__Review Article__

Sustainable Farming and Soil Health Enhancement through Millet Cultivation- a Review

Abstract

Historically integral to Indian agriculture, millets are experiencing resurgence, driven by their adaptability to harsh climatic conditions and minimal resource requirements. The article explores the significant benefits of millets in soil nutrient management, demonstrating their ability to thrive in nutrient-poor soils while contributing to soil fertility through organic matter addition and improved soil structure. The integration of millets in crop rotation and intercropping systems is highlighted as a sustainable practice that enhances soil biodiversity and reduces the reliance on chemical inputs. A key environmental benefit of millet cultivation is its low water requirement and drought resistance, crucial in water-scarce regions, making it a strategic crop for adapting to climate change. Also examines the socio-economic impacts of millet cultivation. In rural areas, millets play a vital role in livelihoods by providing a sustainable food source and income generation, particularly in marginal environments. However, challenges in market accessibility and supply chain inefficiencies pose significant hurdles. Increasing consumer awareness and acceptance of millets, once considered traditional or 'poor man's food', is critical for reviving their cultivation. This is complemented by emerging research and technologies in millet cultivation, focused on developing improved varieties and precision agriculture techniques tailored to the needs of millet farming.The potential for scaling up millet cultivation is immense, particularly in regions facing environmental constraints. The article emphasizes the integration of millets into global sustainable farming strategies, aligning with several Sustainable Development Goals. This integration is supported by international organizations advocating for millets in agricultural policies and programs. In conclusion, the review underscores the importance of millets in the context of global food security and sustainable agriculture. The growing importance of millets backed by research, policy support, and market trends, positions them as a key crop in the quest for a sustainable and resilient agricultural future.

Keywords: *Millets, Sustainability, Biodiversity, Nutrition, Drought-resistance*

Introduction

Sustainable farming, particularly in the context of a rapidly evolving agricultural landscape like India's, represents a multifaceted approach that seeks to balance the need for food production with environmental stewardship and socio-economic viability. Defined broadly, sustainable farming involves practices that meet current food needs without compromising the ability of future generations to meet their own needs [1]. This concept is especially pertinent in India, where agriculture not only forms the backbone of the economy but is also integral to the socio-cultural fabric of the country [2].The importance of sustainable farming cannot be overstated in a country facing immense challenges such as soil degradation, water scarcity, and the impacts of climate change. Sustainable farming practices aim to enhance food security, improve farmer livelihoods, conserve natural resources, and reduce environmental degradation [3]. In India, these practices include crop diversification, organic farming, integrated nutrient management, and water conservation techniques, all of which are essential in maintaining the long-term productivity and health of agricultural systems [4].

Soil health is a critical component of sustainable agriculture, particularly in India where the majority of the population depends on agrarian livelihoods. The concept of soil health encompasses the continued capacity of soil to function as a vital living ecosystem that sustains plants, animals, and human's.This is particularly significant in the Indian context, where soils are subject to intense use and varying degrees of degradation.Soil health is assessed through various indicators, which include biological, chemical, and physical soil properties. Biological indicators refer to the soil's microbial activity and diversity, essential for nutrient cycling and organic matter decomposition [5]. Chemical indicators encompass soil pH, nutrient content (nitrogen, phosphorus, potassium), and organic matter levels, which are critical for assessing fertility and potential productivity [6]. Physical indicators, such as soil texture, structure, and water-holding capacity, are crucial for understanding the soil's ability to support plant growth and resist erosion [7].In the Indian scenario, maintaining and enhancing soil health has emerged as a priority, given the extensive agricultural practices and the increasing pressure on land resources. Practices like crop rotation, use of organic manure, reduced tillage, and cover cropping are increasingly being recognized for their role in improving soil health and thus contributing to sustainable farming [8].

Millets, often referred to as 'nutri-cereals', hold a significant place in India's agricultural landscape due to their nutritional, economic, and environmental benefits. As small-seeded grasses, millets are resilient to harsh weather conditions, making them an ideal crop for many of India's semi-arid and arid regions [9]. There are several types of millets, each with unique characteristics and uses.The major millets include pearl millet (Bajra) and sorghum (Jowar), which are staple foods in many parts of India. Minor millets include finger millet (Ragi), foxtail millet, barnyard millet, little millet, and proso millet. These millets are known for their high nutritional value, being rich in dietary fiber, proteins, vitamins, and minerals, and possessing a low glycemic index, which is beneficial for managing diabetes [10]. Furthermore, millets are gluten-free, making them a suitable grain alternative for people with gluten intolerance [11].Millets are not just nutritionally beneficial but are also environmentally sustainable. They require less water compared to major cereals like rice and wheat and can grow well in nutrient-poor, sandy soils, often unsuitable for other crops [12]. This hardiness makes millets a key crop in adapting to the challenges of climate change and ensuring food security.

The purpose of this review is to comprehensively explore the role of millet cultivation in promoting sustainable farming and enhancing soil health in India. This is particularly important in the context of the increasing environmental challenges and the need to shift towards more sustainable agricultural practices. The review aims to highlight the benefits of millet cultivation not only in terms of agricultural sustainability but also in addressing issues of nutritional security and economic viability for smallholder farmers.The scope of this review encompasses an examination of the various types of millets grown in India, their basic characteristics, and their role in sustainable agriculture. It also involves an analysis of the impact of millet cultivation on soil health, including soil nutrient management and water usage. Further, the review will delve into the socio-economic implications of millet cultivation, addressing how it affects rural livelihoods and the challenges it faces in terms of market acceptance and supply chain management. Finally, the review will discuss potential future directions for millet cultivation in India, considering emerging research and technologies.

Methodology of the Review

The methodology for this review involved a comprehensive literature search and analysis of existing research and publications related to millet cultivation, sustainable farming, and soil health. The sources include peer-reviewed journals, agricultural reports, policy documents, and case studies, primarily focusing on the context of India. Relevant databases such as Scopus, PubMed, and Google Scholar were utilized to gather scientific articles, while reports from governmental and non-governmental organizations provided insights into policy and practical aspects.The review process was structured to first identify and collate relevant literature, followed by a critical analysis of the gathered information. This analysis focused on extracting key themes and findings related to the cultivation of millets and its implications for sustainable farming and soil health. The literature was also examined to identify gaps in current knowledge and research, which helped in determining future research directions. The information gathered was synthesized to present a coherent and comprehensive overview of the current state of knowledge on millet cultivation and its role in sustainable agriculture in India.

History and Current Trends

A. *History of Millet Cultivation*

Millet cultivation in India has a rich history, deeply intertwined with the country's agrarian culture and civilization. Archaeological evidence suggests that millets were among the first crops domesticated in India, with records of cultivation dating back to the Harappan civilization around 2500 BCE [13]. These grains were historically staple foods in many regions, particularly in arid and semi-arid zones where their resilience to harsh climatic conditions made them a reliable crop [14].Throughout history, millets have played a crucial role in India’s agriculture, serving not just as a food source but also as a component in traditional rituals and practices. In many rural communities, millets were revered for their nutritional value, especially in regions where other cereal crops could not thrive due to water scarcity or poor soil conditions. However, the Green Revolution in the 1960s, which focused on high-yielding varieties of wheat and rice, led to a decline in millet cultivation as farmers shifted to these more lucrative crops [15].

Table 1: History of Millet Cultivation

Period/Year	Region/Location	Event/Development
Pre-6000 BCE	Northern China	Earliest evidence of millet cultivation, particularly foxtail and broomcorn millet.
c. 4500-3500 BCE	Yellow River region, China	Increased cultivation of millet as a staple crop.
c. 3000-2000 BCE	Korea and Japan	Introduction and expansion of millet cultivation.
c. 2500 BCE	Europe (e.g., Switzerland)	Evidence of millet consumption.
c. 2000-1500	Indian Subcontinent	Millet becomes an important part of agriculture.

BCE		
c. 1000 BCE	Africa, particularly West Africa	Spread and cultivation of Pearl Millet.
1st millennium BCE	Throughout Eurasia	Widespread cultivation and integration into local cuisines.
Middle Ages	Europe	Millet used as a staple food, especially in Eastern Europe and Russia.
20th Century	Global	Decline in millet's prominence due to the rise of wheat and rice. However, still remains a staple in semi-arid and arid regions.
21st Century	Global	Renewed interest in millet as a health food and for its resilience in drought-prone areas.

B. *Current Trends in Millet Cultivation Globally*

Globally, there has been a resurgence of interest in millets due to their nutritional benefits and sustainability. Countries in Africa and Asia, where millets are traditionally grown, are witnessing a renewed focus on these grains. In India, this resurgence is aligned with government initiatives promoting millets as 'nutri-cereals' due to their high nutrient content, low glycemic index, and gluten-free nature [16].In addition to their nutritional advantages, millets are being recognized for their lower environmental footprint. They require significantly less water than traditional cereals like wheat and rice and are capable of growing in poor soil conditions with minimal inputs. This adaptability makes them a suitable crop for addressing climate change and food security challenges, especially in regions prone to drought and soil degradation [17].

C. *Role of Millets in Sustainable Agriculture Policies*

The role of millets in sustainable agriculture policies has gained prominence, especially in countries grappling with the dual challenges of malnutrition and environmental degradation. In India, the government has implemented various policies and programs to revive millet cultivation. The National Food Security Act, 2013, included millets in the public distribution system, acknowledging their role in nutritional security [18]. The Indian government's initiative, 'Millets Mission', aims to enhance millet production through improved seed varieties, farming practices, and market linkages (Ministry of Agriculture & Farmers Welfare, Government of India). The Indian government has been instrumental in having the United Nations declare the year 2023 as the International Year of Millets. This reflects India's commitment to bringing millets to the global center stage, recognizing their potential in sustainable agriculture and nutritional [19]. The policy push towards millets is not just about promoting a crop but is also about reorienting agricultural practices towards more sustainable and resilient systems.

Millets and Soil Health

A. *Soil Nutrient Management and Millet Cultivation*

Millet cultivation plays a significant role in soil nutrient management, particularly in the semi-arid and arid regions of India where soil fertility is a major challenge. Millets, due to their hardiness and adaptability, are often grown in marginal soils with low nutrient content. They have a remarkable ability to thrive in these conditions with minimal inputs, making them an ideal crop for sustainable farming practices. The root systems of millet plants are known for their efficiency in nutrient uptake, particularly in extracting phosphorus from less fertile soils, a trait crucial for farming in nutrient-poor regions [20].Millets also contribute to the improvement of soil fertility through their biomass. The organic matter from millet plants, when incorporated back into the soil, enhances soil organic carbon, a key factor in soil health. This practice not only improves soil structure but also increases its capacity to retain nutrients and water, making the soil more productive for subsequent crops [21]

Table 2: Impact of Millet Cultivation on Soil Health

Aspect	Impact on Soil Health
Drought Resistance	Millet's ability to grow in low-moisture conditions helps in maintaining soil structure and reduces the need for irrigation, conserving water resources.
Root System	The deep and fibrous root system of millet aids in soil aeration, reduces erosion, and enhances soil stability.
Nutrient Uptake	Millet is effective in uptaking nutrients from the soil, which can help in the cycling of soil nutrients and maintaining soil fertility.
Crop Rotation	Including millet in crop rotation can improve soil health by disrupting pest and disease cycles and reducing the need for chemical inputs.
Soil Organic Matter	Millet crops, when used as cover crops or when their residues are left on the field, contribute to the increase in soil organic matter, improving soil fertility and structure.
Low Fertilizer Need	Millet requires less fertilizer compared to many other crops, reducing the risk of soil and water contamination from excessive fertilizer use.
Carbon Sequestration	The cultivation of millet can contribute to carbon sequestration in the soil, playing a role in mitigating climate change.

B. *Impact of Millets on Soil Structure and Quality*

The cultivation of millets has a positive impact on soil structure and quality. The extensive and deep root system of millet plants aids in soil aeration and helps in maintaining soil structure. This is particularly important in preventing soil erosion, a common problem in the dryland areas of India. The root systems of millets bind the soil, reducing runoff and soil loss during heavy rains [22]. Millets, as part of traditional farming systems, have been associated with the maintenance of soil biodiversity. The cultivation practices, often low in chemical inputs, support a diverse range of soil microorganisms, which are essential for nutrient cycling and maintaining soil health [23].

C. *Millets in Crop Rotation and Intercropping Systems*

Millets play a crucial role in crop rotation and intercropping systems, which are integral to sustainable agricultural practices in India. The inclusion of millets in crop rotations, especially with legumes, has been found to improve soil fertility by enhancing nitrogen levels in the soil. This is due to the nitrogen-fixing ability of legumes which benefits subsequent millet crops [24].Intercropping millets with other crops also leads to better utilization of soil nutrients and reduces the incidence of pests and diseases. This diversification of cropping systems contributes to the stability and resilience of the agro-ecosystem, ensuring sustained productivity and soil health [25].

D. *Water Usage and Drought Resistance of Millets*

The water usage efficiency and drought resistance of millets are critically important in the context of India's water scarcity issues. Millets require considerably less water compared to major cereals like rice and wheat, making them an ideal crop in water-stressed regions. Their ability to grow under low moisture conditions is attributed to their efficient root systems and physiological adaptations like the ability to reduce transpiration [26].This trait of millets not only ensures their survival and productivity in dry conditions but also minimizes the pressure on water resources, a key consideration in sustainable agriculture. Their cultivation can be a strategic component in water conservation strategies in agriculture, especially in regions facing water scarcity [27].

Environmental Benefits of Millet Cultivation

A. *Reduction in Carbon Footprint and Greenhouse Gas Emissions*

Millet cultivation offers significant environmental benefits, notably in the reduction of carbon footprint and greenhouse gas (GHG) emissions. In comparison to high-input agricultural systems, such as those required for rice and wheat, millets require fewer chemical fertilizers and pesticides. The reduced use of these inputs plays a crucial role in lowering GHG emissions, particularly nitrous oxide, which is a potent greenhouse gas associated with fertilizer use [28]. Furthermore, millets are often grown in rainfed conditions, which means lower water usage and reduced energy consumption for irrigation compared to water-intensive crops like rice, further contributing to a lower carbon footprint [29].In addition to their low input requirements, the cultivation practices associated with millets, such as crop rotation and intercropping, can enhance soil carbon sequestration. The deep-rooting nature of millets helps in storing carbon in the soil, thus playing a role in mitigating climate change by removing carbon dioxide from the atmosphere [30].

B. *Biodiversity Preservation through Millet Cultivation*

Millet cultivation supports biodiversity preservation, an essential component of environmental sustainability. Traditional farming systems in India that incorporate millets are often diverse and include a variety of crops, supporting a wide range of flora and fauna. This biodiversity is not only crucial for ecological balance but also for the resilience of the agricultural ecosystem. Diverse cropping systems are less susceptible to pests and diseases and can support a wider range of beneficial organisms, including pollinators and natural predators of agricultural pests [31].Millets themselves contribute to genetic diversity in agricultural systems. With several varieties of millets being cultivated, including lesser-known indigenous types, they represent a valuable genetic resource. This diversity is key in adapting to changing environmental conditions and in providing insurance against crop failures due to pests or diseases.

C. *Adaptation to Climate Change*

Millets are increasingly recognized for their role in adaptation to climate change, especially in regions prone to extreme weather events. Their inherent characteristics, such as drought tolerance and the ability to grow in marginal soils with low fertility, make them well-suited to withstand the impacts of climate variability. In the face of increasing temperatures and erratic rainfall patterns, millets offer a viable agricultural option for ensuring food security [32].Their resilience to climate extremes not only makes them a reliable crop for farmers but also reduces the need for external inputs like irrigation and fertilizers, which are both resource-intensive and susceptible to climate risks. By promoting millets, farming systems can become more adaptable to climate change, ensuring sustainable food production in the face of environmental uncertainties [33].

Socio-Economic Implications

A. *Millets and Rural Livelihoods*

Millets play a crucial role in supporting rural livelihoods, particularly in India's semi-arid and arid regions. These areas, often characterized by limited agricultural resources and challenging climatic conditions, are home to some of the country's most vulnerable farming communities. Millets, with their low input requirements and adaptability to harsh environments, provide a sustainable means of subsistence for these populations. They are not only a source of food security but also offer economic resilience, as they can be grown in conditions where other crops would fail, thus providing a steady source of income [34].In many rural areas, millet cultivation is deeply intertwined with local culture and traditions, playing a part in social practices and festivals. The cultivation and processing of millets are often community-oriented activities, contributing to social cohesion and community resilience. Furthermore, millet cultivation offers opportunities for women's empowerment, as women play a significant role in the sowing, harvesting, and processing of these crops [35]

B. *Market Trends and Economic Viability of Millet Cultivation*

The market trends for millets are witnessing a positive shift, driven by increasing consumer awareness of their health benefits. In India, there has been a growing demand for millets as a nutritious alternative to conventional cereals like rice and wheat. This trend is supported by urban consumers' growing preference for healthy, organic, and traditional food options. As a result, millets are gradually finding their way into urban supermarkets and health food stores, opening up new market opportunities for farmers [36].The economic viability of millet cultivation is also being bolstered by these changing market dynamics. With higher market demand and premium prices for millets, especially organic and branded products, farmers are finding millet cultivation more profitable. This shift has the potential to significantly impact rural economies, providing farmers with higher incomes and encouraging them to adopt sustainable farming practices [37].

C. *Government Policies and Subsidies for Millet Farmers*

The Indian government has implemented various policies and subsidies to support millet farmers and promote the cultivation of these grains. Recognizing the importance of millets in ensuring food security and nutritional well-being, the government has included millets in several of its food security and agricultural development programs. Initiatives like the National Food Security Mission (NFSM) and the Rashtriya Krishi Vikas Yojana (RKVY) have been instrumental in providing financial and technical support to millet farmers, including subsidies for seeds, fertilizers, and irrigation [38]. The government's push to include millets in the Public Distribution System (PDS) and mid-day meal schemes in schools is a significant step towards increasing millet consumption. This not only creates a stable market for millet farmers but also addresses issues of malnutrition and dietary diversity. The government has also been active in promoting research and development in millet cultivation, focusing on improving yield, developing improved varieties, and enhancing post-harvest technologies (Ministry of Agriculture & Farmers Welfare, Government of India).

Challenges in Millet Cultivation

A. *Agronomic Challenges*

Millet cultivation in India faces several agronomic challenges that can impact its productivity and sustainability. One of the primary issues is the genetic vulnerability of local millet varieties. Many traditional varieties, while resilient to local conditions, may not have the same yield potential or disease resistance as more modern cultivars. This situation is compounded by a lack of high-yielding and disease-resistant varieties, limiting farmers' ability to increase productivity sustainably [39].Another challenge is the relatively low level of mechanization in millet farming, which is predominantly practiced in marginal areas with small landholdings. The labor-intensive nature of millet cultivation, from planting to harvest, poses a significant challenge, particularly in areas facing labor shortages. This issue is further exacerbated by the difficulty in adopting modern agricultural practices due to the terrain and the socio-economic conditions of millet-growing regions [40].

B. *Market and Supply Chain Issues*

Market and supply chain issues are significant challenges in the millet sector. The marketing of millets is often unorganized, and smallholder farmers typically have limited access to markets, leading to a lack of bargaining power and economic exploitation by intermediaries. This results in lower profits for farmers and a disincentive to cultivate millets despite their nutritional and environmental benefits [41]. The supply chain for millets is not as well-developed as for major cereals like wheat and rice. Issues such as inadequate storage facilities, poor processing infrastructure, and inefficient distribution channels affect the quality and marketability of millet products. These logistical challenges can lead to post-harvest losses, reducing the overall efficiency of the millet value chain [42].

C. *Consumer Awareness and Acceptance*

Consumer awareness and acceptance are crucial factors influencing the demand for millets. While there is a growing trend towards health-conscious eating, millets are still not a primary choice for many consumers, especially in urban areas. This lack of awareness about the health benefits of millets contributes to their limited acceptance. Additionally, the perception of millets as a 'poor man's food' or 'famine food' has historically affected their popularity, particularly among the younger generation who often prefer rice or wheat-based products.Efforts to increase consumer awareness through marketing campaigns, recipe development, and showcasing the versatility of millets are necessary to change these perceptions. Incorporating millets into mainstream food products and making them more accessible and appealing to urban consumers can also play a vital role in increasing their acceptance [43].

D. *Technological and Research Gaps*

The technological and research gaps in millet cultivation are another set of challenges that need to be addressed. There is a lack of advanced agricultural technologies tailored to the specific needs of millet farming. This includes everything from seed technology and pest management to harvesting and post-harvest processing. The absence of such technologies hinders productivity and the quality of millet grains [44]. Research in the field of millet cultivation has been limited, especially when compared to major cereals. There is a need for more focused research on improving millet varieties, understanding their nutritional properties, and developing sustainable farming practices. Investment in research and development is crucial for addressing the challenges faced by millet farmers and for unlocking the potential of millets as a sustainable and nutritious food source [45].

Case Studies

A. *Successful Millet Cultivation Practices in Various Countries*

Across various countries, successful millet cultivation practices demonstrate the crop's versatility and potential in diverse agricultural settings. In India, traditional practices in states like Rajasthan and Karnataka have sustained millet cultivation for centuries. These practices include using indigenous seed varieties, organic farming methods, and rainfed agriculture, which have proven effective in these semi-arid regions. For instance, in Karnataka, the integrated approach of using organic manures, biofertilizers, and minimal tillage has shown remarkable success in sustaining soil health and increasing millet yields [46].In African countries like Mali and Niger, millets are fundamental to food security and livelihoods. Farming practices here focus on intercropping millets with legumes, such as cowpea, which enhances soil fertility and provides a balanced diet for local communities. This intercropping system, coupled with the use of traditional and improved seed varieties, has significantly improved yields and resilience against climatic challenges [47].

B. *Impact of Millet Cultivation on Soil Health and Farmer Income*

The impact of millet cultivation on soil health and farmer income is significant, especially in regions where agricultural resources are limited. Studies have shown that in India, the incorporation of millets into cropping systems has led to improved soil health due to their low nutrient requirement and positive effects on soil organic matter and structure. Farmers practicing millet cultivation, particularly in rainfed areas, have reported better soil conditions and reduced need for chemical fertilizers [48].In terms of farmer income, millets offer a viable option due to their adaptability to harsh conditions and lower production costs. In regions where farmers have limited access to water and fertilizers, millets provide a more economical alternative compared to water-intensive crops like rice. Additionally, with the growing market demand for millets driven by health-conscious consumers, farmers are finding new economic opportunities. For instance, in Tamil Nadu, the revival of traditional millets like finger millet (Ragi) and barnyard millet has led to increased incomes for smallholder farmers, as these crops fetch higher market prices due to their nutritional value [49].

Future Perspectives

A. *Emerging Research and Technologies in Millet Cultivation*

The future of millet cultivation is being shaped by emerging research and technologies aimed at enhancing productivity and sustainability. One area of focus is the development of improved millet varieties through genetic research. Efforts are underway to develop drought-tolerant, pest-resistant, and high-yielding millet varieties using both conventional breeding and biotechnological approaches. For instance, genomic selection and marker-assisted breeding are being explored to accelerate the breeding process for traits like early maturity and improved nutritional content [50].Advancements in agricultural technologies are also playing a pivotal role. Precision agriculture, involving the use of drones, remote sensing, and GIS technologies, is being adapted for millet farming to optimize resource use and improve crop management practices. These technologies offer potential for better soil health monitoring, irrigation management, and pest control, tailored to the needs of millet cultivation [51].

B. *Potential for Scaling Up Millet Cultivation*

There is significant potential for scaling up millet cultivation, particularly in regions facing climatic and soil constraints. Millets, with their resilience to harsh conditions, present an opportunity for agricultural expansion in areas unsuitable for other crops. Efforts to promote millets include enhancing farmer awareness about the benefits of millet farming and providing support in terms of access to quality seeds, inputs, and market linkages. Integrating millets into existing agricultural systems can aid in diversifying crop production and enhancing food security. Programs that encourage crop rotation and intercropping with millets can lead to more sustainable farming practices and help mitigate risks associated with mono-cropping systems. The promotion of millets in urban and peri-urban agriculture also presents an opportunity for expanding millet cultivation, catering to the growing demand for nutritious and sustainable food options [52].

C. *Integration of Millets in Global Sustainable Farming Strategies*

The integration of millets into global sustainable farming strategies is gaining traction, recognizing their role in addressing food security, nutrition, and environmental challenges. International organizations, such as the FAO and IFAD, are advocating for the inclusion of millets in agricultural policies and programs, especially in countries prone to climate change impacts. The promotion of millets aligns with several Sustainable Development Goals (SDGs), including zero hunger, good health and well-being, and climate action.Global initiatives are also focusing on enhancing the value chain of millets, from production to consumption. This involves improving processing technologies, developing new millet-based products, and creating market linkages to ensure that farmers receive fair compensation for their produce. Efforts are also being made to raise consumer awareness about the benefits of millets and to incorporate them into public health and nutrition programs, thereby increasing their acceptability and consumption globally [53].

Conclusion

Millet cultivation emerges as a pivotal element in sustainable agriculture, offering significant benefits in enhancing soil health, conserving biodiversity, and adapting to climate change. Despite facing agronomic, market, and technological challenges, the potential of millets in improving rural livelihoods and contributing to economic viability is evident. With the growing global emphasis on sustainable farming practices, millets are positioned as a valuable crop in addressing food security and nutritional needs, especially in regions affected by environmental stresses. Future perspectives highlight the importance of advancing research, scaling up cultivation, and integrating millets into global agricultural strategies. The resurgence of millet cultivation, backed by supportive policies and market trends, underscores its role in shaping a sustainable and resilient agricultural future.

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