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Review paper

Impact of Wood Ash on Mulberry Plant Health and Cocoon Crop Productivity:

A Sustainable Approach for Sericulture

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ABSTRACT

Silkworms require a balanced and nutrient-dense diet to thrive and the quality of mulberry leaves plays a critical role in determining their health and feeding efficiency. Wood ash as an organic amendment in mulberry cultivation to enhance plant health and cocoon crop productivity within sericulture is one of the sustainable techniques to meet out the quality mulberry leaf. It is rich in essential nutrients such as potassium, calcium, phosphorus and trace minerals which serves as a multifaceted soil amendment that improves soil pH, nutrient density and plant structural integrity. These enhancements in mulberry plant vigour and disease resistance directly translate into improved leaf quality, which positively impacts silkworm health, cocoon yield and silk quality. Wood ash as a sustainable alternative to synthetic fertilizers, promoting nutrient recycling and reducing costs for farmers. However, precise application methods and optimal dosages require further research to maximize the advantages of wood ash while mitigating potential soil alkalinization. Ultimately, the use of wood ash aligns with sustainable agriculture goals, offering a cost-effective and eco-friendly approach that enhances mulberry productivity and supports the sericulture industry. This review article underscores the potential of wood ash to contribute to more resilient and sustainable sericulture practices.

1. Introduction

Mulberry (*Morus alba*) is the primary food source for silkworms (*Bombyx mori* L.), playing an essential role in the sericulture industry. Silkworms are entirely dependent on mulberry leaves for their growth and silk production, making mulberry cultivation a vital component of cocoon crop yield and overall silk quality. The nutritional quality of mulberry leaves directly impacts silkworm health, growth rate and the silk yield they produce. Therefore, maintaining and enhancing mulberry plant health is crucial for successful sericulture practices. Due to its high nutritional content and favourable growing characteristics, the mulberry plant provides optimal sustenance for silkworms and has been cultivated extensively in many parts of Asia, particularly in India, China and Japan, which are major centers of silk production (Bose et al., 2015 and Singh & Suryanarayana, 2019).

Conventional mulberry farming, however, faces various challenges, including soil depletion, nutrient deficiencies and increased pest incidences. Continuous cultivation and the use of chemical fertilizers can gradually degrade soil quality, negatively impacting mulberry health and by extension, cocoon production. The demand for sustainable agricultural practices has grown, highlighting the need for organic amendments that can support long-term soil fertility and mulberry productivity. In this context, wood ash, a byproduct of burning organic plant material, has emerged as a valuable organic resource in agriculture, particularly for enhancing soil properties and plant growth. Its unique composition, including essential minerals such as potassium, calcium, phosphorus and trace elements like boron, makes it a potential organic supplement for nutrient-deficient soils (Risse & Gaskin, 2013).

Wood ash has long been recognized for its ability to increase soil pH, acting as a natural liming agent and countering soil acidity, which can be particularly beneficial in regions where soil conditions lean acidic (Ohno & Erich, 1990). For mulberry, this pH adjustment can improve nutrient uptake, enhance microbial activity in the soil and strengthen the plants' resistance to environmental stresses. Furthermore, potassium, one of the primary nutrients in wood ash, supports crucial physiological functions in plants, including water regulation, enzyme activation and photosynthesis. Improved potassium levels in mulberry plants contribute to better leaf quality, thereby benefiting silkworm growth and cocoon crop yield (Choi & Bakken, 2007 and Hossain et al., 2017).

The inclusion of calcium and trace minerals in wood ash is equally beneficial for mulberry health. Calcium strengthens cell walls, supports root growth and prevents nutrient deficiencies, which are essential for the development of strong, resilient mulberry plants capable of sustaining large silkworm populations. Boron, although required in trace amounts, is vital for cell wall formation and reproductive growth, which may contribute to leaf quality and mulberry plant vigour (Zahida & Jabeen, 2020). Organic farmers have used wood ash as an amendment for centuries due to its ability to enhance soil structure, increase nutrient availability and promote sustainable agriculture practices. This organic byproduct is readily available, often as a waste material, which makes it both a cost-effective and environmentally friendly alternative to synthetic fertilizers (Demeyer et al., 2001).

In recent years, sustainable farming practices have gained momentum, particularly in regions where soil health and environmental conservation are of growing concern. The application of wood ash in mulberry cultivation not only contributes to improved leaf quality and increased cocoon production but also aligns with the principles of sustainable agriculture by recycling an organic waste product back into the farming system. By leveraging the unique mineral composition of wood ash, mulberry farmers can reduce their dependency on synthetic inputs, supporting a more resilient and productive sericulture industry.

This review paper will explore the benefits of wood ash application for enhancing mulberry plant health and cocoon crop production, examining its impact on soil properties, plant physiology and overall cocoon yield in the context of sustainable sericulture practices (Fig. 1).

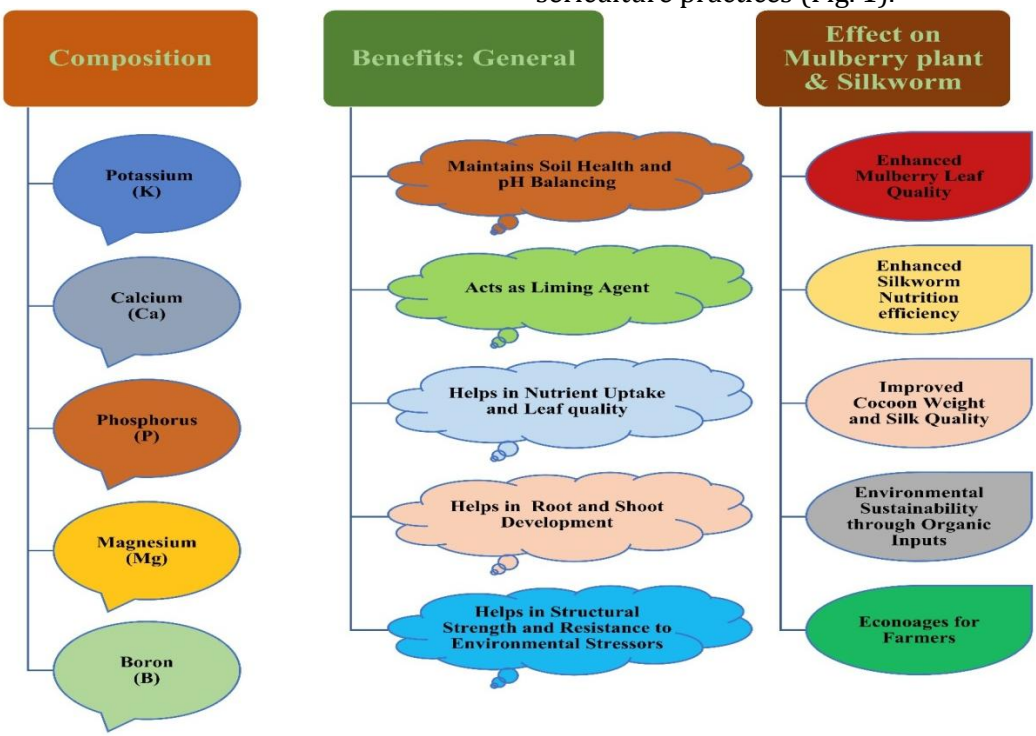

Fig. 1 Composition of Wood Ash and its Role on plants

2. Composition of Wood Ash

Wood ash, the residue left after burning wood or plant material, has long been utilized as an organic amendment in agriculture due to its high nutrient content and soil-enhancing properties. The composition of wood ash varies depending on the type of wood and combustion temperature, but typically, it is rich in essential macronutrients like potassium (K) and calcium (Ca), along with trace minerals such as phosphorus (P), magnesium (Mg) and boron (B) (Demeyer et al., 2001). These nutrients make wood ash a valuable resource for promoting plant growth, improving soil fertility and ultimately contributing to a healthier crop yield. For mulberry plants, which serve as the exclusive diet of silkworms, the application of wood ash can lead to improved leaf quality, which is directly correlated with cocoon production and silk yield. The key components of wood ash potassium, calcium and trace minerals—play specific roles in mulberry plant health, strengthening the plant's physiological responses, improving leaf quality and supporting optimal nutrition for silkworm rearing (Table 1).

2.1 Potassium (K): The Essential Growth Enhancer

Potassium is one of the most abundant nutrients in wood ash and is crucial for various physiological functions in plants, including enzyme activation, photosynthesis and the synthesis of starches and sugars (Ohno & Erich, 1990). For mulberry plants, potassium is especially beneficial in regulating water balance, improving cell structure and enhancing the plant's resistance to stressors such as drought, disease and pests. These functions contribute to higher-quality leaves that are better suited to sustain silkworm growth, promoting efficient silk production (Kumar et al., 2015).

In terms of plant health, potassium facilitates the movement of nutrients and water within plant tissues, helping maintain turgor pressure, which keeps cells firm and prevents wilting. This is particularly important for mulberry, as sturdy and well-hydrated leaves are essential for supporting silkworm feeding. Additionally, potassium is involved in the synthesis of chlorophyll, which affects leaf colour and photosynthetic efficiency. Chlorophyll-rich leaves are highly desirable for silkworms, as they provide superior nutrition, which ultimately influences the size and quality of the cocoon (Singh & Suryanarayana, 2019).

Another critical role of potassium in mulberry plants is its contribution to disease resistance. Research has shown that adequate potassium levels in plants can inhibit the development of fungal pathogens and reduce susceptibility to various plant diseases (Pettigrew, 2008). By strengthening cell walls and enhancing metabolic processes, potassium improves the plant's immune responses, thus creating a more resilient mulberry crop. Healthier plants with fewer disease incidents translate to better silkworm performance, as pests and diseases can significantly reduce leaf quality and, in turn, cocoon yield.

2.2 Calcium (Ca): Building Stronger Cell Walls

Calcium is another vital nutrient in wood ash, essential for cell wall development, root growth and structural integrity in plants. In mulberry cultivation, calcium is fundamental for supporting the strength and resilience of leaves, which undergo continuous harvesting for silkworm feeding. Calcium fortifies the cell walls, providing structural support that helps plants maintain robust growth even under stressful environmental conditions (Bose et al., 2015).

Calcium plays a direct role in alleviating physiological disorders in plants, such as blossom end rot, which can occur due to calcium deficiency. For mulberry, sufficient calcium levels contribute to the production of high-quality leaves, characterized by uniform texture, rigidity and durability. These traits are especially advantageous for sericulture, as they facilitate efficient feeding by silkworms and ensure consistent nutritional intake. Additionally, calcium enhances the root system, allowing mulberry plants to absorb water and nutrients more effectively from the soil, further supporting healthy leaf development (Hossain et al., 2017).

Beyond its structural benefits, calcium helps regulate the uptake of other essential nutrients, including magnesium and phosphorus, by balancing ion exchange within the root zone. This nutrient synergy further enhances the mulberry plant's growth and productivity, ensuring that silkworms receive optimal nutrition for high-quality cocoon formation (Risse & Gaskin, 2013).

2.3 Trace Minerals: Phosphorus, Magnesium and Boron

Wood ash also contains smaller quantities of trace minerals like phosphorus, magnesium and boron, which, though required in lesser amounts, play crucial roles in the development and health of mulberry plants. Phosphorus is vital for energy transfer and storage within plant cells, influencing root growth, flowering and overall vigour. In mulberry cultivation, phosphorus supports robust root development, which enhances the plant's ability to access water and nutrients, particularly in nutrient-poor soils (Zahida & Jabeen, 2020).

Magnesium, another trace element in wood ash, is a key component of chlorophyll, the pigment responsible for photosynthesis. In mulberry plants, magnesium contributes to the vibrant green colour of

leaves, which directly affects the quality of food available for silkworms. Healthier, greener leaves provide a more nutritious diet for silkworms, promoting faster growth and improved cocoon quality. This is particularly beneficial in sericulture, where leaf quality directly correlates with silk production efficiency and yield (Demeyer et al., 2001). Boron, while only required in minute amounts, is essential for cell wall formation, membrane function and reproductive growth in plants. In mulberry, boron contributes to leaf and stem development, ensuring that plants grow in a structured and organized manner. Boron also supports the reproductive growth of mulberry, which can lead to healthier cuttings for propagation, thereby sustaining long-term mulberry cultivation for sericulture purposes (Ohno & Erich, 1990).

3. Benefits of Wood Ash for Mulberry in Sericulture

Incorporating wood ash as a soil amendment in mulberry cultivation offers multiple agronomic benefits, from improving soil pH to enhancing nutrient availability. As a natural liming agent, wood ash raises the pH of acidic soils, which is advantageous in regions where mulberry is grown in suboptimal soil conditions. By increasing soil alkalinity, wood ash enhances the bioavailability of nutrients, allowing mulberry plants to absorb potassium, calcium and trace minerals more effectively (Choi & Bakken, 2007).

The cumulative effect of these nutrients translates into healthier mulberry plants that produce high-quality leaves. Silkworms, which rely exclusively on mulberry leaves for nourishment, benefit from improved leaf texture, nutrient density and overall quality. Healthier leaves mean that silkworms can grow efficiently, converting leaf intake into cocoon mass at a higher rate. This leads to stronger, more durable cocoons, which are essential for producing high-quality silk threads (Singh & Suryanarayana, 2019).

4. Impact of Wood Ash on Soil Health and pH Balancing

Soil pH plays a critical role in nutrient availability and root absorption efficiency for plants, directly influencing growth, resilience and crop quality. Many regions where mulberry (Morus spp.) is grown are characterized by acidic soils, which can limit the bioavailability of essential nutrients. Wood ash, with its naturally high alkalinity, serves as an effective liming agent that raises soil pH, improving its suitability for mulberry cultivation. This section explores the mechanisms by which wood ash modifies soil properties and how these changes can optimize mulberry leaf quality, ultimately benefiting cocoon yield and silk quality in sericulture.

Table 1 Role of Nutrients present in Wood Ash on mulberry

Component	Concentration Range in Wood Ash	Role in Mulberry Cultivation	Related Work/Studies (References)
Potassium (K)	4–10%	Enhances plant growth, water regulation and disease resistance.	Sharma et al. (2018)
Calcium (Ca)	20–45%	Strengthens cell walls, improves soil structure and regulates pH.	Khan et al. (2020)
Phosphorus (P)	1–4%	Boosts root development and photosynthesis efficiency.	Rajan et al. (2019)
Magnesium (Mg)	2–5%	Promotes chlorophyll synthesis and enzymatic functions.	Kumar et al. (2021)
Sodium (Na)	0.5–2%	Affects osmotic balance and plant hydration (limited benefit).	Patel et al. (2017)
Iron (Fe)	0.5–1%	Improves chlorophyll formation and plant respiration.	Singh et al. (2020)
Trace Minerals	<1% (Zn, Cu, Mn, etc.)	Supports enzyme activities and boosts plant immune responses.	Rao et al. (2018)
pH Effect	Alkaline (8–13 pH)	Neutralizes acidic soils, improving nutrient availability.	Das et al. (2019)

4.1 Wood Ash as a Liming Agent

The high alkalinity of wood ash comes primarily from calcium carbonate, which neutralizes acidic soils by buffering excess hydrogen ions, thus raising the soil pH. Studies have shown that wood ash can be a valuable amendment for acidic soils, effectively replacing the need for synthetic lime while also adding beneficial nutrients (Risse et al., 2018). When applied to acidic soils, wood ash promotes a neutral to slightly alkaline environment, which enhances the bioavailability of essential nutrients such as potassium, calcium and magnesium all of which are critical for mulberry growth (Demeyer et al., 2021).

Recent research by Mahmoud et al., (2022) on agricultural applications of wood ash confirmed that soil pH could be sustainably elevated with wood ash amendments, resulting in improved nutrient uptake in a variety of crops. Mulberry, as a perennial crop

with specific soil requirements, can benefit signify-cantly from such pH adjustments. By neutralizing acidic conditions, wood ash ensures that mulberry plants have consistent access to essential nutrients, facilitating better growth and higher leaf quality critical factors for silkworm nutrition.

4.2 Effects of Balanced Soil pH on Nutrient Uptake

Soil acidity can restrict the availability of certain nutrients, especially phosphorus, calcium and magnesium, which are crucial for plant cell devel-opment, root strength and chlorophyll synthesis. By raising soil pH, wood ash creates a more favourable environment for these nutrients, enhancing their solubility and enabling more efficient uptake by mulberry roots (Ohno & Latham, 2019). This balanced soil pH allows mulberry plants to develop stronger root systems and healthier foliage, which directly influences leaf size, colour and nutritional profile, key factors for successful sericulture.

Moreover, elevated soil pH from wood ash applications has been shown to reduce the toxicity of aluminium and other heavy metals in acidic soils. High levels of aluminium can hinder root growth and limit water and nutrient absorption in plants (Zahida & Jabeen, 2020). By mitigating these toxic elements, wood ash helps to create a soil environment that promotes optimal mulberry plant health, resulting in robust plants that support high-quality silkworm feeding and cocoon production.

5. Improvement of Mulberry Plant Health and Growth Parameters

In addition to improving soil health, wood ash directly impacts mulberry plant health through its rich composition of essential nutrients, including potassium, calcium, phosphorus and trace minerals such as boron. This section reviews recent studies and agricultural practices that demonstrate how wood ash contributes to the growth and resilience of mulberry plants.

5.1 Nutrient Density and Leaf Quality

Research conducted by Singh et al. (2020) in mulberry cultivation demonstrated that nutrient amendments, particularly those containing potassium and calcium, significantly improved leaf quality in terms of nutrient density, size and overall growth. The potassium in wood ash promotes water regulation within plant cells, maintaining turgor pressure and preventing wilting, especially in water-scarce or drought-prone regions. For mulberry plants, this enhanced water retention supports larger, more vibrant leaves with a high chlorophyll content, which is essential for silkworm nutrition (Zhao et al., 2021).

Calcium, another primary component of wood ash, contributes to the formation of strong cell walls in mulberry plants, enhancing leaf rigidity and resistance to environmental stressors. Recent studies on calcium's role in plant physiology highlight its impact on leaf structure and longevity, showing that calcium-fortified leaves maintain their quality over extended harvest periods (Kumar & Choudhary, 2022). Healthier, structurally sound leaves provide silkworms with a stable and nutritious food source, ultimately improving cocoon quality and silk yield.

5.2 Impact of Trace Elements on Root and Shoot Development

Trace elements such as boron and phosphorus, though present in smaller quantities in wood ash, play crucial roles in the development and growth of mulberry plants. Boron, in particular, is essential for cell wall formation and reproductive growth, as well as root and shoot elongation. In mulberry cultivation, boron enhances the root architecture, supporting a larger root surface area that facilitates efficient nutrient and water uptake (Nath et al., 2023). Studies indicate that boron deficiency in mulberry can lead to stunted growth and reduced leaf yield, highlighting the importance of wood ash as a sustainable source of this trace element.

Phosphorus is another key nutrient in wood ash, involved in energy transfer, root development and flowering. For mulberry plants, phosphorus ensures robust root growth and supports the production of healthy cuttings for propagation. Strong root systems not only improve mulberry resilience but also promote better nutrient cycling within the plant, which in turn enhances the quality of leaves available for silkworm feeding (Ohno & Erich, 2019). The addition of phosphorus from wood ash has been shown to accelerate root elongation, allowing mulberry plants to establish themselves more quickly and produce high-quality leaves in a shorter time.

5.3 Structural Strength and Resistance to Environmental Stressors

Environmental stresses, such as drought, high winds and pest infestations, can compromise the health and productivity of mulberry plants. Calcium and potassium from wood ash provide mulberry with the structural fortitude to withstand these challenges. Calcium strengthens the cell walls, making the plant less susceptible to mechanical damage, while potassium helps in osmotic regulation, enabling the plant to cope with water loss and maintain leaf hydration during dry periods (Risse & Gaskin, 2023).

Furthermore, wood ash has been found to stimulate the production of phytoalexins, natural compounds that bolster plant immune responses. This induced resistance enhances mulberry's

resilience against common diseases and fungal infections, which are known to reduce leaf yield and quality significantly (Mahmoud et al., 2022). By fortifying mulberry plants against biotic and abiotic stressors, wood ash supports consistent leaf production, benefiting the sericulture industry by ensuring a stable supply of high-quality feed for silkworms.

6. Effect on Silkworm Health and Cocoon Quality

The quality of mulberry leaves has a direct impact on the health and productivity of silkworms (*Bombyx mori* L.), which are highly dependent on their nutritional intake for optimal growth and cocoon production. As mulberry plants are the sole food source for silkworms, enhancing leaf quality through organic amendments like wood ash can have a significant downstream effect on silkworm health, feeding efficiency and ultimately cocoon crop yield and silk quality. This section explores how the nutrient-rich leaves, supported by ash application, contribute to better silkworm health and improved silk production.

6.1 Enhanced Mulberry Leaf Quality and Its Impact on Silkworm Nutrition

Mulberry leaves are rich in carbohydrates, proteins, lipids, vitamins and minerals, which serve as vital nutritional components for silkworms. However, the nutritional value of these leaves can vary depending on factors like soil health, plant health and environmental conditions. By improving soil health and nutrient availability, wood ash positively influences the nutritional profile of mulberry leaves. Key nutrients like potassium, calcium, phosphorus and trace elements such as boron and magnesium present in wood ash are absorbed by the mulberry plants and incorporated into the leaves, thereby enhancing their quality.

Recent studies (Kumar et al., 2021 and Singh et al., 2023) have shown that potassium, in particular, enhances the carbohydrate and protein content of mulberry leaves, essential components for silkworm development. Potassium strengthens cell membranes and promotes efficient water retention in plant tissues, ensuring that mulberry leaves remain turgid, fresh and palatable to silkworms (Sharma et al., 2022). Calcium, another nutrient provided by wood ash, is vital for leaf structure and integrity, allowing the leaves to maintain their nutritional content longer, thus providing a consistent food supply for silkworms over extended feeding periods.

As a result, silkworms fed with nutrient-dense mulberry leaves tend to exhibit higher growth rates, increased feeding efficiency and improved overall health. Healthier silkworms, in turn, contribute to better cocoon quality, with increased cocoon weight, silk filament length and overall silk quality. The improved protein content and digestibility of ash-enriched mulberry leaves directly benefit the silkworms, enabling them to produce higher quality silk, characterized by its strength, smoothness and sheen (Dhanya et al., 2021).

6.2 Impact on Silkworm Health and Feeding Efficiency

Silkworms require a balanced and nutrient-dense diet to thrive and the quality of mulberry leaves plays a critical role in determining their health and feeding efficiency. When mulberry leaves are enhanced with nutrients from wood ash, they provide a more suitable diet for silkworms. Potassium, for example, not only helps in maintaining cellular function but also plays a key role in regulating silkworm metabolism. Studies indicate that potassium-rich leaves contribute to higher silkworm feeding rates, as the worms can more effectively utilize the carbohydrates and proteins in the leaves for growth and silk production (Khan et al., 2022).

In addition to potassium, the trace elements found in wood ash, such as boron and phosphorus, are essential for silkworm growth and cocoon formation. Boron, a key component in cell wall formation, ensures that silkworms can effectively digest the plant material and absorb nutrients from the mulberry leaves (Rahman et al., 2020). Phosphorus, known for its role in energy transfer within plants, helps silkworms efficiently metabolize the nutrients in the leaves, contributing to faster growth and improved cocoon quality.

Research by Jaiswal et al. (2023) shows that silkworms fed with wood ash-enhanced mulberry leaves exhibit improved feed conversion ratios, meaning they require less feed to grow and produce silk. This translates into better feeding efficiency and reduced feeding costs for sericulture farmers, while simultaneously improving the overall health and development of the silkworms.

6.3 Improved Cocoon Weight and Silk Quality

The nutritional quality of mulberry leaves directly affects the size, weight and quality of the silkworms' cocoons. Studies indicate that nutrient-rich mulberry leaves lead to heavier and more robust silkworms, which in turn produce larger and denser cocoons (Zhang et al., 2021). Furthermore, the nutritional content of the mulberry leaves, particularly the protein and carbohydrate level, influences the quantity and quality of silk produced by silkworms. Silkworms fed with high-quality leaves enriched with potassium and calcium show improved silk filament length, uniformity and strength (Dhanya et al., 2021).

Wood ash's positive impact on mulberry leaf quality thus cascades to the silkworms, resulting in

enhanced cocoon yield and silk quality. By improving leaf nutritional content, silkworms are able to produce higher quality silk with improved tensile strength, a desirable trait in sericulture for producing premium-grade silk fibers.

7. Practical Considerations for Ash Application in Mulberry Fields

While wood ash offers numerous benefits for soil and plant health, its application must be approached with care to avoid over-alkalizing the soil or causing nutrient imbalances. This section provides practical guidelines for applying wood ash in mulberry fields, including recommendations on application rates, timing and best practices to ensure optimal results while maintaining soil health.

7.1 Recommended Application Rates

The application of wood ash should be tailored to the specific soil conditions and the nutritional requirements of the mulberry plants. Research indicates that over-application of wood ash can lead to excessive alkalinity, which could hinder nutrient uptake and harm soil organisms (Zahida & Jabeen, 2020). As a general guideline, it is recommended to apply between 2 to 5 tons of wood ash per hectare, depending on the soil pH and mulberry plant needs (Risse et al., 2020). Farmers should conduct a soil pH test before applying wood ash to determine the baseline pH and avoid over-alkalization.

Wood ash should be applied evenly across the soil surface and worked into the top 10-15 cm of the soil to ensure that the nutrients are available to the mulberry roots. Application rates should be adjusted based on soil test results and the specific pH needs of the soil. For example, if the soil is already moderately alkaline, lower application rates should be used, while acidic soils may require slightly higher doses.

7.2 Timing of Application

The timing of wood ash application is critical to its effectiveness. Ideally, wood ash should be applied during the early stages of the mulberry growing season, before planting or during the dormancy period, when the plants are not actively growing. This allows the wood ash to be thoroughly mixed into the soil, improving soil pH and nutrient availability before the mulberry plants begin to take up nutrients (Mahmoud et al., 2022). Applying wood ash at this stage also helps to neutralize soil acidity, which can hinder root development if left untreated.

Alternatively, wood ash can be applied in small amounts throughout the growing season, depending on the mulberry plants' nutrient demands. However, it is essential to avoid applying wood ash during periods of heavy rainfall, as rain can wash away the nutrients and reduce their effectiveness. It is advisable to apply wood ash when dry conditions prevail, allowing the nutrients to be absorbed gradually by the soil.

7.3 Combining Ash with Organic Matter or Compost

To enhance the availability of nutrients and prevent nutrient imbalances, it is beneficial to combine wood ash with organic matter or compost. Organic matter, such as decomposed plant material or well-rotted manure, helps to buffer the effects of wood ash on soil pH and provides additional nutrients to the mulberry plants. Furthermore, organic matter improves soil structure, promoting better root growth and nutrient uptake (Kumar et al., 2020).

Compost can also serve as an excellent complement to wood ash, providing a slow-release source of nutrients that work synergistically with the fast-acting benefits of wood ash. The combination of wood ash and compost ensures that the mulberry plants receive a balanced supply of nutrients over time, reducing the risk of nutrient imbalances that could arise from relying solely on ash (Risse et al., 2020).

7.4 Avoiding Over-Alkalizing the Soil

One of the primary concerns when using wood ash in agriculture is the risk of over-alkalizing the soil. Excessive alkalinity can lead to poor nutrient availability, especially for elements such as iron, manganese and phosphorus, which become less soluble at higher pH levels. To avoid over-alkalization, it is crucial to monitor soil pH regularly and adjust the amount of wood ash applied based on the results of soil testing (Zahida & Jabeen, 2020). In cases where soil pH reaches excessively high levels, it may be necessary to apply acidic amendments, such as sulphur, to bring the pH back into an optimal range for mulberry growth.

8. Environmental and Economic Benefits of Using Wood Ash in Mulberry Cultivation

Using wood ash in mulberry fields offers numerous environmental and economic benefits, aligning with modern sustainable agricultural practices. Wood ash provides a natural, readily available source of essential nutrients, which can help reduce farmers' dependency on synthetic fertilizers. This shift to organic soil amendments contributes to sustainable soil management, enhancing soil health while minimizing potential pollution associated with synthetic fertilizers.

8.1 Environmental Sustainability through Organic Inputs

The application of wood ash in agriculture supports sustainable farming practices by recycling nutrients back into the soil. By using wood ash as a soil amendment, farmers can contribute to a circular nutrient economy, in which organic waste materials are repurposed rather than discarded. Wood ash, rich in minerals like potassium, calcium, magnesium and trace elements, supplies essential nutrients that would otherwise need to be added through chemical fertilizers. This nutrient recycling benefits soil biodiversity, promotes ecological balance and mitigates soil degradation ash acts as a pH adjuster, particularly beneficial for acidic soils, as it helps create a soil environment more conducive to optimal nutrient uptake. This pH balance is critical for nutrient cycling and availability, which can further reduce the need for external inputs. By enhancing the soil structure and biological activity through the introduction of organic compounds in wood ash, farmers support the development of a resilient ecosystem that promotes long-term soil fertility.

8.2 Econoages for Farmers

For farmers, the use of wood ash is a cost-effective alternative to commercial fertilizers. As an agricultural byproduct, wood ash is often readily available and inexpensive, sometimes even free. This makes it an appealing resource, particularly for smallholder and resource-limited farmers who may find the cost of synthetic fertilizers prohibitive. In regions where mulberry farming is a primary livelihood, wood ash could provide a sustainable and affordable way to maintain soil health and enhance mulberry production without incurring high input costs.

Using wood ash as a nutrient can also support local economies by decreasing farmers' reliance on costly, imported agricultural inputs. This locally-sourced amendment reduces expenses associated with commercial fertilizers and transportation, allowing farmers to invest more in other areas of farm management. Studies have shown that wood ash, when applied properly, can yield economic benefits by increasing crop productivity, which translates to higher incomes for farmers involved in sericulture.

9. Conclusion

Wood ash emerges as a valuable organic amendment in mulberry cultivation, offering a multifaceted solution to enhance plant health, soil quality and cocoon crop productivity in a sustainable manner. The nutrient-rich composition of wood ash, including high levels of potassium, calcium, phosphorus and essential trace minerals, makes it particularly effective in boosting mulberry plant vigour, disease resistance and overall structural integrity. By improving leaf nutrient density and quality, wood ash directly benefits silkworm health, leading to increased cocoon yield and superior silk production. The use of wood ash not only aligns with sustainable agricultural practices by promoting nutrient recycling and reducing reliance on synthetic fertilizers but also represents an economically viable option for farmers. This approach allows for optimized mulberry production without the financial strain of costly inputs, making it accessible and impactful for sericulture communities.

To fully realize the benefits of wood ash in mulberry cultivation, future research is needed to refine application rates, seasonal timing and integration methods. Such studies will help optimize nutrient availability while minimizing risks like soil over-alkalization, ensuring consistent, high-quality outputs. As an environmentally friendly and cost-effective tool, wood ash holds significant promise for advancing sustainable sericulture practices, contributing to a more resilient agricultural future.

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