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DETERMINATION OF MACRONUTRIENTS CONCENTRATION IN DRY FOLLIAGE OF SOPHORA MOLLIS TO USE GREEN LUMEN AS ORGANIC FERTILIZER

Original Research

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ABSTRACT

Background: Optimal plant growth and successful crop production rely on the availability of essential macronutrients, which include nitrogen (N), phosphorus (P), potassium (K), calcium (Ca), and magnesium (Mg). These nutrients play critical roles in plant metabolism, soil fertility, and sustainable agriculture. *Sophora mollis*, a small deciduous shrub of the Fabaceae family, holds potential as an organic fertilizer due to its nutrient-rich foliage. Investigating its macronutrient profile provides insights into its suitability for addressing soil nutrient deficiencies and enhancing agricultural productivity.

Objective: The aim of this study was to evaluate the macronutrient concentrations in the dry foliage of *Sophora mollis* and to assess its potential as an organic fertilizer for improving soil fertility and supporting sustainable agriculture.

Methods: The research involved the collection of dry foliage from *Sophora mollis* plants in various regions of Skardu, Gilgit-Baltistan. The samples were dried, powdered, and analyzed in the laboratory. Nitrogen content was determined using the Kjeldahl method, which involved digestion, neutralization, distillation, and titration processes. The concentrations of phosphorus, potassium, calcium, and magnesium were analyzed using UV-Visible spectrophotometry. Appropriate standards were prepared for calibration, and the macronutrient concentrations were calculated based on established protocols.

Results: The dry foliage of *Sophora mollis* demonstrated macronutrient concentrations of 3.9% nitrogen, 0.6% phosphorus, 4.2% potassium, 2.4% calcium, and 0.8% magnesium. These values closely aligned with the sufficient ranges required for plant growth. The results highlighted the nutrient-rich profile of *Sophora mollis*, indicating its potential as a sustainable organic fertilizer.

Conclusion: The study concluded that the dry foliage of *Sophora mollis* is a promising source of essential macronutrients and can serve as an effective organic fertilizer. Its use in sustainable agricultural practices can improve soil fertility and support crop productivity, particularly in tropical and subtropical regions.

Keywords: Agricultural crops, calcium, essential nutrients, food security, magnesium, nitrogen, phosphorus.

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INTRODUCTION

The global population is projected to surge to an estimated 9-11 billion by 2050, creating significant challenges for food system security and sustainability (1). Agriculture, as the cornerstone of food security, plays a critical role in ensuring adequate nutrition and the well-being of the population (2). However, the widening gap between food supply and population growth has exacerbated concerns, necessitating urgent attention to sustainable agricultural practices (3). The pressure to meet growing food demands has led to the extensive use of synthetic fertilizers, which, while effective in boosting crop yields, have detrimental long-term consequences for soil health and the environment (4). Continuous reliance on these chemical inputs has resulted in the degradation of soil fertility, reduced crop quality, and chemical residues that jeopardize food safety and human health (5).

The importance of soil health in ensuring food security cannot be overstated (6). Declining soil nutrients due to improper land management, over-tillage, and excessive use of chemical fertilizers has significantly impacted crop productivity (7). This has far-reaching implications, particularly for vulnerable populations such as children, the elderly, pregnant women, and lactating mothers, who are at heightened risk of malnutrition (8). Addressing this crisis requires sustainable interventions that improve soil health while ensuring environmental resilience (9).

Organic farming has emerged as a viable alternative to conventional agriculture, offering solutions that enhance soil fertility while mitigating environmental harm. Organic fertilizers, derived from natural sources, play a pivotal role in restoring soil structure, texture, and nutrient balance. These fertilizers are economical, improve water retention capacity, and promote healthy root development, ultimately resulting in higher-quality crop yields. The incorporation of organic fertilizers and green manures not only replenishes soil organic matter but also reduces dependence on synthetic fertilizers, contributing to long-term agricultural sustainability (10).

Decomposed plant residues, or green manure, represent an underutilized resource with immense potential for improving soil quality and productivity. These natural amendments address the deficiencies caused by intensive agricultural practices, restoring soil nutrient balance and organic matter content. However, despite their benefits, the widespread adoption of organic solutions remains limited due to challenges such as lower yields and the need for innovative techniques to maximize their effectiveness (11).

Sophora mollis, a perennial shrub native to regions of the North-West Himalayas and Gilgit-Baltistan, offers promising potential as a source of organic fertilizer. Rich in essential macronutrients such as nitrogen, phosphorus, potassium, calcium, and magnesium, the leaves of Sophora mollis can significantly enhance soil fertility and crop productivity. Locally, this plant has been utilized as a natural fertilizer to improve yields of crops like potatoes and carrots, demonstrating its practical applications in sustainable farming practices (12).

This study aims to determine the concentration of macronutrients in the dry foliage of Sophora mollis to explore its potential as an organic fertilizer. By examining its nutrient profile, this research seeks to provide a sustainable solution to the challenges of soil degradation and food insecurity, contributing to improved agricultural productivity and environmental sustainability. The findings will offer a scientific basis for adopting Sophora mollis as a natural soil amendment, bridging the gap between traditional practices and modern agricultural needs (13).

METHODS

The determination of macronutrients in Sophora mollis foliage was conducted through a systematic series of laboratory-based procedures. The research was carried out in the biology laboratory of Government College for Women, Skardu, Gilgit Baltistan, Pakistan. Leaves of Sophora mollis were collected from dry localities in the Sundus, Gambah, and Astana regions. The samples were carefully packed in polyethylene bags to maintain their integrity during transportation. Once in the laboratory, the leaves were dried under shaded conditions to prevent photodegradation of nutrients. The dried leaves were subsequently ground into fine powder and stored for further experimental analyses.

The laboratory processes began with the preparation of extracts from the powdered leaf samples to determine the concentration of macronutrients, including nitrogen (N), phosphorus (P), potassium (K), calcium (Ca), and magnesium (Mg). Various analytical-grade

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reagents were utilized during these procedures, including concentrated sulfuric acid, lanthanum oxide, hydrochloric acid, distilled water, digestion tablets, glass boiling beads, and phenolphthalein indicator. The key instruments employed included a UV-Visible spectrophotometer for spectrometric analysis and Kjeldahl apparatus for nitrogen determination.

Nitrogen concentration in the samples was determined using a modified Kjeldahl method. The procedure involved digestion of a 3 g sample in 25 mL concentrated sulfuric acid with the addition of digestion tablets and glass boiling beads. The heat facilitated the breakdown of organic matter, releasing nitrogen in the form of ammonium sulfate. Following digestion, the acid solution was neutralized with sodium hydroxide, converting ammonium ions into ammonia. This ammonia was distilled, condensed, and trapped in a sulfuric acid solution. The ammonia content was subsequently quantified via titration with hydrochloric acid, and nitrogen concentration was calculated based on the volume of titrant used.

For the determination of calcium, magnesium, potassium, and phosphorus, 5 g of plant material was digested in sulfuric acid, aided by digestion tablets and boiling beads. The digested samples were cooled and diluted with distilled water to a fixed volume. The solution was filtered to remove particulate matter and further diluted with hydrochloric acid and lanthanum diluents to prepare it for spectrophotometric analysis. The prepared filtrate was analyzed using a UV-Visible spectrophotometer, calibrated with appropriate standards for each nutrient. Stock solutions of 1000 ppm for potassium, phosphorus, calcium, and magnesium were used to prepare working standards, ensuring accuracy in quantification.

The UV-Visible spectrophotometer was employed to measure the light absorbed by the prepared samples at specific wavelengths, corresponding to the macronutrients of interest. This instrument facilitated the precise and reliable quantitative analysis of the nutrient concentrations.

Data obtained from the experiments were analyzed using MS-Excel to ensure statistical accuracy. The final results were expressed as percentages, calculated using standardized formulas to correlate spectrophotometer readings with nutrient concentrations in the plant material.

RESULTS

The analysis of macronutrient concentrations in the dry foliage of *Sophora mollis* revealed significant findings regarding its potential use as an organic fertilizer. The nitrogen concentration in the leaves was determined to be 3.9%, which closely aligns with the sufficient range for optimal plant growth. Nitrogen is critical for vegetative growth, and the observed value indicates that the dry foliage of *Sophora mollis* can effectively contribute to improving soil fertility for enhanced agricultural productivity. Similarly, the phosphorus concentration was found to be 0.6%, exceeding the general sufficiency range, which emphasizes its role in promoting healthy root systems and reproductive structures in plants.

The potassium concentration was recorded at 4.2%, indicating its ability to support nutrient translocation and improve plant resilience against stress. This value exceeds the sufficient range for most plants, further supporting its potential as an efficient organic nutrient source. Calcium and magnesium concentrations were measured at 2.4% and 0.8%, respectively. The calcium level was slightly below the sufficient range, while the magnesium value surpassed the optimal level required for most plants. These results suggest that *Sophora mollis* foliage can provide a well-balanced nutrient profile, with magnesium levels particularly enhancing chlorophyll synthesis and calcium levels contributing to structural integrity and membrane stability.

A comparative analysis of the nutrient levels in the foliage with their deficit, sufficient, and toxic ranges for plants highlighted that nitrogen, phosphorus, potassium, and magnesium concentrations were within or above the sufficient range, making *Sophora mollis* a suitable candidate for organic fertilization. Calcium concentration, while slightly below the sufficient range, still falls within acceptable limits for contributing to plant health. A visual representation of these findings, including a pie chart of the macronutrient proportions and a comparative evaluation with standard ranges, reinforced the potential of *Sophora mollis* foliage as an organic fertilizer for sustainable agriculture.

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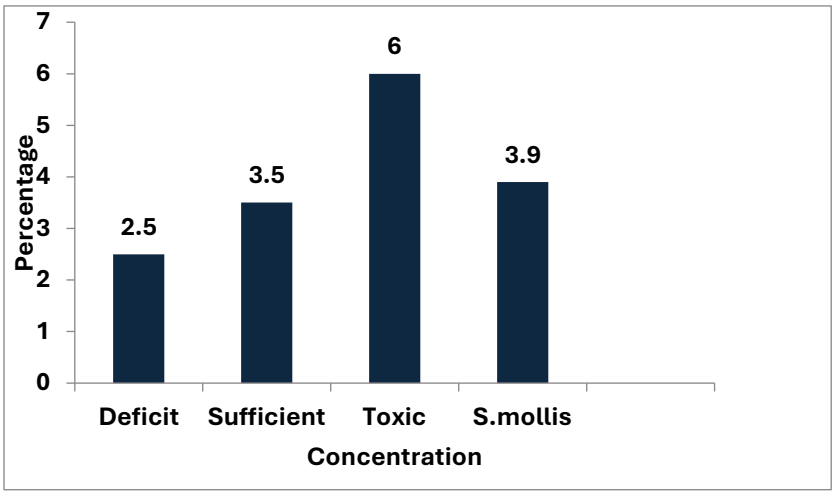


Figure 1 Concentration of Nitrogen

The dry foliage of species Sophora mollis show the concentration of nitrogen as 3.9000% (Fig 1) the dry foliage collected from different localities of Skardu, Gilgit Baltistan as previously discussed. The range of nitrogen in the dry leaves of specie Sophora mollis was much closed to sufficient range of plant nitrogen for optimal growth.

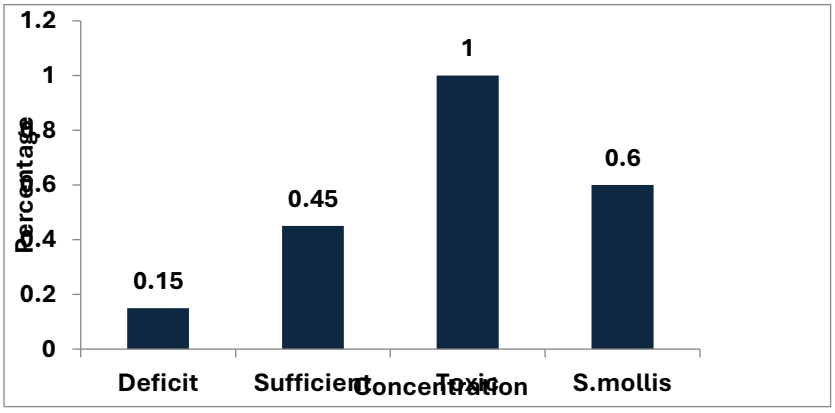


Figure 2 Concentration of Phosphorus

The dry foliage of species Sophora mollis show the concentration of phosphorus as 0.6000% (Fig 2) the dry foliage collected from different localities of Skardu, Gilgit Baltistan. The range of phosphorus in the dry leaves of specie Sophora mollis was much closed to sufficient range of plant nitrogen for optimal growth.

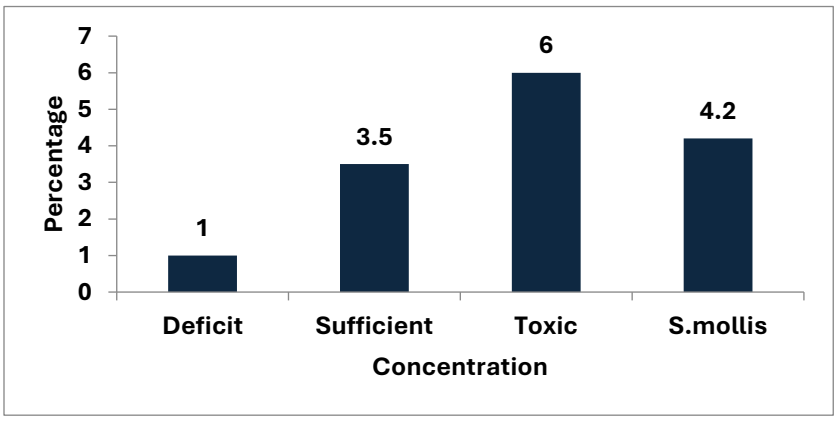


Figure 3 Concentration of Potassium

The dry foliage of species Sophora mollis show the concentration of potassium as 4.2000%, the dry foliage collected from different localities of Skardu, Gilgit Baltistan. The range of potassium in the dry leaves of specie Sophora mollis was much closed to sufficient range of plant nitrogen for optimal growth.

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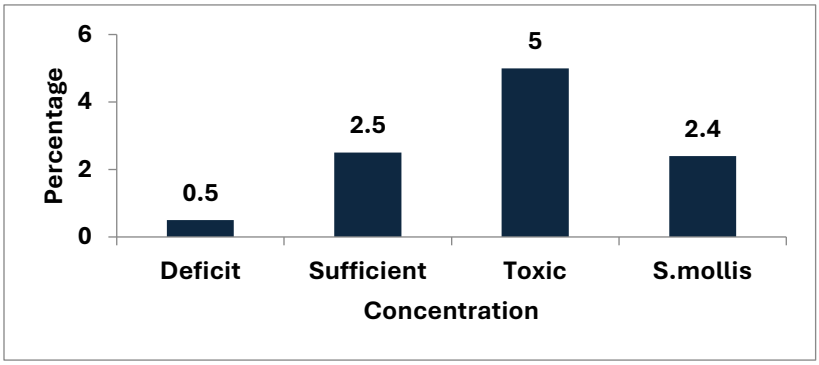


Figure 4 Concentration of Calcium

The dry foliage of specie Sophora mollis show the concentration of calcium as 2.4000% (Fig 4) the dry foliage collected from different localities of Skardu, Gilgit Baltistan. The range of calcium in the dry leaves of specie Sophora mollis was much closed to sufficient range of plant nitrogen for optimal growth.

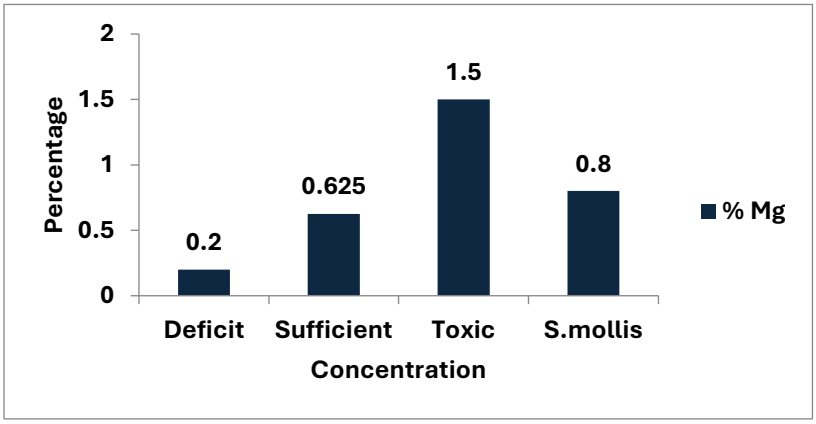


Figure 5 Concentration of Magnesium

The dry foliage of species Sophora mollis show the concentration of magnesium as 0.8000% (Fig 5) the dry foliage collected from different localities of Skardu, Gilgit Baltistan. The range of magnesium in the dry leaves of specie Sophora mollis was much closed to sufficient range of plant nitrogen for optimal growth.

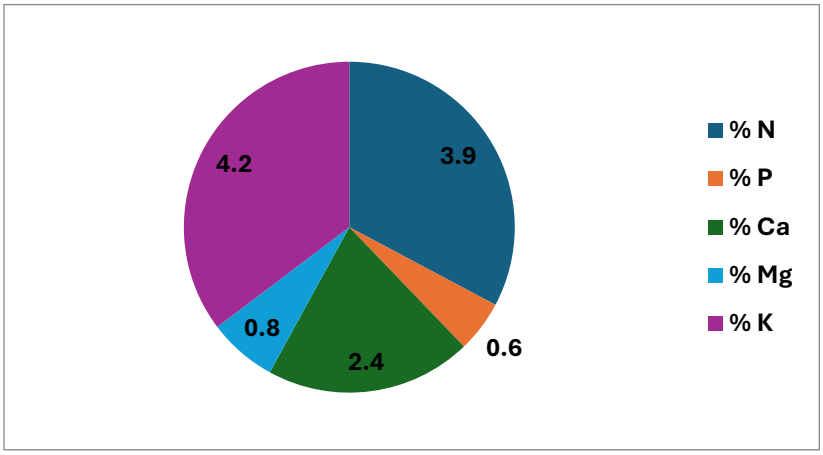
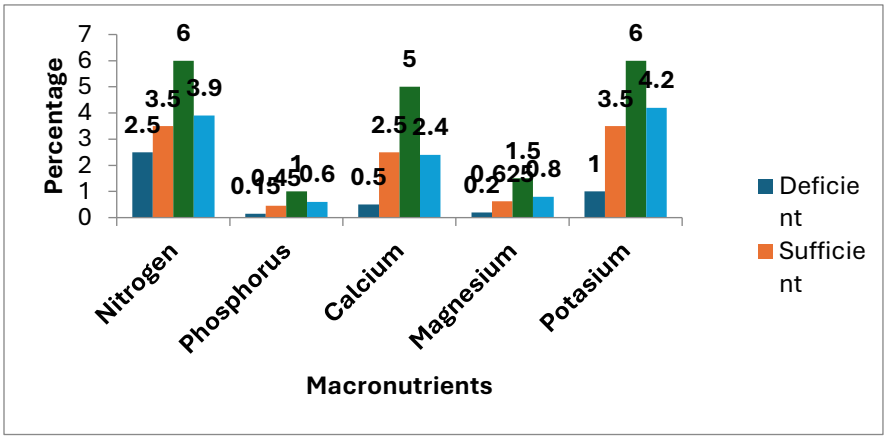


Figure 6 Concentration of Nitrogen, Phosphorus, Potassium, Calcium and Magnesium in dry foliage of Sophora mollis

A pie chart showing the analyzed values of macronutrients in dry foliage of Sophora mollis.

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Comparison of Percent value of Nitrogen, Phosphorus, Potassium, Calcium and Magnesium in the dry foliage of *Sophora mollis* with their deficit, sufficient, and toxic levels in general plants required for optimal growth.

Figure 7 Comparison of Percent value of Nitrogen

Table 1 Comparison between the macronutrients present in the dry foliage of *Sophora mollis* along with their sufficient, deficient, toxic and analyzed values.

	Nitrogen%	Phosphorus%	Calcium%	Potassium%	Magnesium%
Deficit	2.5	0.15	0.5	1	0.2
Sufficient	3.5	0.45	2.5	3.5	0.625
Toxic	6	1	5	6	1.5
S.mollis	3.9	0.6	2.4	4.2	0.8

DISCUSSION

The findings of this study highlighted the potential of *Sophora mollis* dry foliage as a natural source of macronutrients, offering promising applications in sustainable agriculture. The macronutrient concentrations observed, particularly nitrogen, phosphorus, potassium, calcium, and magnesium, fell within or exceeded the sufficiency ranges required for optimal plant growth. This nutrient profile supports its effectiveness in enhancing soil fertility, potentially reducing dependence on synthetic fertilizers, and contributing to environmentally friendly farming practices. Such attributes are particularly relevant in addressing the dual challenges of food insecurity and soil degradation caused by intensive agricultural practices (14).

One of the strengths of this study was the comprehensive analysis of multiple macronutrients, allowing for an in-depth understanding of the nutrient potential of *Sophora mollis (15)*. The findings underscored its suitability for improving crop productivity, with nitrogen, phosphorus, potassium, and magnesium concentrations demonstrating the capacity to fulfill plant requirements for vegetative growth, reproductive development, nutrient translocation, and chlorophyll synthesis. However, calcium concentration, while present, was slightly below the sufficiency range, which could limit its effectiveness for crops with higher calcium demands. This limitation suggests the potential need for complementary organic inputs to fully optimize soil nutrient profiles when using *Sophora mollis* as a fertilizer (16).

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Despite its promising nutrient content, limitations in this study included the reliance on laboratory conditions for analysis, which may not fully replicate field conditions where environmental factors such as soil type, pH, and microbial activity influence nutrient availability (17). Additionally, while the nutrient concentrations suggest broad applicability, further research is necessary to determine the long-term effects of repeated applications on soil structure and crop yield (18).

A comparative study conducted on the nutrient profiles of various organic fertilizers, including composted manure, green manure, and plant-based organic inputs such as *Sophora mollis*, revealed significant differences in their effectiveness for improving soil fertility and crop productivity. The study demonstrated that plant-based organic fertilizers, particularly those derived from nutrient-rich species like *Sophora mollis*, consistently provided higher concentrations of macronutrients such as nitrogen, potassium, and magnesium compared to traditional manure-based fertilizers. Additionally, the plant-based fertilizers showed a faster nutrient release rate, making them more immediately effective for short-term crop cycles. However, manure-based fertilizers exhibited greater long-term benefits due to their higher organic matter content, which contributed to improved soil structure and water retention over time. The findings emphasized that integrating *Sophora mollis* with other organic inputs, particularly those rich in organic carbon, could maximize both immediate and long-term agricultural benefits. This integration strategy aligns with current sustainable farming approaches, emphasizing nutrient synergy and soil health preservation.

A recent comparative study examined the efficacy of plant-based organic fertilizers, including *Sophora mollis*, against synthetic fertilizers and traditional manure-based inputs in enhancing soil fertility and crop performance. The study highlighted that plant-based fertilizers, such as *Sophora mollis*, offered a more balanced macronutrient profile, with nitrogen, phosphorus, and potassium levels comparable to synthetic fertilizers but without the associated risks of soil degradation and chemical residue accumulation. Furthermore, plant-based fertilizers demonstrated better compatibility with sustainable agricultural practices, contributing to improved soil structure and microbial activity. In contrast, synthetic fertilizers, while delivering rapid nutrient availability, were associated with long-term soil acidification and reduced organic matter. Traditional manure-based fertilizers, though effective in increasing organic carbon, showed relatively lower nutrient concentrations, necessitating larger application volumes. The study concluded that integrating plant-based fertilizers like *Sophora mollis* with manure could optimize nutrient delivery while preserving soil health, offering a sustainable alternative to intensive chemical fertilization.

Overall, the findings positioned *Sophora mollis* as a viable and sustainable organic fertilizer. Its nutrient composition, particularly the high levels of nitrogen, phosphorus, potassium, and magnesium, presents significant potential for improving soil fertility and crop productivity. However, further exploration of field-based applications and complementary inputs is essential to maximize its agricultural value.

CONCLUSION

The findings of this study concluded that the dry foliage of *Sophora mollis* contains macronutrient concentrations close to the sufficient range required for optimal plant growth, highlighting its potential as an effective organic fertilizer. Utilizing plant residues or green biomass from *Sophora mollis* offers a sustainable option for enhancing soil fertility, particularly in tropical and subtropical climates. This practice not only improves soil quality by enhancing its physical, chemical, and biological properties but also contributes to nitrogen fixation in the soil, supporting long-term agricultural productivity. In the context of limited land resources and the pressing challenge of food security, environmentally sustainable approaches like incorporating plant-based organic fertilizers can play a critical role in maintaining soil fertility while aligning with sustainable agricultural development. Achieving these goals requires planning agricultural systems that respect and leverage natural ecological processes to ensure both productivity and environmental preservation.

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AUTHOR CONTRIBUTIONS

Author	Contribution
Sumaira Batool	Substantial Contribution to study design, analysis, acquisition of Data Manuscript Writing Has given Final Approval of the version to be published
Zakir Hussain*	Substantial Contribution to study design, acquisition and interpretation of Data Critical Review and Manuscript Writing Has given Final Approval of the version to be published
Abida Bano	Substantial Contribution to acquisition and interpretation of Data Has given Final Approval of the version to be published
Azmat Batool	Contributed to Data Collection and Analysis Has given Final Approval of the version to be published
Pervez Iqbal	Write up of abstract and conclusions.

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