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D Sowdhanya
Department of Food Technology and Nutrition, Lovely Professional University, Phagwara, Punjab, India

Corresponding Author:
D Sowdhanya
Department of Food Technology and Nutrition, Lovely Professional University, Phagwara, Punjab, India

Agricultural, pharmaceutical, and Industrial applications of the underutilized legume *Mucuna pruriens*

D Sowdhanya

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Abstract
The diverse applications of *Mucuna pruriens* (velvet bean) in various fields, including agriculture, pharmaceuticals, and industry. *Mucuna pruriens* is a highly esteemed medicinal plant that has been extensively used in traditional medicine systems across different countries. It exhibits a wide range of therapeutic properties, including sedative, anti-inflammatory, anti-depressant, and anti-Parkinson's activities, making it a promising candidate for further exploration in modern medicine. In agricultural applications, *Mucuna pruriens* stands out for its nitrogen-fixing capacity, vigorous growth, and adaptability to dry farming practices and low soil fertility conditions. It offers high protein content, substantial seed yield, and resistance to diseases, making it a potential candidate for cultivation in soil affected by salinity. Intercropping systems involving *Mucuna pruriens* and other crops have shown potential in enhancing crop production and soil fertility. Pharmaceutically, *Mucuna pruriens* seeds are rich in bioactive compounds such as L-Dopa, ursolic acid, and betulinic acid, which have demonstrated neuroprotective effects and potential therapeutic benefits in neurodegenerative disorders like Parkinson's disease. The plant extracts have also shown antimicrobial, antioxidant, and anti-lipase activities, suggesting their potential in the treatment of various diseases and disorders. In industrial applications, *Mucuna pruriens* seed extract has been utilized for the synthesis of nanoparticles with antibacterial and dye degradation properties. The plant material has been explored for the production of activated carbon for the removal of textile dyes from wastewater. Additionally, *Mucuna pruriens* offers starch with potential applications in food systems and industries. Overall, the review highlights the ethnobotanical significance and diverse medicinal, agricultural, pharmaceutical, and industrial applications of *Mucuna pruriens*. Further research and exploration of this plant's potential can contribute to its utilization in various fields, offering sustainable and cost-effective solutions.

Keywords: Bioactive compounds, L-Dopa, dry farming, textile dyes

1. Introduction

Mucuna pruriens var. *utilis*, commonly known as mucuna, is an annual leguminous vine found in various tropical regions. Its growth is limited to the wet season, as it does not survive during colder periods. The plant features large trifoliate leaves, consisting of three leaflets, and exhibits long, vigorous twining stems that can reach lengths of two to three meters depending on environmental conditions. Under optimal conditions, mucuna typically begins flowering towards the end of March or early April when planted at the onset of the growing season (Chakoma *et al*., 2016) [7].

Mucuna pruriens (Mp) is a highly regarded medicinal plant in India, valued for its extensive utilization in various pharmacological formulations and as a source of numerous phytoconstituents found in indigenous drug preparations. In recent times, there has been a growing interest in the utilization of herb-drug combinations in the shrimp industry. This is primarily due to the herb-drug combinations being readily available, biodegradable, cost-effective, and exhibiting broad-spectrum activity. Furthermore, the phytochemicals present in these combinations are non-hazardous to the environment and do not accumulate toxins. Moreover, their extensive application poses no risks to human health or the surrounding environment (Shanmugavel *et al*., 2022) [26]. L-Dopa, first synthesized in 1911, has emerged as a promising therapeutic agent for the treatment of progressive neurodegenerative diseases. *Mucuna pruriens* seeds contain a significant concentration of L-Dopa, which has stimulated interest in exploring the biomass of this plant as a natural source of this compound. Specifically, the extraction of L-Dopa from *Mucuna pruriens* seeds has been investigated using methanol as the solvent. The resulting extract was found to contain 12.16 wt % of L-

Dopa, indicating its potential as a valuable source of this compound (Benfica *et al*., 2021) [3].

Seeds of *Mucuna pruriens* are recognized as a rich source of minerals and possess diverse functionalities in medicinal applications. They have demonstrated efficacy in treating Parkinson's disease, impotence, and worms. Moreover, these seeds exhibit anabolic, androgenic, analgesic, anti-inflammatory, anti-depressant, anti-spasmodic, anti-venom, anti-lithiatic, anti-bacterial, anti-parasitic, febrifuge, cholesterol-lowering, hypoglycemic, immune-modulating, blood pressure-lowering, and uterine-stimulating properties. Despite the vulnerability of mucuna species to frost and their limited adaptability to cold and wet soils, a significant proportion of these species exhibit reasonable resilience to various abiotic challenges such as drought, low soil fertility, and high soil acidity (Sharanya *et al*., 2022) [27].

It is a highly esteemed medicinal plant extensively employed in Ayurvedic medicine and various traditional medicinal systems across different countries. It exhibits a wide range of therapeutic applications, including sedative properties, urinary tract infection relief, treatment of chest complaints, and management of snake bite intoxication. Furthermore, it serves as a flavoring agent in confectionery products such as cakes, sweet breads, and candy. Notably, *Mucuna pruriens* has been utilized as an herbal remedy for addressing male infertility and nervous disorders. The rich ethnobotanical significance and diverse medicinal properties of *Mucuna pruriens* make it a promising candidate for further scientific exploration and utilization in modern medicine (Shelke *et al*., 2022) [28].

2. Agricultural applications

Mucuna pruriens is distinguished by its notable nitrogen-fixing capacity, vigorous growth pattern, and abundant production of vegetative matter. The plant showcases promising agronomic characteristics such as high protein content ranging from 20% to 30%, substantial seed yield, and resistance to diseases. Additionally, it demonstrates excellent adaptability to dry farming practices and low soil fertility conditions. These advantageous attributes position *M. pruriens* as a prospective candidate for cultivation in soil affected by salinity (Mahesh *et al*., 2015) [14]. This study aimed to assess the adoption of yam cultivation in combination with a mixed intercropping system involving *Mucuna pruriens* var *utilis* and maize in the Guinea-Sudan zone of Benin. The incorporation of this herbaceous legume into crop-livestock integration offers potential for enhancing yam production and other crops within a rotational framework. The integration of forage legumes into traditional fallow management practices can contribute to improved forage availability during periods of feed scarcity while simultaneously enhancing soil fertility (Maliki *et al*., 2016) [15].

The maize-mucuna rotation system reduces trade-offs in CR use for feed and mulch, while enhancing soil fertility. *Mucuna pruriensis* serves as supplementary feed and locally available organic soil enhancement. Conservation Agriculture's financial viability depends on subsidized fertilizer availability, benefiting half of the farming population. However, alternative biomass options have limited poverty-alleviating effects. In conclusion, the integration of mucuna in the rotation system offers a promising approach to mitigate trade-offs, enhance soil fertility, and provide supplementary feed and income for farmers (Tui *et al*., 2015) [30]. Certain crops possess allelochemicals, which are phytotoxic secondary compounds that play a role in suppressing weed growth. An example of such allelopathy can be observed in the velvet bean plant (*Mucuna pruriens* (L.) DC varutilis), where the control of weeds is attributed to the presence of L-3,4-dihydroxyphenylalanine (L-DOPA). The impact of velvet bean extract, varying in tissue type and concentration, was found to significantly influence all germination parameters, with leaf extracts exhibiting greater inhibitory effects on goosegrass seed germination compared to stem and root extracts. Interestingly, root extracts of velvet bean exhibited hormetic effects on the radicle and plumule growth of goosegrass. Overall, it was observed that velvet bean leaf extracts had a more detrimental impact on the vigour index of goosegrass (Rugare *et al*., 2020) [24].

Intercropping bananas with both annual and perennial crops is a prevalent and necessary practice in East and Central Africa, primarily driven by the limited farm sizes and the necessity to fulfill multiple household requirements. *Mucuna pruriens*, a tropical legume, is extensively utilized in the region for various purposes such as forage, fallow, soil cover, and green manure due to its remarkable growth rate. This leguminous plant possesses the ability to fix atmospheric nitrogen, thereby enriching the soil with essential nutrients. Research findings indicate that mucuna can yield a substantial dry biomass production, ranging from 7 to 11 tons per hectare, demonstrating its potential as a productive and valuable component in intercropping systems (Blomme *et al*., 2022) [5].

The adoption of a yam-based system, incorporating mixed intercropping of *Mucuna pruriens* var *utilis* and maize (TMM), is more prevalent in densely populated areas compared to regions with low population density. In high-density zones, land pressure is substantial, leading to a scarcity of fertile soils for yam production. Smallholder farmers in these areas are inclined towards developing sustainable and productive systems to overcome these challenges. They recognize the benefits of *Mucuna pruriens*, such as increased yam productivity, soil moisture retention, effective weed control (especially Imperata cylindrica), and soil fertility restoration. Integrating *Mucuna pruriens* into yam-based systems offers a viable approach for smallholder farmers seeking enhanced productivity and sustainable land management practices (Maliki *et al*., 2016) [15].

Velvet beans have demonstrated their capa15city to enhance soil fertility, making them a promising resource for improving agricultural productivity. Moreover, these beans possess the potential to serve as valuable protein supplements for ruminant livestock in the context of livestock production systems. The investigation of velvet bean components revealed that the forage exhibited a significant crude protein content of 28%, while the grain and pod contained 23% and 17% crude protein, respectively. These findings underscore the protein supplement potential of all velvet bean components, indicating their suitability for incorporation into dairy concentrate rations. Thus, velvet beans present a viable option for enhancing both soil fertility and livestock productivity through their valuable contribution as a protein supplement in ruminant diets (Mwape *et al*., 2010) [19].

The utilization of *Mucuna pruriens* within a no-tillage agricultural system has the potential to enhance the accumulation of soil organic matter, consequently leading to an augmentation in soil carbon (C) and nitrogen (N) stocks. Specifically, it results in an elevation of the soil C/N ratio at a depth of 0-0.05 meters during the dry season, particularly in plots where *Mucuna pruriens* residues have been incorporated (C/N = 18). This increase in the soil C/N ratio serves as an indicator of the rise in soil carbon content, likely attributed to the substantial presence of aromatic compounds within the *Mucuna pruriens* species (Carvalho *et al*., 2016). *Mucuna pruriens* var. utilis cover crops were introduced in Africa to improve crop production on degraded soils in the humid forest zone. The dominant soil types in this region, Acrisols and Nitisols, are inherently poor even without degradation. Cover crops were introduced alongside system changes, emphasizing biomass retention for nutrient conservation. However, traditional slash and burn practices commonly used by farmers can diminish the benefits of nitrogen-fixing cover crops due to the loss of biomass nitrogen. Adoption of slash and mulch systems may be challenging unless mulching significantly increases crop yields, especially in areas where farmers prioritize labor-saving methods over soil fertility management (Hauser *et al*., 2020) [12].

3. Pharmaceutical applications

The plant *Mucuna pruriens* L. possesses a significant concentration of L-dopa within its seeds, making it a viable option for treating nervous system disorders such as Parkinson's disease. A novel and environmentally friendly approach was developed to synthesize magnesium oxide nanoparticles (MgO NPs) using an aqueous extract derived from *M. pruriens* seeds. The presence of bioactive compounds in the *M. pruriens* seed extract was confirmed through Fourier-transform infrared (FTIR) spectroscopy. These bioactive compounds are believed to function as both reducing and capping agents for the MgO NPs. The extract from *M. pruriens* contains flavonoids and a substantial amount of L-dopa, an amino acid analogue, which exhibits strong antioxidant properties (Rahmani-Nezhad *et al*., 2017) [22]. L-Dopa, which was first synthesized in 1911, has shown promise as a therapeutic agent for progressive neurodegenerative diseases. It is abundantly present in the seeds of *Mucuna pruriens*, thus generating interest in utilizing this biomass as a natural source of L-Dopa. L-Dopa is an amino acid widely employed in the treatment of neurodegenerative disorders, specifically Parkinson's disease. Parkinson's disease is the second most prevalent neurodegenerative disorder worldwide, surpassed only by Alzheimer's disease, and affects approximately 0.3% of the global population (Benfica *et al*., 2021) [3].

In addition to its protective effects, L-DOPA has been investigated for its potential role in neuroprotection, as it may enhance neuronal survival and function. Preclinical studies suggest that L-DOPA may exert neuroprotective effects by modulating neurotransmitter systems and reducing oxidative stress in neurodegenerative disorders such as Parkinson's disease. Moreover, L-DOPA has been explored for its potential antioxidant properties and its ability to scavenge free radicals, which could contribute to its therapeutic benefits in various disease states characterized by oxidative damage (Dhanani *et al*., 2015) [9]. Ursolic acid (UA) and Betulinic acid (BA) are significant bioactive components that exhibit similar neuroprotective effects. Among various parts of *Mucuna pruriens* (Mp), the seeds are widely used as anti-Parkinson's disease (PD) agents due to their higher percentage of L-DOPA. Moreover, Mp's neuroprotective potential has been explored in ischemic stroke models, yielding positive outcomes. Recent clinical trials on PD patients have also demonstrated convincing results regarding Mp's anti-PD activity. Furthermore, Mp exhibits therapeutic activity in other conditions such as cancer, diabetes, skin infections, anemia, and hypertension (Rai *et al*., 2020) [23].

The α-amylase inhibitor was isolated from the seeds of an underutilized legume, *Mucuna pruriens*. The isolated inhibitor existed as a monomeric form with a molecular weight of 25.6 kDa. It was observed that the purified amylase inhibitor effectively inhibited the activity of human salivary α-amylase. The inhibitory activity demonstrated by α-amylase inhibitors, particularly in mammalian α-amylase, holds significant potential for the management of nutritional and diabetes-related disorders (Bharadwaj *et al*., 2018) [4].

Mucuna pruriens seeds exhibit protective effects against venomous snakebites, attributed to the presence of neurotoxins, cardiotoxins, cytotoxins, phospholipase A2 (PLA2), and proteases. A study investigating the effects of *Mucuna pruriens* seed aqueous extract (MPE) on Echis carinatus venom (EV) revealed short-term (24-hour) and long-term (1-month) protection. MPE confers protection via immune mechanisms, stimulating antibody production against venom proteins. *In vitro* analysis showed increased procoagulant activity upon MPE administration, likely due to an immunogenic multiform glycoprotein present in MPE (Pathania *et al*, 2020) [21]. The findings of this study provide evidence that *Mucuna pruriens* seed meal exerts beneficial effects on sexual behavior, reproductive organ weight, semen characteristics, and biochemical parameters in rabbits. These results support the traditional medicinal use of *Mucuna pruriens* seeds as a sexual function enhancer. The observed aphrodisiac property of *Mucuna pruriens* suggests its potential utility in improving the reproductive performance of male rabbits when included in their diet at a concentration of up to 3% (Mutwedu *et al*., 2019) [18].

In this study, the *Mucuna pruriens* leaf extract demonstrated the highest anti-lipase potential, with an IC50 value of 355.5 μg/mL. The concentration of chlorogenic acid was found to be highest in *M. pruriens*, measuring at 69.09 ppm. The anticholinesterase activity of *M. pruriens* seed extracts was also observed, indicating its potential for inhibiting acetylcholinesterase and suggesting its effectiveness in treating neurodegenerative disorders. Moreover, M. pruriens seeds were effective in reducing blood glucose levels in alloxan-diabetic rabbits through insulin release stimulation. Additionally, the cytotoxic activity of the isoquinoline alkaloid present in *M. pruriens* was noted. Overall, the plant extracts exhibited significant cytotoxic potential against HeLa, PC3, and 3T3 cell lines, likely due to the presence of various cytotoxic compounds (Fatima *et al*., 2023) [11].

The seeds extracted with ethanol displayed the highest antioxidant activity at 76.96%, while the leaves extracted with petroleum ether exhibited a slightly lower activity at 72.50%. The leaf and seed extracts of *Mucuna pruriens* demonstrated significant potential in scavenging free radicals. The presence of various compounds within these extracts acted as antioxidants, effectively controlling the generation of free radicals resulting from diverse chemical reactions within cells. Notably, the maximum antioxidant activity of *Mucuna pruriens* was observed in terms of percentage inhibition, with the highest values recorded as 76.96% for seeds extracted with ethanol and 72.50% for leaves extracted with petroleum ether (Shelke *et al*., 2022) [28].

Zinc oxide (ZnO) nanoparticles were synthesized using *Mucuna pruriens* seed extract as a bio-template, offering a cost-effective and nontoxic approach. The presence of pure nanoparticles was evident from EDAX spectra and XRD peaks analysis. FT-IR analysis indicated the participation of polyphenols, flavonoids, and terpenoids in reducing and stabilizing the nanoparticles. The antibacterial activity of ZnO NPs was assessed by studying the growth curve kinetics, revealing their bacteriostatic nature. SEM and EDAX analysis of native Bacillus subtilis and nanoparticle-treated Bacillus subtilis demonstrated the interaction of ZnO NPs with the cell membrane, resulting in pit formation, intracellular leakage, and eventual cell death. This research highlights the potential of *Mucuna pruriens* seed extract as a bio-template for the environmentally friendly synthesis of ZnO nanoparticles with effective antibacterial properties (Agarwal *et al*., 2020) [1].

The antihypertensive efficacy of *Mucuna pruriens* protein hydrolysates exhibiting potent hypotensive effects at lower doses, along with their demonstrated ACE inhibitory activity *in vitro* and *in vivo*, suggests their potential as functional ingredients with antihypertensive properties for human consumption. Incorporating these hydrolysates as part of functional food formulations holds promise for managing hypertension. However, further investigations are necessary to elucidate the underlying mechanisms of action, optimize dosages, and assess long-term effects in human subjects. Caution should be exercised, and consultation with healthcare professionals is recommended, especially for individuals with pre-existing medical conditions or those taking antihypertensive medications (Chel-Guerrero *et al*., 2017) [8].

The inhibitory capacity of *Mucuna pruriens* L. peptide fractions against dipeptidyl peptidase-IV (DPP-IV) was evaluated *in vitro*, showing promising results. These peptides are likely to be resistant to gastrointestinal digestion, indicating the potential for their use in pharmacological effects when administered parenterally. However, further research is needed to assess the specific bioavailability of these peptides and their susceptibility to digestion in rats, considering their amino acid composition. Investigating the inhibitory potential of *Mucuna pruriens* L. peptide fractions on DPP-IV enzyme activity in the future would provide valuable insights into their therapeutic applications (Ortega *et al*., 2019) [20].

The peptide fraction with a molecular weight range of 5-10 kDa has been found to exhibit significant cytotoxic activity against HepG2 and QGY-7703 cell lines. Additionally, both the 5-10 kDa and >10 kDa fractions have demonstrated activity against hepatitis C virus (HCV). The cytotoxic concentration (CC50) of the 5-10 kDa fraction against the tested cell line was measured as 703.04 ± 5.21 µg/mL. Notably, the peptide fraction in the 5-10 kDa range displayed the highest activity in protecting DNA from damage. This study provides evidence for the potential use of *Mucuna pruriens* peptide fractions in the treatment of liver cancer, HCV infection, and as agents for protecting DNA integrity.

4. Industrial applications

Activated carbon derived from *Mucuna pruriens* seed shells, an abundant agricultural waste, was chemically activated and utilized for the removal of congo red and malachite green, which are textile dyes, from aqueous solutions. The experimental adsorption studies demonstrated that the extent of adsorption was influenced by factors such as particle size, adsorbent dosage, pH, contact time, and initial concentration of the dyes. It was observed that *Mucuna pruriens* seed shells activated with phosphoric acid exhibited remarkable adsorption capacity for the treatment of textile wastewater containing congo red and malachite green (Igwegbe *et al*., 2015) [13]. The green synthesis of selenium nanoparticles (SeNPs) using *Mucuna pruriens* seed extract under physiological conditions, such as room temperature, is a simple, environmentally friendly, and highly efficient process. Utilizing plant material not only ensures ecological sustainability but also enhances cost-effectiveness due to their abundance. The synthesized SeNPs demonstrate significant dye degradation activity, surpassing conventional hydrogen peroxide, which typically requires a catalyst for effective degradation (Menon *et al*., 2021) [17].

Mucuna pruriens (velvet bean) offers a high-starch content and depigmented starch with diverse applications in food systems and industries. It can be used in syrups, jellies, candies, sausages, baked goods, sauces, seasonings, and more. However, its low stability in refrigerated or frozen foods limits its use as a thickener or gelling agent. *Mucuna pruriens* starch provides improved functionality as a food additive, but careful consideration of other ingredients and processing conditions is necessary. Overall, it presents a promising alternative to corn starch (Segura-Campos *et al*., 2015) [25].

The corrosion inhibition of mild steel in a 1 molar hydrochloric acid solution (1 M HCl) by *Mucuna pruriens* seed extract (MPSE) was investigated. The presence of MPSE resulted in a notable reduction in the corrosion rate of mild steel. This decrease in corrosion rate was attributed to the chemical adsorption of MPSE, which effectively blocked the surface of the mild steel. Potentiodynamic polarization measurements indicated that MPSE acted as a mixed-type inhibitor, with a stronger influence on the anodic reactions (Akalezi *et al*., 2016) [2].

This study presents an investigation into the leaching process of natural pigment from *Mucuna pruriens* for the purpose of dyeing chrome-tanned leather samples. The extracted dye was tested for its coloring ability on wet blue goat leathers. The dyed leather samples were subjected to thorough evaluation through reflectance measurements and visual assessment tests to determine the color value, strength, and fastness properties. The results indicated that the dyed leather exhibited superior color value, increased strength, and enhanced fastness properties compared to the control samples (Sundari *et al*., 2015) [29]. An alpha-amylase inhibitor was isolated and characterized from the seeds of *Mucuna pruriens*, a leguminous plant. The purification process involved extracting the inhibitor from soaked seeds, resulting in an inhibitor activity of 61.18. The fold purity of the isolated alpha-amylase inhibitor was determined to be 36.68, and the yield obtained from the purification process was 14.01%. Further analysis revealed that the purified amylase inhibitor exhibited heat stability, retaining 80.50% of its activity when exposed to a temperature of 65 °C. These findings suggest that the alpha-amylase inhibitor derived from *Mucuna pruriens* seeds possesses desirable characteristics for potential applications in inhibiting alpha-amylase activity (Meena *et al*., 2020) [16].

5. Conclusion

Mucuna pruriens plant is highly esteemed in traditional medicine systems for its diverse therapeutic applications, including sedative properties, urinary tract infection relief, treatment of chest complaints, and management of snakebite intoxication. It is also used as a flavoring agent in confectionery products. *Mucuna pruriens* has been particularly recognized for its potential in addressing male infertility and nervous disorders. The pharmaceutical applications of *Mucuna pruriens* are significant. The plant's seeds contain a substantial concentration of L-Dopa, a therapeutic compound used in the treatment of progressive neurodegenerative diseases such as Parkinson's disease. L-Dopa extracted from *Mucuna pruriens* seeds has shown promise as a natural source of this compound. The plant also contains other bioactive components, such as flavonoids and antioxidants, which contribute to its neuroprotective and medicinal properties. *Mucuna pruriens* has been explored for its potential in neuroprotection, anti-Parkinson's activity, and management of diabetes-related disorders. Furthermore, *Mucuna pruriens* has been found to possess anti-lipase, anticholinesterase, and anti-venom properties. It has demonstrated aphrodisiac effects, potential for inhibiting acetylcholinesterase, and cytotoxic activity against certain cell lines. The plant extracts also exhibit antioxidant activity and scavenging of free radicals.

Furthermore, *Mucuna pruriens* seeds contain significant bioactive compounds, including L-Dopa, ursolic acid, betulinic acid, and α-amylase inhibitors, which contribute to its therapeutic potential. The extract from mucuna seeds has shown promise in the treatment of neurodegenerative disorders, such as Parkinson's disease, due to its high L-Dopa content. It also exhibits neuroprotective effects, antioxidant properties, and potential in managing nutritional and diabetes-related disorders. Additionally, mucuna seeds have demonstrated protective effects against snakebites and have been found to enhance sexual function and reproductive performance. Moreover, mucuna plant extracts exhibit significant antioxidant and anti-lipase activity, suggesting their effectiveness in scavenging free radicals and treating neurodegenerative disorders. The plant's cytotoxic properties against certain cell lines indicate its potential in cancer treatment. The synthesis of nanoparticles using mucuna seed extracts offers a cost-effective and environmentally friendly approach in the field of nanotechnology.

Mucuna pruriens is a versatile plant with a wide range of agricultural and pharmaceutical applications. Its agronomic characteristics, such as nitrogen-fixing capacity, high protein content, and adaptability to adverse soil conditions, make it a promising candidate for cultivation in areas affected by salinity and low soil fertility. Intercropping mucuna with other crops, such as yam and maize, can enhance crop productivity, soil fertility, and weed control, offering sustainable land management practices for smallholder farmers. In agriculture, *Mucuna pruriens* has several advantageous characteristics. It has a high protein content and substantial seed yield, making it a promising crop. It can adapt well to dry farming practices and low soil fertility conditions. The plant's nitrogen-fixing capacity and ability to produce abundant vegetative matter contribute to its agronomic value. *Mucuna pruriens* is often intercropped with other crops like yam and maize to enhance productivity and soil fertility. It has been found to reduce trade-offs in feed and mulch use, providing additional benefits to farmers.

Overall, the diverse medicinal properties, agricultural benefits, and pharmacological applications of *Mucuna pruriens* highlight its ethnobotanical significance and potential for further scientific exploration. Its utilization in traditional medicine systems, as well as its integration into modern agricultural practices, holds promise for sustainable agriculture, improved human health, and economic development. However, further research and studies are needed to fully understand and harness the potential of this remarkable plant.

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