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Review Article

GEOGRAPHIC DISTRIBUTION, ECOLOGICAL ADAPTABILITY AND AGRONOMIC STRATEGIES FOR BLACK PLUM (*VITEX DONIANA* SWEET) DOMESTICATION IN THE NIGERIAN SAVANNA

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ABSTRACT

Vitex doniana Sweet (Lamiaceae), commonly known as black plum, is a versatile tree species vital to Nigeria's agroforestry systems, recognized for its nutritional, medicinal and ecological benefits. This comprehensive review synthesizes recent advances in the species geographic range, ecological preferences, morphological variation, propagation methods, phytochemical properties and conservation challenges, based on 83 georeferenced occurrence records from the Global Biodiversity Information Facility (GBIF) and studies published since 2010. The analysis shows *Vitex doniana's* extensive presence across Nigeria's savanna and forest zones, especially in Delta, Oyo and Taraba states, demonstrating its adaptability to a variety of habitats. Key findings include notable morphological diversity influenced by climatic and soil factors, promising propagation techniques and a diverse phytochemical profile supporting medical research. In addition to ecological understanding, the review incorporates agronomic considerations for domestication in Nigerian savannas, including soil management, nutrient application, water regulation, spacing, weed control and intercropping practices. These practical insights are essential for guiding large-scale cultivation and agroforestry integration. Challenges such as low seed germination, human activities and climate change continue to threaten the species' survival, calling for integrated strategies. This review recommends combining agroecological zoning, advanced propagation, agronomic standardization and community-led conservation to promote sustainable domestication and biodiversity protection in Nigeria.

Keywords: *Vitex doniana*, geographic distribution, ecological preferences, domestication, Nigerian savanna, agroforestry, conservation

INTRODUCTION

Vitex doniana Sweet, a deciduous tree of the Lamiaceae family (formerly Verbenaceae), is a cornerstone of traditional agroforestry systems across tropical Africa, particularly in Nigeria, where it is celebrated for its multifaceted contributions to food security, traditional medicine, and ecological sustainability [1]. Locally known as "oori-nla" (Yoruba), "dinya" (Hausa), "uchakoro" (Igbo), and "black plum" (English), this multipurpose species provides edible fruits and leaves, medicinal extracts, timber, and ecological services such as nitrogen fixation and soil fertility enhancement [2,3]. Its fruits are consumed raw, processed into beverages, or used in jam and wine production, while its leaves serve as a staple vegetable in rural and peri-urban communities, addressing nutritional deficiencies [4,5]. The bark, roots, and leaves are integral to traditional pharmacopoeia, treating ailments such as hypertension, diabetes, infertility, liver diseases, and infections, aligning with the World Health Organization's estimate that over 80% of Africa's population relies on traditional medicine for primary healthcare [6,7].

Despite its socioeconomic importance, *V. doniana* remains under-researched, with studies often addressing isolated aspects such as distribution or phytochemistry, rather than integrating geographic, ecological, agronomic, and conservation perspectives into a unified strategy for sustainable cultivation in Nigeria's savanna ecosystems. In late 2024, the Federal Government of Nigeria conferred a Research and Development mandate on the Cocoa Research Institute of Nigeria (CRIN) to include *Vitex doniana* Sweet, with the crop officially launched for research in May 2025, highlighting the urgent need for comprehensive strategies to support its domestication. Over-harvesting, habitat fragmentation due to deforestation, and poor natural regeneration from low seed germination rates exacerbate population declines, particularly in southern Benin and Nigerian savanna zones [1,8,9,10]. Climate variability further threatens its distribution and ecological performance, yet comprehensive models predicting these impacts remain scarce [11].

This review consolidates previously fragmented research, encompassing geographic distribution, ecological adaptability, morphological diversity, propagation potential, and phytochemical composition into an integrated domestication strategy for *Vitex doniana*. Using 83 georeferenced Global Biodiversity Information Facility [12] records and post-2010 literature, the study applies agroecological zoning, evaluates propagation and agronomic techniques, and proposes conservation measures tailored to the Nigerian and West African savanna context. Specifically, it aims to: (i) identify cultivation hotspots and priority regions in Nigeria (ii) elucidate ecological preferences and their implications for agroforestry integration and sustainable cultivation (iii) assess propagation techniques to overcome regeneration constraints, supporting scalable cultivation and genetic diversity preservation (iv) recommend practical agronomic practices to enhance domestication in savanna environments (v) develop conservation strategies to mitigate anthropogenic and climatic pres-

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sures, ensuring sustainable utilization and long term population viability.

By addressing these objectives, this synthesis aligns with CRIN's new mandate and positions *V. doniana* as a priority species for agroforestry development, contributing to Nigeria's goals for sustainable agriculture, biodiversity conservation, and rural economic empowerment.

METHODS FOR LITERATURE REVIEW AND GBIF DATA PROCESSING

To compile a comprehensive dataset on the geographic distribution and ecological preferences of *Vitex doniana* in the Nigerian savanna, occurrence records were retrieved from the Global Biodiversity Information Facility (GBIF) database [12]. We queried GBIF using the taxon "*Vitex doniana* Sweet" and applied the following filters to exclude synonyms and misidentified entries: (i) geographic scope restricted to Nigeria's savanna zone (bounding box: 4.5°N-12.9°N, 2.9°E-12.4°E), (ii) records with georeferenced coordinates (latitude and longitude), (iii) occurrence status marked as "present," and (iv) collection dates between 1914 and 2025 to capture both historical and contemporary distributions. This yielded 83 georeferenced occurrence records.

Data cleaning was performed to ensure accuracy and reliability. Cross-referencing coordinates, collection dates, and collector names removed duplicate records. Records with imprecise coordinates (rounded to fewer than two decimal places) or falling outside Nigeria's savanna boundaries were excluded. Outliers were detected using spatial anomaly detection to identify points inconsistent with known ecological ranges. Habitat metadata were reviewed to confirm consistency with known ecological ranges within the Nigerian savanna. For ecological and morphological synthesis, GBIF data were supplemented with peer-reviewed studies published between 2010 and 2025, sourced from major scientific databases.

GEOGRAPHIC DISTRIBUTION

Geographic distribution refers to the spatial extent of a species occurrence across a region, shaped by biotic and abiotic factors. Understanding the distribution of *V. doniana* is critical for identifying regions suitable for domestication, assessing its ecological adaptability, and predicting its resilience to environmental changes such as climate variability and land use pressures [1,11].

Vitex doniana, a widespread species of the Vitex genus, occurs across tropical Africa, with significant populations in Nigeria's diverse ecosystems, including Guinea and Sudan savannas, coastal woodlands, riverine forests, and plateaus (4.5°N-12.9°N, 2.9°E-12.4°E) [1,12,13]. Analysis of 83 georeferenced GBIF records (1914-2025) identifies high occurrence in Delta (14.5%), Oyo (12.0%), and Taraba (8.4%) states, notably in the Mambilla Plateau (6.7°N, 11.2°E), Oba Hills (7.8°N, 4.1°E), and Delta's coastal wetlands (5.4-5.7°N, 5.7-6.7°E) [12] (Figure 1). This distribution reflects ecological plasticity across elevations up to 440 m, supported by insect and bird mediated cross pollination, which enhances genetic diversity [14,15]. Integration into traditional agroforestry systems, such as planting along field boundaries, highlights its domestication potential [14]. However, deforestation and agricultural expansion have fragmented populations, particularly in southern Nigeria, mirroring trends in Benin, where forest cover declined from 35.5% to 10% between 1986 and 2016 [9]. These environmental conditions, particularly nutrient-rich alluvial soils in Delta and Taraba, likely influence the species phytochemical profile, with wetter zones potentially enhancing flavonoid and tannin content critical for medicinal applications [6,14].

Below is a table summarizing distribution by state, climate zone, and dominant soil type, including estimated soil zone prevalence based on national classification.

Table 1. Distribution of *Vitex doniana* in Nigeria by state, climate zone, and dominant soil type

State	% Of GBIF Records	Climate Zone(s)	Dominant Soil Type (Zone)	Approx. Soil Zone Prevalence
Delta	14.5 %	Lowland Rainforest / Mangrove Swamp (Am)	Alluvial soils (coastal swamp/floodplain)	~100 % coastal/alluvial
Oyo	12.0 %	Southern Guinea Savanna / Lowland Rainforest (Aw/Am)	Ultisols / Oxisols (forest soils)	~50 % forest soils
Taraba	8.4 %	Northern Guinea Savanna / Montane (Aw)	Ferruginous sandy soils / Alfisols (savanna)	~60 % savanna soils
Anambra	6.0 %	Southern Guinea Savanna / Freshwater Swamp (Aw)	Ultisols / Entisols (swamp/alluvial)	~70 % swamp/alluvial
Akwa Ibom	4.8 %	Lowland Rainforest (Am)	Ultisols / Oxisols (forest soils)	~80 % forest soils
Kano	3.6 %	Northern Guinea / Sudan Savanna (Aw/BSh)	Ferruginous sandy soils / Alfisols	~80 % savanna soils
Others (Mixed)	50.6 %	Varies (Aw, Am, Swamp, Savanna)	Mixed: Ultisols, Alfisols, Alluvial, Entisols	Mixed zones

Source: [12,16, 17,18,19]

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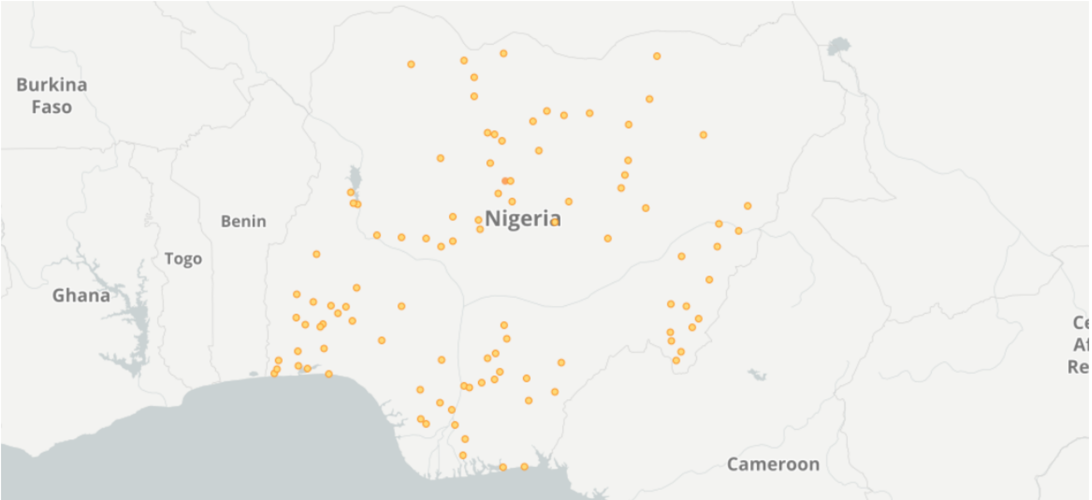

Figure 1. Distribution Map of *Vitex doniana* in Nigeria. Source: GBIF [12]

ECOLOGICAL PREFERENCES OF BLACK PLUM

Ecological preferences encompass the specific environmental conditions, temperature, rainfall, soil type, elevation, and habitat that optimize a species' growth, reproduction, and survival. These preferences are critical for determining suitable cultivation sites, assessing ecological adaptability, and predicting responses to environmental stressors such as climate change and land degradation [11].

Vitex doniana thrives in regions with mean annual temperatures of 10-30°C and rainfall of 750-2000 mm, favoring nutrient-rich alluvial soils and high-water tables [14]. GBIF data [12] confirm its prevalence in Delta's wetlands (5.4-5.7°N, 5.7-6.7°E) and Taraba's Mambilla Plateau (6.7-9.3°N, 11.0-12.4°E), extending across savanna woodlands, riverine forests, and coastal wetlands (0-440 m elevation). Its nitrogen-fixing ability enhances soil fertility via litter production, making it ideal for agroforestry integration [20]. Climatic factors, particularly precipitation seasonality, shape morphological traits, with wetter Guinean zones yielding taller trees (up to 25 m) and larger leaves (8-22 cm) compared to drier Sudanian zones [11]. These wetter conditions also correlate with higher flavonoid and tannin content, enhancing the species medicinal potential [6]. Soil versatility, including tolerance for sandy loams, supports cultivation across diverse savanna zones [14]. Flowering (August-November) and fruiting (January-April) align with rainfall patterns, ensuring reproductive success [14]. Biotic interactions, such as insect and bird mediated cross pollination, bolster genetic diversity, aiding resilience [15]. These ecological preferences, particularly in nutrient-rich, moist environments, suggest that cultivation in regions like Delta and Oyo could optimize both biomass and phytochemical yields for agroforestry and pharmacological applications [6].

The extent to which climate change will alter *V. doniana's* ecological preferences remains a critical concern. Hounkpèvi *et al.* [11] found that bio-climatic parameters explain only a small portion of morphological variability, suggesting other factors like soil nutrients, moisture, or topography may play significant roles. Predictive models assessing climate change impacts on habitat suitability are lacking, limiting the ability to forecast shifts in ecological niches. The role of soil variability across Nigeria's savanna zones, particularly the performance of *V. doniana* on sandy or clayey soils, requires further investigation to optimize cultivation strategies [14]. The impact of anthropogenic pressures, such as deforestation, on ecological performance is poorly understood [9].

The ecological plasticity of *V. doniana* supports its domestication across Nigeria's diverse savanna ecosystems, particularly in regions with moderate rainfall and nutrient-rich soils. Agroecological zoning, integrating high-resolution climatic, soil, and topographic data, can guide the selection of cultivation sites, prioritizing areas like Delta, Oyo, and Taraba with favorable conditions [13]. The species nitrogen-fixing ability enhances its value in sustainable agroforestry systems, reducing reliance on chemical fertilizers and promoting soil health [20]. Cultivation strategies should focus on water management, given the species' preference for high water tables, and incorporate traditional agroforestry practices to enhance community acceptance.

Table 2. Ecological Characteristics of *Vitex doniana* in Nigeria

State	Coordinates (Lat, Long)	Elevation (m)	Habitat Description	Record Years
Delta	5.4-5.7°N, 5.7-6.7°E	0-50	Coastal/Wetland	2017-2018
Oyo	7.4-8.0°N, 3.4-4.6°E	100-300	Savanna/Forest	1966-2014
Taraba	6.7-9.3°N, 11.0-12.4°E	200-440	Plateau/Savanna	1972-2010
Anambra	6.2-6.3°N, 7.1-7.2°E	50-150	Forest/Wetland	2010-2011
Akwa Ibom	4.5-4.8°N, 6.8-8.0°E	0-50	Coastal/Forest	1914-2021

Source: GBIF [12]

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MORPHOLOGICAL VARIABILITY AND ENVIRONMENTAL INTERACTIONS

Morphological variability refers to the diversity in physical traits within a species, driven by genetic factors, environmental conditions, and their interactions. Understanding these variations is crucial for selecting desirable traits for domestication, such as high fruit yield or robust growth, and for assessing the species adaptability to environmental stressors [11].

Morphological variability in *V. doniana*, observed across Nigeria and Benin, reflects environmental influences [11]. In wetter Guinean zones, trees reach 20.5 ± 3.2 m with larger leaves (15.2 ± 4.1 cm length, 5.8 ± 1.7 cm width) and fruits (2.8 ± 0.4 cm), driven by nutrient-rich alluvial soils and high-water availability [11,14]. These conditions likely enhance flavonoid and tannin concentrations, boosting medicinal value [6]. In drier Sudanian zones, trees are shorter (15.3 ± 2.8 m) with smaller leaves (10.4 ± 2.3 cm length, 3.5 ± 1.0 cm width) and fruits (2.1 ± 0.3 cm), indicating drought tolerance [11]. The species deciduous nature and boles (mean diameter: 120 ± 25 cm) support timber and biomass potential [14]. These morphological differences, tied to ecological gradients, guide domestication by identifying traits suited to specific savanna zones and pharmacological applications [6].

Hounkpèvi et al. [11] suggest that genotypic control is primary, but the limited influence attributed to climatic factors indicates that other elements, such as soil nutrients or topography, warrant further investigation. The lack of standardized morphological descriptors complicates accurate trait characterization, hindering cultivar development [1]. The significant morphological variability of *V. doniana* offers opportunities for selective breeding of cultivars with enhanced traits, such as larger fruits or leaves for nutritional and medicinal purposes or robust growth for timber production. These traits, linked to ecological conditions, can guide domestication efforts in Nigerian savanna zones, with molecular genetic studies needed to identify markers for high-yielding, resilient cultivars.

PROPAGATION STRATEGIES

Propagation strategies encompass sexual (seed-based) and asexual (cuttings, somatic embryogenesis) methods to reproduce plants, critical for scaling up cultivation, conserving genetic resources, and overcoming natural regeneration barriers. For *V. doniana*, propagation is a key bottleneck due to its low germination rates and hard seed coat [21].

Vitex doniana's hard seed coat results in low germination rates (11.25-61%) and prolonged germination periods (2-6 months), posing challenges for large-scale cultivation [2,8]. N'Danikou *et al*. [21] achieved 54-72% germination using alternating soaking and drying treatments, which facilitate water uptake through the seed coat's impermeable layers. Acid scarification (30-60 minutes) and total hull removal yielded germination rates of 17-75%, with hull removal achieving rapid emergence within two days, making it a promising technique for nursery production [8]. Vegetative propagation via stem cuttings has shown significant potential, with 30 cm cuttings (2-4 cm diameter) achieving 100% sprouting [21,22]. Juvenile cuttings (3-5 cm) demonstrated 40-50.7% regeneration, with larger cuttings performing better due to higher nutrient reserves [20]. Somatic embryogenesis, explored by Colombe *et al.* [23], offers potential for large-scale propagation of transgenic plants, though challenges in sterilization and ethylene inhibition persist. Coppicing at 20-40 cm heights enhances sprouting intensity and biomass yield, with vigorous seedlings showing faster growth and higher leaf production [3]. The species' fast growth (4.14-5.36 m in 3-5 years) and comparable timber properties to *Tectona grandis* highlight its commercial potential [3].

The inconsistency of germination rates and the lack of standardized dormancy-breaking protocols remain significant barriers to large-scale propagation [21,24]. The efficacy of hormonal treatments in vegetative propagation is debated, with studies suggesting minimal impact on sprouting, possibly due to inappropriate application methods [2,25]. Balancing sexual and asexual propagation methods to maintain genetic diversity while ensuring rapid propagation is a key challenge. The scalability of somatic embryogenesis is limited by the need for advanced tissue culture facilities and expertise, which are often unavailable in rural settings [23]. Vegetative propagation, particularly stem cuttings and coppicing, offers rapid, scalable solutions for *V. doniana* cultivation, enabling early fruiting and higher yields [2,3]. Standardized seed treatments, such as alternating soaking and drying or dehulling, could enhance sexual propagation, preserving genetic diversity for long-term sustainability [21,24]. Integrating these methods into community-based nurseries can support large-scale domestication efforts, particularly in high-priority regions like Taraba and Kano.

AGRONOMIC CONSIDERATIONS FOR DOMESTICATION OF *VITEX DONIANA* IN NIGERIAN SAVANNAS

Although the ecological preferences of *Vitex doniana* provide valuable information on its natural habitat and environmental adaptability, they do not fully address the practical requirements for successful cultivation under managed conditions. Knowing the species thrives in certain soil types or rainfall zones does not automatically translate to high productivity when grown as a domesticated crop [26]. In cultivated systems, several variables, such as land preparation, nutrient application, spacing, and pest management, must be actively controlled to ensure optimal growth and yield. Therefore, it becomes necessary to go beyond ecological suitability and also focus on field-level agronomic considerations.

Soil and Land Preparation

Vitex doniana performs optimally in deep, well-drained alluvial and sandy loam soils enriched with organic matter, within a pH range of 5.5 to 7.5 [4,25]. Effective land preparation involves deep ploughing to a depth of 20–30 cm, complete removal of competing vegetation, and the construction of raised beds or ridges, particularly in waterlogged or low-lying areas prone to poor drainage [21]. In degraded savanna soils, the application of compost or aged manure improves soil physical properties and enhances microbial activity, thereby creating favourable conditions for root development and early seedling establishment [20].

Nutrient and Fertility Management

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Although *Vitex doniana* contributes to soil fertility through litter fall and limited nitrogen fixation, external nutrient supplementation remains necessary during early growth stages [27]. Split application of these inputs during the early rainy season improves nutrient availability and uptake. In nutrient-deficient soils, foliar sprays containing micro nutrients such as zinc and boron have shown potential in boosting leaf production and flowering [28], although further empirical research is required to confirm consistency and economic feasibility.

Water Management

Vitex doniana displays moderate tolerance to drought stress but achieves optimal growth and productivity under consistent soil moisture conditions [29]. The species performs well within rainfall regimes of 750-2000 mm annually [14]. During extended dry periods, particularly at the seedling stage, regular watering is necessary to prevent growth retardation [21]. In semi-arid environments, water conservation can be improved through the use of small basins or contour bounds. In high rainfall regions, such as parts of Delta State, effective drainage systems are required to mitigate risks associated with water-logging and root rot.

Planting Geometry and Spacing

In monoculture plantations, spacing can range between 5 m x 5 m and 6 m x 6 m due to the tree structure, equating to approximately 278-400 trees per hectare [30]. For agroforestry applications, wider spacing of 8-10 m reduces shading on companion crops. Under intercropping arrangements involving legumes or vegetables, alley cropping at 8 m x 4 m allows for a balance between light distribution and biomass yield. Plant spacing directly influences canopy structure, root distribution and ease of access during harvesting operations [31], and should be determined according to site-specific agroecological conditions and production objectives.

Weed, Pest, and Disease Management

Weed competition has been identified as a major constraint to early seedling establishment in tree crops [32] such as *Vitex doniana*. Manual weeding or the application of organic mulches is recommended at intervals during the first year of establishment to reduce competition for moisture and nutrients [3]. Although *V. doniana* is generally considered resilient, reports have documented infestations by sap-sucking insects such as aphids, stem borers, and fungal pathogens, including leaf spot and root rot in both nursery and field settings [33]. Adoption of integrated pest management (IPM) approaches such as neem-based biopesticide application, routine field sanitation, and the selection of pest-resistant genotypes can improve crop resilience while limiting reliance on synthetic agrochemicals.

Growth Monitoring and Yield Potential

Under favourable growing conditions, *V. doniana* seedlings exhibit rapid vegetative development, reaching heights of 1.5-2.0 m within the first 12 months [26]. Biomass production from coppicing trials has yielded between 3.2-5.4 t/ha/year of edible leaves under short rotation cycles lasting 4-6 months [3]. Mature trees maintained under semi-wild or minimally managed systems have demonstrated fruit yields ranging from 10 to 30 kg per annum [14]. Further agronomic experimentation is required to refine pruning practices and to understand the trade-offs between leaf and fruit yields across varying cultivation systems.

Intercropping and Agroforestry Integration

Vitex doniana has demonstrated compatibility with a range of arable crops commonly cultivated in Nigerian savannas [26], including cassava (Manihot esculenta), yam (*Dioscorea spp.*), African yam bean (*Sphenostylis stenocarpa*), and Bambara groundnut (*Vigna subterranea*). These cropping systems benefit from the species' contributions to soil fertility, moderated microclimates, and partial shading effects. Strategic intercropping enhances resource-use efficiency, minimizes production risk, and improves land productivity, particularly within smallholder systems [4]. Experimental trials assessing crop combinations, spatial arrangements, nutrient dynamics, and productivity trade-offs are essential for optimizing performance in integrated systems.

Harvesting and Post-Harvest Handling

Leaf harvesting from *V. doniana* typically involves manual plucking or coppicing, with harvesting frequency ranging from two to three cycles per season, depending on rainfall distribution [3]. Fruits are harvested by hand during the peak ripening period, usually from January to April [15]. Post-harvest handling techniques include washing, sun-drying, or refrigeration to preserve product quality and prevent microbial spoilage [33]. Establishing value chains for dried leaves and processed fruit products such as juices, jams, or herbal teas requires standardized hygiene protocols and appropriate packaging practices to meet both local and commercial market standards.

PHYTOCHEMICAL COMPOSITION AND PHARMACOLOGICAL POTENTIAL

Phytochemical composition encompasses the diverse chemical compounds in plants such as flavonoids, tannins, saponins, alkaloids, terpenoids, and phenolic acids that contribute to their nutritional and medicinal qualities. These bioactive compounds form the basis of *Vitex doniana*'s traditional uses and its promising pharmacological properties.

Vitex doniana contains significant phytochemicals, including flavonoids (58.9-232.6 mg/100 g), saponins (31.7-96.7 mg/100 g), alkaloids (173.3-194.8 mg/100 g), phenols, and tannins (up to 4200.7 mg/100 g), driving its antioxidant, antibacterial, antifungal, anti-inflammatory, and immunomodulatory properties [34,35]. These compounds, particularly flavonoids and tannins, are influenced by ecological factors, with nutrient-rich alluvial soils and wetter Guinean zones (e.g., Delta, Oyo) likely enhancing their concentrations, as seen in larger fruits and leaves [6,11,14]. GC-MS profiling identified secondary metabolites like sesquiterpenes, diterpenoids, phytosterols (e.g., γ-sitosterol), and triterpenoids, contributing to anti-inflammatory, anticancer (e.g., against prostate cancer cell lines), and hypolipidemic effects [36]. Crude extracts exhibit stronger bioactivity than isolated compounds, suggesting synergistic interations [37]. Variations in alkaloid detection, likely due to soil quality or climate, highlight the need to optimize cultivation in high-water-table regions to maximize medicinal potential [34].

Clinical validation remains limited; no comprehensive human trials have yet confirmed *V. doniana's* traditional medici-

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nal claims or its efficacy as a pharmaceutical agent. Nonetheless, the available toxicological studies indicate low toxicity and good safety margins in preclinical models, highlighting its potential for development into safe and effective natural therapies. [37,39].

CONSERVATION AND ANTHROPOGENIC PRESSURES

Conservation strategies aim to protect and sustain wild populations through in-situ and ex-situ approaches. Anthropogenic pressures, such deforestation, and agricultural expansion, threaten species survival and necessitate targeted conservation efforts [1].

V. doniana faces intense anthropogenic pressure from leaf harvesting, timber exploitation, charcoal production, and agricultural expansion, leading to population declines and fragmentation in Nigeria and Benin [1,9]. In southern Benin, forest cover declined from 35.5% to 10% between 1986 and 2016, with similar trends likely in Nigeria's savanna zones [9]. In-situ conservation strategies, such as on-farm cultivation and preservation in sacred forests, are proposed to reduce pressure on wild stands [1]. Ex-situ approaches, including germplasm collection and orchard cultivation, are recommended to preserve genetic diversity and support domestication [21,40]. The balance between in-situ and ex-situ conservation strategies is debated, with concerns about genetic erosion from over-reliance on vegetative propagation, which may reduce genetic diversity [2,41]. The lack of community awareness and standardized conservation protocols complicates sustainable management, particularly in rural areas where harvesting pressures are high.

Conservation strategies are critical for sustaining *V. doniana's* genetic resources and supporting domestication. Integrating the species into agroforestry systems can reduce pressure on wild populations, while community engagement and awareness programs can promote sustainable harvesting practices. Ex-situ conservation through germplasm banks can preserve diverse morphotypes for breeding programs [1].

KNOWLEDGE GAPS AND FUTURE DIRECTIONS

To advance the domestication of *Vitex doniana* in Nigerian savanna ecosystems, several critical knowledge gaps must be addressed. Comprehensive, high-resolution GIS-based distribution models integrating climatic, soil, and topographic data are essential to refine cultivation zones and predict range shifts under climate change scenarios. Predictive studies using climate models are needed to assess the species resilience to rising temperatures and altered rainfall patterns, ensuring its adaptability in changing environments. Genetic studies to identify markers for desirable traits, such as high fruit yield or drought tolerance, will enhance breeding programs for improved cultivars. Developing standardized protocols for seed and vegetative propagation is crucial to overcome inconsistent germination and ensure scalable cultivation while preserving genetic diversity.

Non-conventional methods, such as somatic embryogenesis and plantlet regeneration, offer promising alternatives to conventional propagation techniques, addressing the recalcitrant nature of *Vitex doniana* seeds and enabling mass distribution to Nigerian black plum farmers. Research on environmental impacts on phytochemical profiles can optimize cultivation for medicinal purposes, enhancing the species pharmacological value. Community-based conservation initiatives, supported by awareness programs and policy frameworks, are vital to promote sustainable harvesting and protect wild populations through on-farm cultivation.

CONCLUSION

Black Plum (*Vitex doniana* Sweet) exhibits significant potential for domestication in Nigerian savanna ecosystems due to its wide geographic distribution, ecological adaptability, and socio-economic value. Its ability to thrive across diverse habitats, coupled with its rich phytochemical profile, positions it as a valuable candidate for integration into agroforestry systems, contributing to food security, medicinal applications, and ecological benefits. However, challenges such as low germination rates, anthropogenic pressures, and climate uncertainties require a multidisciplinary approach. By integrating high-resolution agroecological zoning, advanced propagation techniques (including somatic embryogenesis), genetic improvement for desirable traits, and practical agronomic management, such as optimized soil preparation, nutrient management, water regulation, spacing, and pest control, *V. doniana* can be cultivated effectively. Community-based conservation strategies, supported by policy frameworks, will further ensure sustainable harvesting and biodiversity conservation. This review provides a strategic framework for researchers, policymakers, and farmers to unlock the full potential of Black Plum through sustainable domestication, enhancing livelihoods and ecosystem resilience in Nigeria.

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REFERENCES

1. Adoukonou-Sagbadja H., Ahoyo D., Tovignan T.K., Zavinon F., Ahoton L. Conservation status and phenotypic diversity of natural populations of Vitex doniana sweet in southern Benin assessed using quantitative morphometric traits // South African Journal of Botany. – 2023. – DOI: 10.1016/j.sajb.2023.03.023.

2. Achigan-Dako E.G., N'danikou S., Tchokponhoue D.A., Komlan F.A., Larwanou M., Vodouhe R.S., Ahanchede A. Sustainable use and conservation of Vitex doniana Sweet: unlocking the propagation ability using stem cuttings // Journal of Agriculture and Environment for International Development. – 2014. – Vol. 108. – pp. 43–61. – DOI: 10.12895/jaeid.20141.195.

3. N'Danikou S., Houdegbe A.C., Tchokponhoué D., Agossou A.O., Komlan F.A., Vodouhe R., Ahanchede A., Achigan-Dako E. Initial Plant Vigor and Short Rotation Coppices Improve Vegetable Production in Vitex doniana Sweet (Lamiaceae) // Plants. – 2020. – Vol. 9, No. 10. – DOI: 10.3390/plants9101253.

4. Achigan-Dako E.G., Pasquini M.W., Assogba-Komlan F., N'danikou S., Yedomonhan H., Dansi A., Ambrose-Oji B. Traditional vegetables in Benin: diversity, distribution, ecology, agronomy, and utilisation. – Benin: Institut National des Recherches Agricoles du Benin, 2010. – 10.13140/RG.2.1.1803.1121.

5. Abdullahi S., Dankat C., Ayuba A., Auta C., Danjuma I. Assessment of Proximate, Minerals and Amino Acids Content of Black Plum (Vitex doniana) Young Leaves as Dietary Vegetable Substitute // International Journal of Health and Human Rights. – 2022. – Vol. 1, No. 2. – pp. 170–177. – DOI: 10.57012/ijhhr.v1n2.001.

6. Ifeanacho M.O., Ogunwa S.C., Amadi P.U. Phytochemical Composition of Vitex doniana // Analytical Chemistry Letters. – 2019. – Vol. 9, No. 6. – pp. 863–875. – DOI: 10.1080/22297928.2020.1722221.

7. Ayodeji A.O., Victor U., Emmanuel O.O. Pharmacological activities of Gongronema latifolium, Vernonia amygdalina and Vitex doniana: a review // Journal of Pharmacognosy and Phytochemistry. – 2020. – Vol. 9, No. 4. – pp. 1822–1828.

8. Neya T., Daboue E., Neya O., Ouédraogo I. Germination Characteristics of Parinari curatellifolia Planch. Ex Benth, Vitex doniana Sweet and Zanthoxylum zanthoxyloides (Lam) Watermann // Annual Research & Review in Biology. – 2017. – Vol. 12. – DOI: 10.9734/arrb/2017/32209.

9. Akpoyètè D.H., Landeou R.C., Orékan V.O. Anthropisation et dynamique des paysages en Pays Agonlin au Bénin // European Scientific Journal. – 2018. – Vol. 14, No. 36. – pp. 571–594. – DOI: 10.19044/esj.2018.v14n36p571.

10. Oumorou M., Sinadouwirou T., Kiki M., Glele Kakaï R., Mensah G.A., Sinsin B. Disturbance and population structure of Vitex doniana Sw. in northern Benin, West Africa // International Journal of Biological and Chemical Sciences. – 2010. – Vol. 4, No. 3. – pp. 624–632.

11. Hounkpèvi A., Azihou A.F., Kouassi É.K., Porembski S., Glèlè Kakaï R. Climate-induced morphological variation of black plum (Vitex doniana Sw.) in Benin, West Africa // Genetic Resources and Crop Evolution. – 2016. – Vol. 63. – pp. 1073–1084. – DOI: 10.1007/s10722-016-0409-9.

12. GBIF.org. GBIF occurrence download [Electronic resource]. – 2025. – URL: https://doi.org/10.15468/dl.e52s3m (accessed 07.07.2025).

13. Orwa C., Mutua A., Kindt R., Jamnadass R., Anthony S. Agroforestree Database: a tree reference and selection guide version 4.0 [Electronic resource]. – 2009. – URL: http://www.worldagroforestry.org/sites/treedbs/treedatabases.asp (accessed 07.07.2025).

14. Vitex doniana (black plum) // CABI Compendium. - 2022. - DOI: 10.1079/cabicompendium.56529. — CABI International.

15. Sinébou V., Quinet M., Ahohuendo B.C., Jacquemart A.L. Reproductive traits affect the rescue of valuable and endangered multipurpose tropical trees // AoB Plants. – 2016. – Vol. 8. – pp. 1–17. – DOI: 10.1093/aobpla/plw051.

Geoinfotech. Agroecological zones in Nigeria [Electronic resource]. – 2022. – Available at: https://geoinfotech.ng/geoinfotech-blog/agroecological-zones-in-nigeria/.

Keypoint.ng. Major soil zones in Nigeria [Electronic resource]. – 2023. – Available at: https://keypoint.ng/major-soil-zones-in-nigeria/.

FAO. Soil resources in Nigeria [Electronic resource]. – 2022. – Available at:https://openknowledge.fao.org/server/api/core/bitstreams/cc16b7de-dda4-4666-b5a6-ff3e93ea1884/content/x5463e0a.htm.

Scribd. Soil types in Nigeria [Electronic resource]. – 2019. – Available at: https://www.scribd.com/document/835396285/Soil-Types-in-Nigeria.

20. Mapongmetsem P.M., Benoit L.B., Nkongmeneck B.A., Ngassoum M.B., Gubbuk H., Baye-Niwah C., Longmou J. Litterfall, decomposition and nutrients release in Vitex doniana Sweet. and Vitex madiensis Oliv. in the Sudano–Guinea Savannah // Akdeniz Üniversitesi Ziraat Fakültesi Dergisi. – 2005. – Vol. 18, No. 1. – pp. 63–75

21. N'Danikou S., Achigan-Dako E., Tchokponhoué D.A., Komlan F., Gebauer J., Vodouhè R., Ahanchede A. Enhancing germination and seedling growth in Vitex doniana Sweet for horticultural prospects and conservation of genetic resources // Fruits. – 2014. – Vol. 69. – pp. 43–56. – DOI: 10.1051/fruits/2014017.

22. Haruna M., Nakhooda M., Shaik S. Development of seed germination and in vitro propagation protocols for Vitex doniana // South African Journal of Botany. – 2024. – Vol. 167. – pp. 399–409. – DOI: 10.1016/j.sajb.2024.02.025.

23. Colombe D., Jane K., Catherine M., Lucien D., Christophe K., Peter N., Modeste K.K. Induction and regeneration of somatic embryos from Vitex doniana (Lamiaceae) leaf explants // International Journal of Biosciences, Biochemistry and Bioinformatics. – 2015. – DOI: 10.5897/ijbmbr2014.0216.

24. N'Danikou S., Soulémane N., Akpo E., Adjileye A., Logbo J., Mensah A.G.C., Fandohan A.B. Seed soaking treatments differently effect seed germination and seedling phenology for different populations of Vitex doniana Sweet // Seed Science and Technology. – 2024. – DOI: 10.15258/sst.2024.52.3.01.

25. Michael P.J., Samuel L. Vegetative propagation of cacao (Theobroma cacao L.): comparison of a liquid hormone preparation against a commercial rooting hormone powder // Malaysian Applied Biology. – 2018. – Vol. 47, No. 1. – pp. 45–50.

26. N'Danikou S., Achigan-Dako E.G., Tchokponhoué D.A., Agossou C.O.A., Houdegbe A.C., Vodouhè R.S., Ahanchédé A. Modelling socioeconomic determinants for cultivation and in-situ conservation of Vitex doniana Sweet (Black plum), a wild harvested economic plant in Benin // Journal of Ethnobiology and Ethnomedicine. – 2015. – Vol. 11, No. 1. – P. 1–14. – DOI: 10.1186/s13002-015-0017-3.

27. Lemage B., Anmaw Y. Effect of farmland trees Terminalia brownie and Vitex doniana on soil physicochemical properties and maize yield // Journal of Innovative Agriculture. – 2022. – Vol. 9, No. 4. – P. 1–9. – DOI: 10.37446/jinagri/rsa/9.4.2022.1-9.

28. Ruchal O.K., Pandey S.R., Regmi R., Regmi R., Magrati B.B. Effect of foliar application of micronutrient (zinc and boron) in flowering and fruit setting of mandarin (Citrus reticulata Blanco) in Dailekh, Nepal // Malaysian Jour-

DOI: 10.11134/btp.3.2025.1

nal of Sustainable Agriculture. – 2020. – Vol. 4, No. 2. – P. 94–98. – DOI: 10.26480/mjsa.02.2020.94.98.

29. Kakpo A.R., Vodounnon M.J., Agbangba C.E., Hounsou-Dindin G., Dagbénonbakin D.G., Amadji G.L., Buri M.M., Kakaï R.G. Vulnerability of Parkia biglobosa, Vitellaria paradoxa and Vitex doniana to climate change: wild indigenous agroforestry species in Benin // Modeling Earth Systems and Environment. – 2023. – Vol. 10, No. 2. – P. 1599–1614. – DOI: 10.1007/s40808-023-01856-6.

30. Farooq T.H., Xu, Rashid M.H.U., Wen W., Xu J., Tarin M.W.K., Zhu H., Wu P. Impact of stand density on soil quality in Chinese fir (Cunninghamia lanceolata) monoculture // Applied Ecology and Environmental Research. – 2019. – Vol. 17, No. 2. – P. 3553–3566. – DOI: 10.15666/aeer/1702_35533566.

31. Mekonen T., Tolera A., Nurfeta A., Bradford B.J., Mekasha A. Location and plant spacing affect biomass yield and nutritional value of pigeon pea forage // Agronomy Journal. – 2021. – Vol. 114, No. 1. – P. 228–247. – DOI: 10.1002/agj2.20803.

32. Schroeder W.R., Naeem H. Effect of weed control methods on growth of five temperate agroforestry tree species in Saskatchewan // The Forestry Chronicle. – 2017. – Vol. 93, No. 3. – P. 271–281. – DOI: 10.5558/tfc2017-035.

33. Dadjo C., Assogbadjo A.E., Fandohan A.B., Kakaï R.G., Chakeredza S., Houehanou T.D., Van Damme P., Sinsin B. Uses and management of black plum (Vitex doniana Sweet) in Southern Benin // Fruits. – 2012. – Vol. 67, No. 4. – P. 239–248. – DOI: 10.1051/fruits/2012017.

Irampagarikiye R., Diouara A.A.M., Thiam F., Nguer C.M. Vitex doniana Sweet, applications and therapeutic potential: A scoping review // Discover Applied Sciences. – 2025. – Vol. 7, No. 2. – P. 139. – DOI: 10.1007/s42452-025-06581-6.

Dah-Nouvlessounon D., Agossou A.E., Hoteyi I.M.S., Koda D., N'tcha C., Nounagnon M., Didagbé O., Sina H., Adjanohoun A., Baba-Moussa L. Phytochemical analysis, antioxidant and antimicrobial properties of Vitex doniana Sweet leaves and fruits extracts // American Journal of Biochemistry. – 2023. – Vol. 13, No. 1. – P. 14–24. – DOI: 10.5923/j.ajb.20231301.03.

Moriasi G., Ngugi M., Mwitari P., Omwenga G. In vitro anti-prostate cancer efficacy and phytochemical composition of the dichloromethane and ethyl acetate leaf extracts of Vitex doniana (Sweet) // Frontiers in Pharmacology. – 2024. – Vol. 15. – Article 1483856. – DOI: 10.3389/fphar.2024.1483856.

Barry P.R., Sanou A., Konaté K., Aworet-Samseny R.R., Sytar O., Dicko M.H. Toxicological profile, phytochemical analysis and anti-inflammatory properties of leaves of Vitex doniana Sweet (Verbenaceae) // Heliyon. – 2022. – Vol. 8, No. 8. – e10080. – DOI: 10.1016/j.heliyon.2022.e10080. – Retraction in: Heliyon. – 2025. – Vol. 11, No. 6. – e43079. – DOI: 10.1016/j.heliyon.2025.e43079

Adjei S., Amponsah I.K., Bekoe S.O., Harley B.K., Mensah K.B., Mensah A.Y., Baah M.K., Fosu-Mensah G. Fruits of Vitex doniana Sweet: toxicity profile, anti-inflammatory and antioxidant activities, and quantification of one of its bioactive constituents oleanolic acid // Heliyon. – 2021. – Vol. 7, No. 9. – e07910. – DOI: 10.1016/j.heliyon.2021.e07910.

Ushie O.A., Longbap B., Azuaga T.I., Iyen S.I., Ugwuja D.I., Ijoko R.F. Phytochemical screening and proximate analysis of the leaf extracts of Vitex doniana // Scientia Africana. – 2022. – Vol. 21, No. 1. – pp. 149–158. – DOI: 10.4314/sa.v21i1.13.

40. Khoo S., Ching X.L., Lee J.X., Syamsumir D.F., Ling N. Rebuilding of orchid germplasm conservation via molecular multi-omics approaches // Journal of Sustainability Science and Management. – 2024. – Vol. 19, No. 6. – pp. 169–199. – DOI: 10.46754/jssm.2024.06.013.

41. Weathington M., Avent T. Conservation through Propagation and Dissemination // Conservation and Cultivation of Plants. – Informa, 2023. – pp. 121–127. – DOI: 10.1201/9781003282150-7.