals, government reports, institutional publications, and databases like Scopus, Web of Science, and Google Scholar to identify important fodder tree species that are easy to grow as well as widely distributed; protein, macro micro nutrient as well as secondary metabolite rich to ensure round the year quality fodder supply, reduce enteric methane emissions and enhance livestock productivity. Based on the literature review, mulberry species was found to be the potential fodder species to fulfil above mentioned concerns. Thereafter, ICAR-IGFRI, Jhansi, India started collection of mulberry species germplasm via exploration in Himalayan zone as well procurement from various research organizations from India covering various agro-climatic zones for evaluation and selection of high yielding and nutritionally rich genotypes of mulberry for semi arid and temperate conditions.

Results

Mulberry (*Morus* species) belonging to family Moraceae are potential fast growing fodder tree species that are found growing under various agro-climatic zones from arid, semi arid, tropical, subtropical to temperate conditions. Mulberry leaves contain higher crude protein content (14 – 35%) than the traditional forages; are rich in macro as well as micro nutrients (Ca, P, K, Na, Mg, Fe, Zn, Mn, B, Cu, Mo); are highly palatable as well as highly digestible (75–85%); available during during summer season and rich in secondary metabolites especially mulberry leaf flavonoid that enhance livestock production (yield and quality), reduce enteric methane production via inhibiting the growth of methanogenic bacteria and ciliates inside gut and are also utilized in livestock disease management like neonatal calf diarrhea (Bi et al. 2017, Hassan et al. 2020). Moreover, mulberry leaf supplementation to dairy animals has been proved to enhance milk yield and quality (protein, fat content) (Datta et al. 2002, Venkatesh et al. 2015). Supplementation of livestock feed with 5–10% of mulberry silage have been reported to improve rumen micro-biota, fermentation, and enhance the production of fiber-digesting, propionic acid synthesizing and milk fat enhancing microorganisms leading to the improvement in milk yield in dairy animals (Li et al. 2020). Secondary metabolites especially mulberry leaf flavanoids present in mulberry leaf have been reported to enhance milk production improve health and manage serious disease like neonatal calf diarrhea (Gonzalez et al. 2010, Bi et al. 2017, Li et al. 2020). Further, mulberry leaves can be easily converted into hay, silage, leaf meal etc. thereby can also be stored for feeding the livestock during fodder scarcity. Another advantage with mulberry species is that they are fast growing, easy to propagate, and produces high leaf biomass yield of 25-30 t/ha depending upon the species, harvest cycle and plant density (Venkatesh et al. 2015). Moreover, mulberry species can be grown in various forms such as tree, shrub, hedges etc. and being perennial, deep rooted tree species they are less susceptible to changing climatic and weather conditions. Huge genetic variation in mulberry species germplasm with respect to the growth, leaf yield, and fodder quality traits, secondary metabolites (flavonoid

content) as well as biochemical, methane reduction potential, ensiling traits; physiological, phenological, agromorphological traits etc. has been reported (Taikader and Kamble 2009, Kandylis et al. 2009, Gonzalez et al. 2010, Doss et al. 2012, Suresh et al. 2017, Yu et al. 2018, Hassan et al. 2020, Krishna et al. 2020). This genetic diversity among mulberry species germplasm have a huge potential to be exploited for identification of elite germplasm of mulberry species for mitigating enteric methane emissions and ensuring sustainable livestock feeding systems across various agro-climatic zones in India.

However, despite being a potential species for ensuring fodder security, mitigating enteric methane emissions and enhance livestock productivity, mulberry has not been utilized quality fodder production in the country and limited attention to *Mulberry* has been given by livestock and fodder researchers. Therefore, ICAR-Indian Grassland and Fodder Research Institute, Jhansi have initiated the research work on these aspects and collected a diverse collection (73 collections) of mulberry germplasm at IGFRI, Jhansi belonging to the five species (*Morus alba*, *M. latifolia*, *M. indica*, *M. laevigata* and *M. bombycis*). These collections are being evaluated under semi-arid and temperate conditions for fodder yield as well as quality traits and during initial observations under nursery conditions huge variations for growth, morphological, biochemical and fodder traits have been observed in *M. alba* germplasm. The germplasm revealed wide variations for height (81.67 to 200 cm), diameter (8.70 to 15.56 mm), and number of leaves per plant (39.33 to 189.33), total chlorophyll content (0.90 to 1.93 mg/g of fresh weight), and total carotenoid content (24.60 to 88.20 µg/g of fresh weight). Furthermore, significant variation was observed in qualitative morphological traits of leaves. Leaves were either homophyllous or heterophyllous; leaf lobation varied from being unlobed, bilobed, trilobed & tetra-lobed, leaf apex varied from acute or narrowly acute to acuminate; leaf margin was either crenate or crenulate; leaf base was either cordate or truncate or combination of both. These variations can be linked to yield and quality traits, enabling indirect selection.

Given these findings, there is a pressing need to initiate an extensive evaluation of mulberry germplasm collections to identify and screen out promising genotypes suitable for ensuring sustainable livestock feeding system in India.

Discussion

Mulberry species are potential affordable as well as scalable option for ensuring fodder security, mitigating enteric methane emissions and enhance livestock productivity in India. Therefore, there is need to collect diverse germplasm of mulberry species and evaluate it across various agro-climatic zones in India for screening out promising genotypes for fodder yield as well as quality traits and reducing enteric methane production to ensure sustainable livestock feeding system in India.

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