Acta Scientific AGRICULTURE (ISSN: 2581-365X)

Volume 9 Issue 10 October 2025

Review Article

Forage Legumes in Brazil: Diversity, Uses and Potential for Sustainable Systems - A Review

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Received: September 11, 2025

Published: October 08, 2025

Abstract

Brazilian livestock production has consolidated as one of the largest in the world, mainly supported by pasture-based systems. In this context, forage legumes stand out as strategic alternatives to increase animal productivity, improve soil fertility, and reduce dependence on synthetic fertilizers through biological nitrogen fixation. This study aimed to compile and analyze information on ten forage legume species representative of the main Brazilian biomes, based on a narrative and integrative literature review, complemented by technical datasheets prepared by the Forage Study Group of the State University of Goiás. The species addressed were: *Arachis pintoi*, *Macroptilium atropurpureum*, *Desmodium ovalifolium*, *Centrosema brasilianum*, *Cratylia argentea*, *Medicago sativa*, *Clitoria ternatea*, *Stylosanthes guianensis*, *Canavalia brasiliensis*, and *Trifolium repens*. The review results highlight wide variability among species regarding biomass production (4 to 30 t/ha/year), crude protein content (11 to 30%), and digestibility (50 to >70%), in addition to different degrees of adaptation to tropical, semi-arid, and subtropical soils and climates. It is concluded that forage legumes represent key tools for the development of sustainable livestock systems in Brazil, although technological diffusion remains a challenge for their large-scale adoption.

Keywords: Biological Nitrogen Fixation; Forage Intercropping; Sustainability; Animal Nutrition; Pastures

Introduction

Cattle ranching in Brazil has more than doubled since the 1970s, and in 2023 the national herd was estimated at 197 million head [4]. This expansion was only possible due to significant advances in zootechnical indicators, consolidating Brazil as a global benchmark in the sector. In addition to ensuring food security for the population, the production chain drives job and income generation, supported by an extensive slaughter and processing industry, as well as innovations in nutrition, health, reproduction, genetics, and pasture technologies [1-3].

Within the scope of pasture technologies, the constant release of new forages adapted to Brazil's diverse edaphoclimatic conditions has been observed. In this context, forage legumes have gained prominence, especially in intercropping systems, as they combine high nutritional value with the ability to perform biological nitrogen fixation (BNF). This characteristic enhances soil fertility, increases nutrient availability for non-fixing grasses, and reduces dependence on synthetic fertilizers [28,47,48].

Beyond nutritional and agronomic aspects, the adoption of these species must also take into account the country's broad climatic diversity, reflected in its biomes. The Amazon is characterized by a humid equatorial climate (Af), hot and rainy throughout the year; the Cerrado by a seasonal tropical climate (Aw), with rainy summers and dry winters; the Caatinga by a hot semi-arid climate (BSh), with scarce and irregular rainfall; the Atlantic Forest by a humid subtropical climate (Cfa and Cfb), with well-distributed rainfall throughout the year; and the Pampa, also humid subtropical, but with harsher winters and grassland vegetation [8,39]. This diversity favors the cultivation of both tropical and temperate species, broadening the possibilities for sustainable systems based on grass-legume mixtures.

In this context, a comprehensive review of the main forage legumes used across the different Brazilian biomes is required. The objective of this study is to compile and analyze information on these species, contributing to the expansion and dissemination of technical and scientific knowledge, since many forage species remain little known to technicians and extension agents, despite their high potential to strengthen the sustainability of national livestock production.

Methodology

This study consists of a narrative and integrative review of the literature on forage legumes used in Brazil. Scientific information was obtained from national and international databases (SciELO, Scopus, Web of Science, and Google Scholar), using the descriptors "forage legumes," "biological nitrogen fixation," and "forage intercropping," in both Portuguese and English. The review prioritized publications from the last ten years (2015-2025), although classical studies were also included when considered essential for understanding the topic.

In addition to peer-reviewed scientific articles, technical reports and institutional documents were also considered, particularly those from Embrapa and other Brazilian research institutes, as they provide applied information on the use and management of forage legumes under local conditions. The images presented in figure 1 were obtained from institutional databases and are properly referenced in the bibliography.

For the writing of this article, members of the GEFOR Group (Forage Studies Group) at the State University of Goiás, University Unit of Palmeiras de Goiás, collaborated in the preparation of technical datasheets, drawing on information collected from the aforementioned databases, systematizing information on ten forage legume species representative of Brazil's main biomes. Each datasheets followed a standardized model (presented as Supplementary Material 1 - Forage Legume Datasheet), which included fields such as botanical identification, regional adaptation, morphological characteristics, forage value, utilization methods, agronomic advantages, limitations, and practical examples of use.

The process of data systematization involved three steps: (I) identification and selection of references according to relevance and credibility (scientific journals, technical reports, and institutional publications); (II) extraction of quantitative and qualitative information (biomass yield, crude protein, digestibility, climatic and edaphic adaptation, and management recommendations); and (III) synthesis of the information into comparative tables and standardized datasheets. Finally, all data were comparatively organized, highlighting the agronomic, nutritional, and environmental potential of each species, with emphasis on their contribution to sustainable livestock systems in Brazil.

Results - Forage Legume Species

Arachis pintoi (Forage peanut)

The forage peanut (*Arachis pintoi* Krapov. & W.C. Greg.) is a perennial, stoloniferous, prostrate legume native to South America, widely used in tropical systems (Figure 1A; Table 1). It adapts to hot and humid regions with annual rainfall above 1,500 mm, showing good tolerance to acidic soils, high aluminum saturation, and temporary waterlogging. Morphologically, it presents a prostrate and dense growth habit, with compound leaves and yellow flowers, ensuring good ground cover and grazing resistance. Its biomass yield ranges from 7 to 14 t/ha/year, with crude protein contents of 13-25% and digestibility of 60-67%. It is widely used in mixed pastures with tropical grasses, protein banks, and for hay and silage production under forage shortage. Advantages include high efficiency in biological nitrogen fixation and good persistence in low-fertility soils. However, it has low tolerance to cold and prolonged drought, and is susceptible to chrysomelid beetles. Trials conducted in Brazil have demonstrated increased animal weight gain and greater pasture longevity in mixtures with this species [7,29,33].

Macroptilium atropurpureum (Siratro)

Siratro (*Macroptilium atropurpureum* (DC.) Urb.) is a perennial climbing legume native to Central and South America, used in several Brazilian biomes such as the Amazon, Cerrado, and Caatinga (Figure 1B; Table 1). It adapts well to acidic, low-fertility soils and tolerates long dry periods due to its deep root system, although it is sensitive to waterlogging and frost. Morphologically, it has a climbing to prostrate growth habit, compound leaves, and conspicuous purple flowers. Biomass yield ranges from 4 to 10 t/ha/year, with crude protein levels of 16-25% and digestibility of 55-65%. It is used for grazing, cut-and-carry feeding, hay, and protein banks, and is recommended in mixtures with *Urochloa* and *Andropogon* grasses, improving forage quality and nitrogen cycling. Advantages include high drought resistance, good adaptation to poor soils, and strong biological nitrogen fixation capacity. Limitations are susceptibility to foliar fungal diseases and low tolerance to cold. Trials in the Cerrado have shown increased animal production in intercropping systems [12,22,32].

Desmodium ovalifolium (Desmodium)

Desmodium (*Desmodium ovalifolium* Wall. ex Benth.) is a perennial subshrubby legume, native to Asia, widely used in Brazilian pastures, especially in the Amazon (Figure 1C; Table 1). It adapts well to high rainfall regions (1,200-2,500 mm/year), acidic and infertile soils with high aluminum saturation, and shows good shade tolerance and low drought tolerance. Morphologically, it has a prostrate to erect stem, compound leaves, and stoloniferous habit. Biomass yield can reach 8-12 t/ha in the rainy season and 4-5 t/ha in the dry season, with crude protein of 13-16% and digestibility around 50%. It is used under controlled grazing, cut-and-carry, hay, and protein banks, and is recommended in mixtures with *Urochloa* and cut grasses. Advantages include persistence in poor soils and good performance in shaded systems, also fitting crop-livestock-forest integration. Limitations include low nitrogen transfer to soils and seed dormancy that requires treatment. Field experience in northern Brazil highlights its efficient use in low-fertility pastures [6,11,17].

Centrosema brasilianum (Centrosema)

Centrosema (*Centrosema brasilianum* (L.) Benth.), also known as cunhã or butterfly pea, is a perennial climbing legume native to South America, cultivated in various regions of Brazil, especially in the Cerrado and Amazon (Figure 1D; Table 1). It adapts to acidic, low-fertility soils, annual rainfall of 1,200-2,000 mm, and shows moderate shade tolerance. Morphologically, it has a climbing growth habit, compound leaves, and large lilac to purple flowers. Biomass yield ranges from 8 to 12 t/ha/year, with crude protein levels of 16-22% and digestibility of 55-65%. It is used in mixed pastures with grasses, hay, silage, and protein banks. Advantages include good drought resistance and high nitrogen fixation efficiency. Limitations include low persistence under overgrazing, susceptibility to waterlogging, and foliar fungal diseases. Embrapa trials highlight its potential in sustainable pasture systems on low-fertility soils [11,18,43].

Cratylia argentea (Cratylia)

Cratylia argentea (Desv.) O. Kuntze is a perennial shrubby legume native to the Amazon and Cerrado, noted for its drought tolerance and suitability to poor soils (Figure 1E; Table 1). Morphologically, it has a shrubby growth habit, compound leaves, and perennial character, mainly used in protein banks and cut-and-carry feeding. Crude protein ranges from 18-23% and digestibility from 50-60%. Advantages include high forage yield during the dry season and adaptation to infertile environments, contributing to soil nutrient cycling. Limitations are lower acceptance under continuous grazing and the need for specific management. Cerrado trials show its potential for strategic supplementation in cattle production [14,41].

Medicago sativa (Alfalfa)

Alfalfa (*Medicago sativa* L.) is the most economically important temperate forage legume worldwide, successfully introduced in Brazil mainly in subtropical regions, especially in the South (Figure 1F; Table 1). It thrives in fertile, deep, well-drained soils with pH near 6.5, but is sensitive to acidity and aluminum toxicity. Morphologically, it has an erect growth habit, perennial cycle, and good persistence under proper management. Biomass yields can reach 20 t/ha/year, with crude protein levels of 18-25% and digestibility above 65%. It is mainly used for hay, rotational grazing, and to a lesser extent for silage. Advantages include high nutritional value, good palatability, and strong contribution to intensive production systems. Limitations are its high fertility requirements, low tolerance to acidity, and poor performance in hot climates. In Brazil, it has been successfully used in high-yield dairy systems [13,26,37].

*Clitoria ternatea (*Clitoria, butterfly pea*)*

Clitoria ternatea L. is a perennial herbaceous legume native to tropical Asia and now widespread across tropical and subtropical regions, including Brazil (Figure 1G; Table 1). It has a twining, prostrate to erect growth habit, reaching up to 3 m in length, with flexible stems, deep roots, and characteristic blue-violet flowers, also used as a natural dye and ornamental plant. It adapts to biomes such as the Semi-arid, Cerrado, Amazon, and Atlantic Forest, growing from 0 to 1,800 m in altitude, under 380-4,000 mm annual rainfall and temperatures between 19-32 °C, preferring well-drained soils with pH 5.5-8.9. Biomass yield ranges from 3.3 t/ha of dry matter at 60 days to up to 30 t/ha/year under irrigated and fertilized conditions, with crude protein contents of 14.2-28.8% and digestibility of 49-65%. It is used for grazing, cut-and-carry, hay, silage, protein banks, and intercropping with grasses such as *Panicum maximum* cv. Massai and *Urochloa decumbens*. Agronomic advantages include hardiness, high tolerance to drought, heat, and shade, high nitrogen fixation efficiency, and soil recovery potential in integrated systems (crop-livestock, crop-livestock-forest, and silvopastoral). Limitations are low tolerance to waterlogging, frost, and late cutting, and the need for seed scarification to overcome dormancy. Trials in the Northeast and Cerrado have demonstrated gains in animal production and forage mass under intercropped and organically fertilized systems, highlighting its potential for sustainable livestock in tropical Brazil [5,27,30,35,40].

*Stylosanthes guianensis (*Stylo*)*

Stylosanthes guianensis (Aubl.) Sw. is a perennial subshrubby legume adapted to acidic, low-fertility soils, widely distributed in Brazilian biomes, especially in the Cerrado and Amazon (Figure 1H; Table 1). It shows high tolerance to drought stress and hardiness, playing a role in the recovery of degraded pastures. Forage yield ranges from 7-12 t/ha/year of dry matter, reaching up to 20 t/ha/year under favorable conditions. Crude protein ranges from 11-20%, with in vitro digestibility between 55-60%, and biological nitrogen fixation capacity near 150 kg N/ha/year. It is used in mixtures with tropical grasses, contributing to pasture longevity and improved animal performance. Limitations include susceptibility to anthracnose (*Colletotrichum gloeosporioides*) and the need for seed treatment to overcome dormancy [24,36,38].

*Canavalia brasiliensis (*Brazilian jack bean*)*

Canavalia brasiliensis Mart. ex Benth. is an annual to short-lived perennial legume with a twining to prostrate habit, used as forage and green manure in tropical systems (Figure 1I; Table 1). It adapts to poor soils with pH 4.5-8.0 and rainfall between 900-1,800 mm/year, tolerating drought for up to 5-6 months. Biomass yield ranges from 8-12 t/ha/year, with crude protein contents of 18-25% and digestibility of 65-75%, along with adequate fiber and high nitrogen fixation rates. It is used in grazing, cut-and-carry, hay, soil cover, and integrated systems, contributing to nutrient cycling and erosion control. Limitations include the presence of antinutritional factors in seeds (e.g., canavanine) and low tolerance to waterlogging [9,31,42].

*Trifolium repens (*White clover*)*

White clover (*Trifolium repens* L.) is a perennial stoloniferous legume typical of temperate and humid subtropical climates, best adapted to southern Brazil (Figure 1J; Table 1). It has high forage value, with annual yields ranging from 8-12 t/ha of dry matter, crude protein of 17-30%, and digestibility above 70%, while fixing 80-300 kg N/ha/year depending on management. It is widely used in mixtures with temperate grasses (such as ryegrass and oats), providing high-quality forage for grazing, hay, and silage. Advantages include high nutritive value and persistence in mixed systems; limitations are low tolerance to prolonged drought, waterlogging, and the risk of bloat under continuous grazing. Trials with the 'BRS URS Entrevero' cultivar show good adaptation to southern Brazil and superior performance in overseeding systems [23,25,34].

Discussion

The comparative analysis of the ten forage legume species shows that environmental adaptation is one of the main factors determining their productive and nutritional performance. Tropical species such as *Arachis pintoi*, *Desmodium ovalifolium*, and *Centrosema brasilianum* exhibit good persistence in humid regions and acidic soils, whereas more rustic legumes such as *Clitoria ternatea*, *Stylosanthes guianensis*, and *Canavalia brasiliensis* stand out for their drought tolerance and strategic use in semiarid environ-

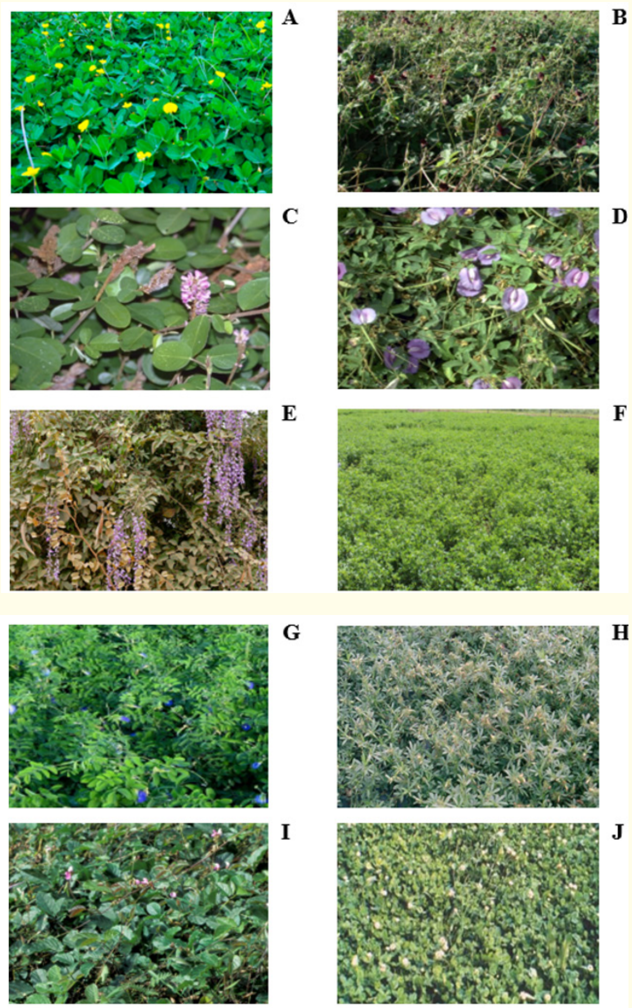

Figure 1: Forage legume species used in Brazil: (A) *Arachis pintoi* (forage peanut) [16], (B) *Macroptilium atropurpureum* (siratro) [46], (C) *Desmodium ovalifolium* (desmodium) [45], (D) *Centrosema brasilianum* (centrosema) [43], (E) *Cratylia argentea* (cratylia) [15], (F) *Medicago sativa* (alfalfa) [21], (G) *Clitoria ternatea* (clitoria) [44], (H) *Stylosanthes guianensis* (stylo) [19], (I) *Canavalia brasiliensis* (Brazilian jack bean) [42] and (J) *Trifolium repens* (white clover) [20].

ments [15,38,44]. Temperate-climate species, such as *Medicago sativa* and *Trifolium repens*, perform better in southern Brazil, where subtropical conditions favor their persistence and high nutritional value [26,34].

Regarding productive and nutritional potential, there is wide variability among species. *Clitoria ternatea* and *Cratylia argentea* can produce up to 30 t and 15 t of dry matter per hectare/year, respectively, under favorable conditions, whereas *Arachis pintoi* shows more moderate yields, between 7 and 14 t/ha/year, but with excellent quality and persistence [35,41]. Alfalfa (*Medicago sativa*) and white clover (*Trifolium repens*) stand out for their high crude protein contents (18-30%) and digestibility above 70%, attributes that make them strategic for intensive systems, especially in dairy production [25,37].

The contribution of these legumes to the sustainability of livestock systems is remarkable, particularly due to their ability to perform biological nitrogen fixation, reducing dependence on synthetic fertilizers. Estimates indicate that species such as *Stylosanthes guianensis* can fix up to 150 kg N/ha/year, while *Trifolium repens* can reach values close to 300 kg N/ha/year, providing strong potential for soil recovery and improved nutrient cycling [23,38]. Furthermore, the use of these species in mixed systems with grasses increases pasture longevity and improves animal performance, as already demonstrated in different regions of Brazil [9,22].

Nevertheless, practical limitations still restrict the large-scale adoption of several of these legumes. Major constraints include susceptibility to diseases, such as anthracnose in *Stylosanthes*; seed dormancy in *Desmodium* and *Stylosanthes*; low cold tolerance in *Arachis pintoi*; and the occurrence of antinutritional factors in *Canavalia* seeds [9,31]. These limitations reinforce the need for advances in breeding programs and management strategies adapted to the edaphoclimatic conditions of each region. In addition, the dissemination of these technologies among technicians and farmers remains limited, highlighting the importance of extension activities and applied research to consolidate the strategic use of forage legumes in strengthening sustainable livestock production in Brazil.

Species	Adaptation (biomes/climate/soil)	Biomass (T DM/ha/year)	Crude Protein (%)	Digestibility (%)	Main Uses	Limitations
Arachis pintoi (forage peanut)	Humid tropical regions; acidic and waterlogged soils	7-14	13-25	60-67	Mixed grazing, hay, silage, protein banks	Low tolerance to cold and drought; pests
Macroptilium atropurpureum (siratro)	Amazon, Cerrado, Caatinga; acidic and low-fertility soils	4-10	16-25	55-65	Grazing, cut-and-carry, hay, protein banks, mixtures	Sensitive to frost and waterlogging; foliar diseases
Desmodium ovalifolium (desmodium)	Humid Amazon; acidic soils, tolerates shade, low drought tolerance	4-12	13-16	~50	Controlled grazing, hay, protein banks, mixtures	Seed dormancy; low N transfer
Centrosema brasilianum (centrosema)	Cerrado and Amazon; acidic and poor soils, shade-tolerant	8-12	16-22	55-65	Grazing, hay, silage, protein banks	Sensitive to waterlogging and overgrazing; diseases
Cratylia argentea (cratylia)	Cerrado and Amazon; poor soils, dry regions	7-15	18-23	50-60	Protein banks, cut-and-carry feeding	Low acceptance under direct grazing
Medicago sativa (alfalfa)	Southern Brazil; subtropical climate, fertile and well-drained soils	up to 20	18-25	>65	Haymaking, rotational grazing, silage	Requires high fertility; sensitive to soil acidity
Clitoria ternatea (clitoria)	Semi-arid, Cerrado, Amazon and Atlantic Forest; well-drained soils	3.3-30	14-29	49-65	Grazing, cut-and-carry, hay, silage, protein banks, mixtures	Low tolerance to waterlogging and frost
Stylosanthes guianensis (stylo)	Cerrado, Amazon and Caatinga; acidic and low-fertility soils	7-12	11-20	55-60	Mixed grazing, pasture recovery, silage	Susceptible to anthracnose; seed dormancy
Canavalia brasiliensis (Brazilian jack bean)	Cerrado and Semi-arid; low to medium fertility soils	8-12	18-25	65-75	Grazing, hay, green manure, soil cover	Antinutritional compounds; low tolerance to waterlogging
Trifolium repens (white clover)	Southern Brazil; humid subtropical climate, fertile soils	8-12	17-30	>70	Grazing, hay, silage, mixtures	Low tolerance to drought and waterlogging; risk of bloat

Table 1: Agronomic and zootechnical characteristics of forage legumes used in Brazil.
Source: Prepared by the authors based on technical sheets and scientific literature.

Conclusions

The review of ten forage legumes used in Brazil demonstrates that these species represent a strategic alternative for strengthening national livestock production, combining high nutritional value, good adaptation to different edaphoclimatic conditions, and a relevant contribution to the sustainability of production systems. A wide variability was observed in terms of productive potential, crude protein content, and digestibility, which allows the selection of suitable species for each biome, ranging from humid tropical environments to semi-arid and subtropical regions.

Despite their high potential, several legumes remain underutilized or little known by technicians and farmers, either due to specific agronomic limitations or insufficient technological dissemination. In this context, it is essential to expand genetic improvement research, validate mixed pasture systems in different biomes, and strengthen rural extension programs. The integration of these species into diversified livestock systems can reduce nitrogen fertilization costs, increase pasture resilience, and contribute decisively to building a more efficient and sustainable Brazilian livestock sector.

Acknowledgements

The authors thank the Universidade Estadual de Goiás (*State University of Goiás* - UEG), through the Dean of Undergraduate Studies (PRG), for the institutional initiatives that enabled the submission and approval of Teaching Projects, as well as the publication of Call No. 15/2025/PRG - Teaching Practice Initiation Scholarship (BEN), which made possible the creation of the GEFOR teaching group and the granting of a scholarship to a student member of the group.

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