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COMPREHENSIVE REVIEW ON THE CHEMICAL CONSTITUENTS AND PHARMACOLOGICAL PROPERTIES OF DICHANTHIUM ANNULATUM: UNVEILING NATURE'S PHARMACOPEIA

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ABSTRACT

Dichanthium annulatum, commonly known as Marvel grass or Kleberg bluestem, is a perennial grass species of significant ecological, agricultural, and medicinal importance. This review provides a comprehensive overview of the botanical description, geographical distribution, chemical constituents, pharmacological properties, ethnobotanical uses, and potential areas for further research regarding Dichanthium annulatum. The botanical description highlights the morphological characteristics of Dichanthium annulatum, including its growth habit, stem structure, leaf morphology, and inflorescence arrangement. Geographically, the grass species is distributed across various tropical and subtropical regions worldwide, thriving in habitats such as pasture lands, roadsides, and fallow fields. Its ability to withstand diverse environmental conditions makes it a valuable resource for soil conservation, erosion control, and livestock forage. Phytochemical analysis reveals the presence of flavonoids, phenolic compounds, and terpenoids in Dichanthium annulatum, which contribute to its diverse pharmacological properties. These bioactive compounds exhibit antioxidant, anti-inflammatory, antimicrobial, and anticancer activities, making the grass species a potential source of novel therapeutic agents. Additionally, Dichanthium annulatum holds traditional medicinal significance, with folk remedies utilizing its aerial parts for treating fever, rheumatism, and skin conditions. Further research opportunities include exploring the genetic diversity, pharmacological mechanisms, and phytochemical composition of Dichanthium annulatum. Challenges related to research funding, standardized biological assays, and commercialization must be addressed to translate scientific findings into practical applications. Overall, Dichanthium annulatum exemplifies

the intricate relationship between humans and the natural world, emphasizing the importance of responsible stewardship and interdisciplinary research in harnessing the benefits of plant biodiversity for ecosystem health and societal well-being.

KEYWORDS: Further research opportunities include exploring the genetic diversity, pharmacological mechanisms, and phytochemical composition of Dichanthium annulatum.

1. INTRODUCTION

Dichanthium annulatum, commonly known as Kleberg bluestem or Kleberg's rosette grass, is a perennial grass species native to Africa and now widely distributed across tropical and subtropical regions worldwide. Belonging to the Poaceae family, this grass is renowned for its adaptability and resilience, making it a prominent component of various ecosystems, particularly in grasslands, savannas, and disturbed areas.

Characterized by its tufted growth habit and slender, erect stems, Dichanthium annulatum typically reaches heights ranging from 30 to 90 centimeters. Its leaves are narrow, and elongated, and often have a bluish-green hue, giving the plant its common name, "bluestem." The inflorescences of this grass consist of compact clusters of spikelets, each containing tiny flowers.[1]

One of the most remarkable features of Dichanthium annulatum is its amazing ability to thrive in diverse environmental conditions. It exhibits a high tolerance for drought, poor soil fertility, and grazing pressure, making it a valuable species for land reclamation and erosion control efforts. Its extensive root system also contributes to soil stabilization and prevents nutrient leaching.

In some regions, Dichanthium annulatum is considered invasive, outcompeting native vegetation and altering ecosystem dynamics. Its rapid spread can lead to the formation of dense monocultures, reducing biodiversity and disrupting ecological balance. However, in managed landscapes, it is often utilized for pasture improvement and as forage for livestock due to its palatability and nutritional value.

Fig No 1: Dichanthium annulatum.

Despite its ecological significance and economic utility, efforts are underway to manage the spread of Dichanthium annulatum in areas where it poses a threat to native biodiversity. Strategies such as targeted grazing, mechanical control, and the introduction of competitive native species are being employed to mitigate its impact and restore ecological integrity.[2]

Dichanthium annulatum stands as a testament to the remarkable adaptability of certain plant species and underscores the complex relationship between humans and the natural world. While it offers benefits in terms of soil conservation and forage production, its unchecked proliferation highlights the importance of responsible stewardship and conservation practices to preserve ecological balance.[3]

Importance of studying its chemical constituents and pharmacological properties: Studying the chemical constituents and pharmacological properties of Dichanthium annulatum is paramount for unlocking its potential therapeutic applications and understanding its ecological significance. Through rigorous phytochemical analysis, researchers can identify and characterize the diverse array of bioactive compounds present in the plant. This exploration may unveil novel molecules with medicinal properties, laying the foundation for drug discovery and development. Additionally, investigating the pharmacological activities of Dichanthium annulatum can shed light on its potential therapeutic effects, including anti-inflammatory, antioxidant, antimicrobial, antidiabetic, and anticancer activities. Such studies not only contribute to the expansion of our pharmacological toolkit but also validate traditional medicinal practices associated with the plant. Furthermore, understanding the chemical composition and pharmacological properties

of Dichanthium annulatum aids in elucidating its ecological interactions and impact on ecosystem dynamics. This holistic approach underscores the importance of interdisciplinary research in harnessing the full potential of plant biodiversity for human health and environmental conservation.[4]

Taxonomical Classification: Class, Order, Family, Genus, Species: The taxonomical classification of Dichanthium annulatum is as follows.

Class: Magnoliopsida

Order: Poales

Family: Poaceae (alt. Gramineae)

Genus: Dichanthium

Species: Dichanthium annulatum (Forssk.) Stapf.[5,6]

Geographical Distribution: Regions, Habitats: Geographical Distribution of Dichanthium annulatum.

Regions: Dichanthium annulatum, also known as Marvel grass, is native to various regions across the globe. It is found in continental tropical and subtropical areas of the Old World, including countries like Afghanistan, Algeria, Angola, Assam, Africa, tropical and temperate Asia, the Middle East, and Papua New Guinea.

Habitats: Marvel grass thrives in a range of habitats, typically growing in moderately dry to moist areas with annual summer rainfall varying from 300 to 2,600 mm. It can tolerate poor drainage but not permanently waterlogged conditions. This grass species is commonly found in pasture lands, roadsides, fallow fields, weedy lawns, dunes, and open wastelands. It prefers warm-season growth environments and can recover from frost damage with the onset of warm conditions. Marvel grass is not shade-tolerant and is known to withstand heavy grazing, forming an open turf. It flowers throughout the growing season, with the possibility of two harvests per year in some regions.[7,8]

Botanical Description

Growth Habit: Marvel grass is a perennial, densely tufted grass with erect or ascending stems that are usually simple. The nodes are often bearded.

Stems: The stems spread outwards and then grow erect at the ends, reaching up to 1 meter long and 60 cm in erect height. Each node on the stem is usually bearded.

Leaves: The leaves are linear, finely acuminate, glaucous, glabrous, or sparsely hairy above with small bulbous-based hairs. The leaf margins are scabrid. The sheaths are bearded at the tip, and the ligule is oblong, obtuse, membranous, and glabrous.

Inflorescence: The racemes are subdigitately fascicled, pinkish, or nearly white. The peduncles are glabrous, and the joints and pedicels are half as long as the spikelets, sparingly ciliate.

Spikelets: The sessile spikelets are variable in length, elliptic-oblong, and closely imbricating. The callus is thick and shortly bearded at the base. The lower involucral glume is elliptic-oblong, obtuse, ciliolate at the rounded or truncate apex, thin, with narrowly incurved margins, ciliate keels, and a hairy or glabrous back. It has 5-9 nerves that do not reach the tip. The upper involucral glume equals the lower but is narrower, lanceolate, subacute, glabrous, or ciliolate, and 3-nerved. The lower floral glume is as long as the upper involucral glume, linear-oblong, obtuse, nerveless, and glabrous. The flattened white base of a scabrid slender awn represents the upper floral glume.

The pedicellate spikelets are about equal to the sessile ones, male or neuter. The lower involucral glume is elliptic-oblong, obtuse, 7-11 nerved, with bristly keels. The upper involucral glume is narrower and 3-nerved. The lower floral glume is ciliate, and the upper floral glume is small or obsolete.[9,10]

Chemical Constituents

Flavonoids: The phytochemical investigation of Dichanthium annulatum, commonly known as Marvel grass, has unveiled a rich array of flavonoids, shedding light on its intricate chemical composition. Among these compounds, lignoflavone derivatives stand out prominently, with the presence of distinct stereoisomers such as tricin 4'-O-(threo-β-guaiacylglyceryl) ether (Salcolin A) and tricin 4'-O-(erythro-β-guaiacylglyceryl) ether (Salcolin B). Additionally, an epimer of tricin 4'-O-[threo-β-guaiacyl-(7"-O-methyl-9"-O-acetyl)-glyceryl] ether and tricin 4'-O-[erythro-β-guaiacyl-(7"-O-methyl-9"-O-acetyl)-glyceryl] ether has been identified. Complementing these lignoflavone derivatives are other flavonoids, including tricin, tricin 7-O-β-D-glucopyranoside, tricin 7-O-neohesperidoside, and a flavone C-glucoside. Together, these flavonoids not only contribute significantly to the chemical profile of Dichanthium annulatum but also hold potential implications for its biological activities. Through detailed chemical analysis, valuable insights are gained into the

pharmacological properties and potential health benefits associated with this intriguing plant species. Such findings underscore the importance of further exploration into the therapeutic potential of Dichanthium annulatum and its flavonoid constituents.[11,12]

Phenolic Compounds: Phenolic compounds constitute a vital group of metabolites derived from the secondary pathways of plants, playing multifaceted roles in plant growth and development. Their functions encompass diverse aspects crucial for plant survival and interaction with the environment. Firstly, phenolics serve as integral components of cell walls, contributing to structures such as lignins, cutins, and suberins. In this capacity, they offer mechanical support and act as formidable barriers against microbial assaults. Additionally, certain phenolic compounds, including flavonoids and anthocyanins, are responsible for the vibrant colors observed in flowers and fruits. Beyond aesthetics, these pigments play a pivotal role in attracting pollinators and aiding in seed dispersal, thereby ensuring reproductive success for the plant species. Moreover, phenolics serve as formidable defenders against predators, with compounds like tannins and phenolic resins acting as potent feeding deterrents. Furthermore, post-infection, plants deploy phenolic compounds as phytoalexins, bolstering their resistance against microbial attacks. Phenolic compounds also function as signal molecules in intricate plant interactions, eliciting defense responses, allelopathic effects, and even influencing gene transcription in leguminous plants to facilitate nodulation. Recent research has underscored their antioxidant properties, highlighting their significance not only in plant physiology but also in promoting human health. Thus, the multifaceted roles of phenolic compounds underscore their indispensable contribution to the resilience and vitality of plant life.[13-14]

Terpenoids

Terpenoids represent one of the most diverse families of natural products, boasting an extensive array of over 40,000 individual compounds. Renowned for their pharmacological versatility, they exhibit a broad spectrum of therapeutic properties, including anti-inflammatory, antitumor, antibacterial, antimalarial, and antiviral activities, among others. These compounds are ubiquitous in the plant kingdom, occurring as both primary and secondary metabolites. They are abundant in various botanical sources, ranging from medicinal herbs to aromatic spices, and are prevalent in fragrances and essential oils. The widespread distribution of terpenoids underscores their significance in both traditional and

modern pharmacology, offering a vast repository of bioactive compounds with potential applications in medicine, agriculture, and industry.

Other Secondary Metabolites: Plants like Dichanthium annulatum produce a diverse array of secondary metabolites crucial for their growth, development, and interactions with the environment. Phenolic compounds, with their roles in cell wall structure, pigmentation, defense mechanisms, and antioxidant properties, play a pivotal role in plant physiology and human health. Terpenoids, known for their vast chemical diversity and pharmacological activities, offer a treasure trove of bioactive compounds with potential therapeutic applications. Alkaloids, nitrogen-containing compounds found in many plant species, include both medicinal and toxic agents, showcasing the complexity of plant chemistry. Additionally, plant steroids, predominantly in the form of glycosides, contribute to various physiological processes and have been utilized in pharmacotherapy, particularly in combating inflammatory disorders. Together, these secondary metabolites underscore the intricate relationship between plants and their surrounding ecosystems, while also offering potential avenues for drug discovery and therapeutic interventions.[15-16]

Pharmacological properties: Dichanthium annulatum, commonly known as Marvel grass, has garnered significant attention for its diverse pharmacological properties, as evidenced by numerous studies.

1. Antioxidant Activity: Dichanthium annulatum showcases robust antioxidant activity, a crucial attribute for countering oxidative stress, a common precursor to various diseases. Evaluation through diverse assays like DPPH, ABTS, and SOR confirms its efficacy in scavenging free radicals, thereby shielding cells from oxidative damage. Notably, the ethanol extract of D. annulatum exhibits exceptional DPPH radical scavenging activity, surpassing even the renowned antioxidant ascorbic acid. This exceptional performance suggests the presence of potent antioxidant compounds within the plant. Furthermore, the substantial total phenolic content observed in the methanolic extract bolsters its antioxidant prowess. Phenolic compounds, renowned for their antioxidant properties, are abundant in D. annulatum, enhancing its capacity to counteract free radicals and mitigate cellular oxidative stress effectively. This comprehensive antioxidant activity underscores the therapeutic potential of Dichanthium annulatum in promoting overall health and well-being.[11,18]

2. Anti-inflammatory Activity: Dichanthium annulatum demonstrates notable anti-inflammatory activity, attributed primarily to its phenolic compounds, including tricin and its

derivatives. These compounds exhibit promising potential as anti-inflammatory agents by effectively modulating the generation of free radicals, which play a pivotal role in the inflammatory process. By inhibiting the production of inflammatory mediators and concurrently reducing oxidative stress, these compounds manifest anti-arthritic and anti-osteoporotic activities. Given that chronic inflammation underlies numerous diseases such as arthritis and osteoporosis, the anti-inflammatory properties of D. annulatum present promising therapeutic avenues for managing these conditions. The ability of its phenolic constituents to mitigate inflammation and oxidative stress highlights the potential of D. annulatum as a natural remedy for combating inflammatory-related disorders, thus warranting further exploration into its therapeutic applications.[12,18]

3. Antimicrobial Activity: Dichanthium annulatum exhibits substantial antimicrobial activity, particularly in its ethyl acetate extract, against pathogens including Candida albicans and Escherichia coli. This potency suggests the presence of bioactive compounds within the plant endowed with antimicrobial properties. The antimicrobial efficacy of D. annulatum may be attributed to its natural antioxidants, which can disrupt microbial cell membranes and inhibit microbial growth. By targeting the structural integrity of microbial cells and impeding their proliferation, D. annulatum emerges as a potential candidate for the development of antimicrobial agents aimed at combating infections caused by bacteria and fungi. This inherent antimicrobial activity underscores the therapeutic potential of D. annulatum in the realm of infectious disease management and warrants further investigation into its antimicrobial mechanisms and applications.[18]

4. Anticancer Potential: Dichanthium annulatum demonstrates promising anticancer potential, as evidenced by the efficacy of its extracts against various cancer cell lines. Particularly notable are the ethyl acetate and n-hexane extracts, which exhibit potent cytotoxic effects, suggesting the presence of bioactive compounds endowed with anticancer properties. While the exact mechanisms underlying the anticancer activity of D. annulatum extracts require further elucidation, their ability to induce cell death in cancer cells hints at their potential as sources of novel anticancer agents. The observed cytotoxicity against cancer cell lines underscores the therapeutic promise of D. annulatum in the realm of cancer treatment and highlights the need for comprehensive studies to unveil the molecular mechanisms driving its anticancer effects. Further exploration of D. annulatum as a potential

source of anticancer agents holds significant implications for the development of new cancer therapeutics and warrants continued investigation into its pharmacological properties.

Pharmacokinetics and Toxicology

Absorption: The plant compounds of Dichanthium annulatum are likely absorbed through the gastrointestinal tract after oral administration. The absorption process may vary depending on the specific phytochemicals present in the herb.

Distribution: Once absorbed, the phytoconstituents of Dichanthium annulatum are distributed throughout the body via the bloodstream. The distribution pattern may be influenced by factors such as molecular size, lipophilicity, and protein binding.

Metabolism: The metabolism of plant compounds occurs in various tissues, primarily in the liver. Metabolic processes may involve phase I and phase II reactions, leading to the formation of metabolites that are more easily excreted.

Excretion: Metabolites and unchanged compounds are excreted from the body primarily through the kidneys (urine) and the liver (bile). The excretion process helps eliminate the plant constituents from the body.

Safety Profile

Acute Oral Toxicity: Studies have evaluated the acute oral toxicity of Dichanthium annulatum extracts. No deaths were observed within the dose regimen up to 72 hours of routine observation for the extracts. The doses tested were considered safe, with no adverse effects observed.

Safety in Toxicity Profile: Dichanthium annulatum, specifically the whole plant, is a rich source of flavonoids, phenolic contents, and other compounds. These components have been reported to be safe in acute oral toxicity studies, indicating a favorable safety profile for the plant.[12,17,18]

Ethnobotanical Information: Dichanthium annulatum, commonly known as Marvel grass, has been used in traditional medicine for various purposes. Here are some key points regarding its ethnobotanical information.

Cultural Significance

Dichanthium annulatum in Agriculture: Dichanthium annulatum, commonly known as bluestem, holds significant importance in agriculture, particularly in regions like India. As a hardy and versatile grass species, it serves as a vital forage crop for livestock. In India, where livestock rearing is integral to many communities, Dichanthium annulatum plays a crucial role in providing nutrition to cattle, sheep, and other livestock. Its ability to thrive in various climates and soil types enhances its significance as a dependable forage option, contributing to sustainable agricultural practices.

Cultural Integration and Connection to the Land: The cultivation and utilization of Dichanthium annulatum have become deeply integrated into the cultural practices of communities reliant on agriculture. Its presence in pastures and grazing lands not only sustains livestock but also fosters a sense of connection to the land and traditional agricultural practices. The reliance on Dichanthium annulatum reflects the deep interdependence between nature and culture, shaping the cultural identity of communities where it is cultivated and utilized.[19-22]

Traditional Practices

Utilization in Traditional Medicine: Beyond its agricultural utility, Dichanthium annulatum is highly valued in traditional medicinal practices, particularly in regions where it grows abundantly. Throughout history, various cultures have recognized the therapeutic properties of this grass species and incorporated it into traditional medicine systems. In traditional Indian medicine, known as Ayurveda, Dichanthium annulatum is esteemed for its medicinal properties. It is often utilized in the treatment of a wide range of ailments, including fever, rheumatism, and skin conditions.

Harvesting and Processing for Medicinal Use: The leaves, stems, and roots of Dichanthium annulatum are harvested and processed to extract beneficial compounds believed to possess medicinal properties. These compounds are then incorporated into decoctions, infusions, or topical applications, depending on the ailment being treated. The plant's effectiveness in traditional medicine has been passed down through generations, contributing to its continued use in healthcare practices. The traditional medicinal use of Dichanthium annulatum highlights the plant's importance in promoting health and well-being in communities where it is revered.[23-25]

Folk Remedies

Fever Treatment: In traditional folk medicine practices, Dichanthium annulatum is highly regarded for its efficacy in treating fever. The aerial parts of the plant are specifically employed in folk remedies to create a decoction, a concentrated liquid extract. This decoction is believed to possess properties that help alleviate fever symptoms. The plant's usage in fever treatment highlights its role as a natural remedy for common ailments in local communities.

Rheumatism Alleviation: Dichanthium annulatum is also valued in folk remedies for its potential in managing rheumatism, a condition characterized by pain and inflammation in the joints. In traditional folk medicine, the aerial parts of the plant are utilized to prepare a decoction. This decoction is thought to have therapeutic properties that aid in reducing the discomfort associated with rheumatism. The plant's inclusion in folk remedies for rheumatism underscores its perceived effectiveness in addressing musculoskeletal ailments.

Treatment of Skin Conditions: Among its diverse medicinal applications in folk medicine, Dichanthium annulatum is employed in the treatment of various skin conditions. Traditional folk remedies utilize the aerial parts of the plant to create a decoction, which is applied externally to affected areas of the skin. This decoction is believed to possess properties that soothe and heal skin ailments, ranging from rashes to infections. The plant's inclusion in folk remedies for skin conditions highlights its role as a natural remedy for dermatological issues in local communities.[19, 26-28]

Potential Areas for Further Research

Genetic Diversity: Further research could focus on exploring the genetic diversity of Dichanthium annulatum to identify unique materials for developing core germplasm, especially for regions with drier climates. Understanding the genetic makeup can aid in breeding programs for drought tolerance and other desirable traits.

Pharmacological Studies: Investigating the specific mechanisms of action and molecular targets of the bioactive compounds in Dichanthium annulatum can provide insights into its therapeutic potential. Studying its effects on various diseases and conditions can open avenues for novel drug development.[11]

Phytochemical Analysis: Conducting in-depth phytochemical analyses to identify and characterize additional bioactive compounds present in Dichanthium annulatum can expand our understanding of its medicinal properties and potential applications.

Overcoming Limitations and Obstacles

Research Funding: Securing adequate funding for comprehensive research projects on Dichanthium annulatum can be a challenge. Collaborations with research institutions, government agencies, and private organizations may help overcome financial limitations.

Biological Assays: Developing standardized biological assays to evaluate the efficacy and safety of Dichanthium annulatum extracts can be crucial. Establishing reliable testing protocols can ensure consistent and reproducible results in pharmacological studies.[18]

Commercialization: Addressing challenges related to the commercialization of products derived from Dichanthium annulatum, including regulatory approvals, market acceptance, and scalability of production, is essential for translating research findings into practical applications.[29-30]

CONCLUSION

In conclusion, Dichanthium annulatum, commonly known as Marvel grass or Kleberg bluestem, is a versatile perennial grass species with significant ecological, agricultural, and medicinal importance. Its adaptability to diverse environmental conditions, high nutritional value, and pharmacological properties make it a valuable resource with multifaceted applications.

From an ecological standpoint, Dichanthium annulatum plays a pivotal role in soil conservation, erosion control, and ecosystem resilience. Its ability to thrive in challenging conditions contributes to its widespread distribution and ecological significance, although its invasive potential in some regions necessitates careful management strategies.

In agriculture, Dichanthium annulatum serves as a reliable forage crop, providing nutrition to livestock in various regions worldwide. Its resilience to drought, poor soil fertility, and grazing pressure make it an attractive option for pasture improvement and sustainable agriculture practices.

From a medicinal perspective, the chemical constituents of Dichanthium annulatum, including flavonoids, phenolic compounds, and terpenoids, exhibit diverse pharmacological properties such as antioxidant, anti-inflammatory, antimicrobial, and anticancer activities. These bioactive compounds hold promise for the development of novel therapeutic agents and contribute to the plant's traditional medicinal use in treating ailments such as fever, rheumatism, and skin conditions.

Further research into the genetic diversity, pharmacological mechanisms, and phytochemical composition of Dichanthium annulatum is essential to unlock its full potential for human health and environmental conservation. Addressing challenges related to research funding, standardized biological assays, and commercialization will be crucial for translating scientific findings into practical applications.

In essence, Dichanthium annulatum stands as a testament to the intricate relationship between humans and the natural world, highlighting the importance of responsible stewardship and interdisciplinary research in harnessing the benefits of plant biodiversity for the well-being of both ecosystems and society.

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