



Effect of Different Nutrient Management Techniques on Fodder Crop Lucerne (*Medicago sativa* L.): A Review of Effect of the Chemical fertilisers, Balanced Nutrient Supply & Nutrient Interactions, and the Effect of Organic Manures on Growth and Development of Lucerne

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Lucerne (*Medicago sativa* L.), commonly known as alfalfa, is an important perennial forage crop widely cultivated for its high biomass yield and superior nutritional value for livestock. Efficient nutrient management is essential for maintaining productive lucerne stands, improving fodder quality, and sustaining soil fertility. Although lucerne can fix atmospheric nitrogen through symbiosis with *Rhizobium* bacteria, the crop requires balanced fertilization with other essential nutrients such as phosphorus, potassium, sulphur, and micronutrients for optimum growth and productivity. Phosphorus plays a key role in root development, energy transfer, and effective nitrogen fixation, while potassium enhances plant physiological processes, improves crude protein content, and increases tolerance to environmental stresses. Sulphur contributes to protein synthesis and nitrogen metabolism, whereas micronutrients like zinc and molybdenum support various enzymatic and biochemical functions in plants.

The integration of organic manures, mineral fertilizers, and microbial inoculants has been reported to improve nutrient availability, nutrient uptake, and soil health. Research studies also indicate that balanced fertilization significantly increases fodder yield, improves forage quality, and enhances stand longevity in lucerne cultivation. This review summarizes research findings on the influence of potassium fertilization, nitrogen application during early growth stages, manure–fertilizer interactions, and different phosphate sources on lucerne growth, yield, and fodder quality. The combined use of organic and inorganic nutrient sources along with biofertilizers provides an effective integrated nutrient management strategy for sustainable lucerne production and improved soil fertility.

Introduction

Lucerne (*Medicago sativa* L.), commonly known as alfalfa and referred to as the “Queen of Forages,” is an important perennial forage legume widely cultivated for its high biomass production, superior nutritional value, and high crude protein content. It plays a vital role in supporting dairy and livestock production systems by providing high-quality green fodder over a long period. In addition to its forage value, lucerne contributes to soil fertility through biological nitrogen fixation by forming a symbiotic association with *Rhizobium* bacteria in root nodules.

Although lucerne can fix atmospheric nitrogen, the crop requires a balanced supply of other essential nutrients such as phosphorus, potassium, sulphur, and micronutrients for

optimum growth and productivity. Among these nutrients, phosphorus is important for root development and nodulation, while potassium supports several physiological processes and improves plant growth and stress tolerance. Integrated nutrient management practices involving the combined use of mineral fertilizers, organic manures, and biofertilizers have been found to enhance nutrient availability, improve soil health, and increase fodder yield and quality.

Therefore, proper nutrient management is essential for sustaining lucerne productivity and maintaining soil fertility. This review focuses on the role of different nutrient management practices, particularly potassium fertilization, nitrogen application during early growth stages, the use of organic manures, and various phosphate sources, in improving lucerne growth, yield, and forage quality.

Effect of Nitrogen on Early Lucerne Growth

Although lucerne is capable of fixing atmospheric nitrogen through symbiotic bacteria, a small amount of nitrogen fertilizer applied during the early growth stage can support initial plant development. Young plants often require additional nitrogen before the nodulation process becomes fully active. Studies conducted by Vasileva et al. (2011) demonstrated that moderate nitrogen application improved root growth and dry matter production in lucerne. Nitrogen fertilization also enhanced plant tolerance to limited moisture conditions. Improved root systems enabled plants to absorb nutrients and water more efficiently from the soil. Further research by Vasileva and Athar (2012) found that nitrogen application increased crude protein concentration and biomass production compared with untreated control plots. However, excessive nitrogen fertilization can suppress nodule formation and reduce biological nitrogen fixation. This imbalance may lead to reduced sustainability in lucerne cultivation. Therefore, careful nitrogen management is required. Small starter doses of nitrogen may support early plant establishment, but excessive amounts should be avoided to maintain effective symbiotic nitrogen fixation.

Role of Phosphorus and Different Phosphate Sources

Phosphorus is a critical nutrient for root development and energy transfer in plants. In leguminous crops such as lucerne, phosphorus is essential for effective nodulation and nitrogen fixation. Sharma et al. (2013) reported that lucerne responded positively to phosphorus fertilization. Application of 26.4 kg P per hectare produced the highest green fodder yield of 51.8 tonnes per hectare and a dry matter yield of 11.44 tonnes per hectare. Phosphorus fertilization also improved crude protein content and overall plant growth.

1. Phosphorus fertilization and alfalfa performance

A study conducted in Inner Mongolia investigated the effects of different sowing dates and phosphorus fertilization on alfalfa growth and productivity. The experiment used several sowing dates and phosphorus levels to determine their influence on overwintering ability and forage yield.

2. Integrated phosphorus management in lucerne

Another study evaluated the effect of different sources of phosphorus, including inorganic fertilizers, sheep manure, and phosphate-solubilizing bacteria (PSB), on lucerne productivity in the arid region of Rajasthan. Therefore, adequate phosphorus availability at the time of planting is essential for establishing strong lucerne stands and ensuring long-term productivity.

Role of Potassium in Lucerne Growth and Productivity

A three-year field experiment examined the impact of potassium fertilizer on alfalfa yield and forage quality. Different potassium levels were applied to evaluate their effects on yield components and nutritional parameters.

The results showed that forage yield increased with potassium application up to an optimum level and then declined at higher doses. Potassium fertilization improved plant height, shoot mass, and plant density, which contributed to higher yields. It also enhanced

forage quality by increasing crude protein and total digestible nutrients while reducing fiber content.

Research conducted by Wang et al. (2025) demonstrated that moderate potassium application significantly increased lucerne growth and fodder quality. In their findings, optimal potassium levels improved crude protein concentration while reducing neutral detergent fiber (NDF) and acid detergent fiber (ADF) content. Lower fiber content enhances digestibility of forage, thereby improving the nutritional value for livestock. However, excessive potassium application may not always lead to additional yield benefits. Beyond a certain level, potassium accumulation does not significantly increase plant growth and may lead to inefficient fertilizer use. Therefore, maintaining balanced potassium nutrition is essential for achieving maximum productivity while avoiding unnecessary fertilizer inputs.

Fertilizer Management and Lucerne Pasture Productivity

Proper fertilizer management is essential for maintaining productive lucerne stands over long periods. Balanced nutrient supply not only increases yield but also improves stand longevity and reduces weed invasion. Field experiments have shown that the combined application of phosphorus, potassium, sulphur, and zinc significantly increases lucerne biomass production and crude protein content. These nutrients also enhance biological nitrogen fixation and improve overall plant vigor. Balanced fertilization helps maintain dense lucerne stands that effectively cover the soil surface. This reduces the growth of weeds and improves pasture sustainability. Studies have reported that weed biomass can decrease by 53–69% in fertilized lucerne fields compared with unfertilized plots. The form in which nutrients are applied also influences crop performance. For example, zinc supplied through zinc sulphate or coated single superphosphate has been found to be more effective than zinc oxide in improving lucerne yield and nutrient uptake. Overall, integrated fertilizer management supports both higher productivity and improved forage quality in lucerne-based farming systems. Sulphur plays a crucial role in protein synthesis and nitrogen metabolism, making it particularly important for leguminous crops like lucerne.

Influence of Balanced Nutrient Supply on Lucerne Yield and Quality

Lucerne productivity depends not only on the supply of individual nutrients but also on the interactions between them. Balanced fertilization involving multiple nutrients has been shown to improve crop growth, nutrient uptake, and forage quality. Integrated nutrient management practices often combine mineral fertilizers with organic manures and biofertilizers. Organic amendments improve soil structure, enhance microbial activity, and provide a gradual release of nutrients, while mineral fertilizers supply readily available nutrients for immediate plant uptake. Field studies have shown that lucerne responds positively to balanced nutrient application involving phosphorus, potassium, sulphur, and zinc. These nutrients work together to enhance plant growth, increase biomass production, and improve crude protein content of the forage. Another important effect of balanced fertilization is the improvement of the leaf-to-stem ratio. Leaves contain higher protein concentrations compared with stems, making them more valuable as livestock feed. Nutrient management practices that promote leaf growth therefore contribute directly to improved forage quality.

Impact of Organic Manure and Chemical Fertilizers

Both organic and inorganic fertilizers play significant roles in supporting lucerne growth. Organic manures improve soil physical properties, increase microbial populations, and enhance nutrient retention capacity. These benefits contribute to long-term soil fertility and sustainable crop production. Mineral fertilizers, on the other hand, provide immediately available nutrients that promote rapid crop growth during early stages. Because of their quick nutrient release, they often result in higher early yields compared with organic sources alone. Research by Vasileva and Athar (2012) showed that both cattle manure and mineral nitrogen fertilizers increased crude protein yield in lucerne. However, their effects differed in duration.

While mineral fertilizers provided a rapid initial boost in growth, organic manure supplied nutrients gradually and maintained soil fertility over longer periods. A study conducted by Bama (2016) reported that combining poultry manure with rock phosphate and biofertilizers significantly improved lucerne fodder yield. The integrated nutrient treatment produced approximately 60.5 tonnes of green fodder per hectare annually. Additionally, crude protein content of the forage increased under this treatment, demonstrating the positive effect of combining organic and mineral nutrient sources. Combining organic manure with mineral fertilizers often results in better crop performance than using either source alone. Integrated nutrient management improves nutrient availability, enhances soil biological activity, and increases both yield and fodder quality.

Conclusion

The strategic nutrient management is pivotal for maximizing lucerne productivity, nutritional quality, and persistence. Integrated Nutrient Management (INM), combining mineral fertilizers with organic manures, emerges as the superior approach, significantly enhancing green fodder yield and crude protein content while improving soil organic carbon and fertility status. Specifically, phosphorus (P) fertilization is critical for root development and overwintering capability, particularly in late-seeded or sodic soils. Potassium (K) application is essential for increasing relative feed value (RFV) and reducing fiber content, with optimal rates around 273 kg K₂O ha⁻¹ enhancing yield components. While nitrogen (N) fertilization boosts dry matter and protein yield during the establishment year or under water stress, its application requires careful regulation to avoid suppressing nodulation; organic sources like poultry or sheep manure offer sustained benefits and higher protein content over the long term. Furthermore, the inclusion of micronutrients such as Zinc and Sulphur is vital for maintaining stand density, disease resistance, and nitrogen fixation in established pastures. Therefore, a balanced, site-specific fertilization strategy is recommended for sustainable lucerne production.

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