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The influence of fertilization on pasture quality and production performance in ruminants (review)

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Abstract:
Permanent pastures represent a forage resource that provides a significant part of the energy, protein, and mineral substances required in the diet of ruminants. The productivity and nutritional value of permanent pastures are influenced by a number of factors, including pedoclimatic conditions, floristic composition, management practices, water availability, and the level of soil nutrient supply. The addition of fertilizers improves soil structure and supplements nutrients for plant growth. Among these, nitrogen (N) occupies an essential position due to its direct involvement in the processes of plant growth and development, in protein synthesis, and in the formation of forage biomass. In addition to the effects on productivity and nutritional value, fertilization can significantly influence the structure and floristic diversity of permanent pastures. In ruminant nutrition, nitrogen compounds from plants constitute essential substrates for the development of microorganisms involved in the degradation of plant fibers and in the synthesis of microbial protein, with a direct effect on the yields obtained. Optimal fertilization must effectively combine productivity and forage quality with animal production and health, as well as biodiversity conservation. The aim of the study is to evaluate the impact of different doses of chemical fertilizers, particularly nitrogen, on the plant cover and production performance of ruminants.

• Introduction

Permanent grasslands are an essential forage resource for sheep, goat, and cattle production systems. In addition to their role in providing animal feed, they contribute to soil protection, carbon sequestration, nutrient cycling, and the maintenance of natural habitats. The value of a grassland cannot be assessed solely on the basis of the quantity of green biomass produced; it must also be evaluated in terms of dry matter yield, chemical composition, forage digestibility, voluntary feed intake, and the productive response of animals.

Fertilization is one of the agronomic practices used to influence grassland productivity. Nitrogen is involved in the synthesis of proteins and chlorophyll and can stimulate vegetative growth when its availability limits plant development. However, the effects of nitrogen fertilization must be assessed in relation to forage intake and digestibility, nitrogen utilization by animals, and potential environmental losses. Research on reducing nitrogen fertilization has shown that its effects on grass intake, digestibility, and milk production depend on the experimental conditions and the season.

The effects of fertilization are therefore not exclusively agronomic. They are reflected in the quantity and quality of available forage, the way it is utilized by ruminants, and the functioning of the ecosystem. An appropriate management strategy must take into account the type of grassland, the initial soil fertility, climatic conditions, botanical composition, and management system.

In Romania, this issue is particularly important due to the diversity of permanent grasslands, including mountain and sub-mountain grasslands, where production objectives must be aligned with biodiversity conservation. Research findings support the need for fertilization recommendations tailored to local conditions, avoiding the unjustified generalization of results obtained from a specific type of grassland.

• Material and method

The aim of this review is to synthesize the scientific literature on the effects of fertilization on forage yield and quality, the productive performance of ruminants, botanical composition, and environmental impacts. Particular attention is given to Romanian research and its relevance to the sustainable management of permanent grasslands.

The Influence of Fertilization on Dry Matter Yield

For the comparison of experimental results, dry matter yield is a more relevant indicator than fresh biomass yield, as the latter varies depending on the water content of the vegetation.

Organic and Mineral Fertilization

Mineral fertilizers allow for relatively precise nutrient application, whereas farmyard manure and other organic materials supply nitrogen, phosphorus, potassium, and organic matter. However, because their composition is variable, nutrient application rates cannot be determined with the same degree of precision.

The Influence of Fertilization on the Nutritional Quality of Forage

Forage quality is determined by several parameters, including crude protein content, fiber fractions, digestibility, and energy value.
NDF (neutral detergent fiber) and ADF (acid detergent fiber) are indicators of the fiber fractions in forage and contribute to the assessment of its intake potential and digestibility.

Botanical Composition and Grassland Biodiversity

Fertilization can alter the relative proportions of grasses, legumes, and other herbaceous species by changing nutrient availability and competitive interactions.

The Relationship Between Grassland Quality and the Productive Performance of Ruminants

The effect of fertilization on milk and meat production is indirect and depends on the quantity of available forage, its chemical composition and digestibility, voluntary feed intake, and the nutritional requirements of the animals.

Lamb Growth and Sheep Performance

Grassland fertilization can help improve forage availability during periods of feed shortage; however, its effects on lamb performance depend on actual feed availability, forage quality, and animal management.

Nutrient Losses and the Sustainability of Fertilization

Nitrogen that is not taken up by plants may be lost through leaching, ammonia volatilization, and microbial processes that generate nitrous oxide.

Specific Considerations for the Management of Permanent Grasslands in Romania

Pedoclimatic diversity results in significant differences among lowland, hill, sub-mountain, and mountain grasslands. For this reason, a universal fertilization rate cannot be recommended for all types of grasslands.

• Results and discussions

The scientific literature highlights that nitrogen fertilization significantly influences the productivity of permanent grasslands, the nutritional value of forage, and the structure of botanical composition. Increased nitrogen availability stimulates vegetative growth and biomass accumulation; however, the magnitude of the response depends on pedoclimatic conditions, soil fertility, and the management system. Ball et al., as well as Curll et al., emphasize the importance of aligning fertilization with seasonal forage requirements and grazing stocking rates. Nevertheless, an increase in dry matter yield is not, in itself, a sufficient indicator of fertilization efficiency, as forage quality and the risk of nutrient losses must also be taken into account. In this regard, Hoogendoorn et al. highlighted the association between increased nitrogen fertilization intensity and greater nitrogen leaching under the experimental conditions studied.

Regarding nutritional quality, nitrogen fertilization can promote an increase in crude protein content; however, the value of forage for ruminants also depends on digestibility, fiber fractions, and the balance between energy and nitrogenous compounds. Wróbel et al., as well as Cabiddu et al., highlight the importance of integrating fertilization into the overall management of grasslands and animal nutrition. Thus, improvements in the chemical composition of herbage do not automatically guarantee increased milk or meat production, as the animal response depends on actual feed intake and the efficient utilization of nutrients. This relationship is supported by the research of van Vuuren et al., who investigated the effects of reduced nitrogen fertilization on grass intake, digestibility, and milk production simultaneously.

Another essential aspect is the modification of botanical composition under the influence of fertilization. High nitrogen inputs can favor competitive grasses and reduce the contribution of certain herbaceous species, including legumes, thereby affecting floristic diversity. Francksen et al. synthesized the effects of nitrogen fertilization on species richness in European permanent grasslands, while Stevens et al., Clark and Tilman, and Hautier et al. highlighted the mechanisms through which nutrient enrichment can contribute to biodiversity loss. In this context, maintaining grass–legume mixtures is important both for forage nutritional value and for the biological utilization of nitrogen, as demonstrated by the research of Spehn.

Research conducted in Romania confirms the need to tailor fertilization practices to the specific characteristics of grasslands and their intended management objectives. Studies by Samuil et al. and Vîntu et al., as well as research on grasslands dominated by Nardus stricta, highlight the importance of balancing productivity with biodiversity conservation. Similarly, the findings reported by Oprea and Maruşca, Gaga et al., Cirebea et al., and Ghețe et al. provide valuable reference points for understanding the responses of Romanian grasslands to different fertilization practices.

Overall, the reviewed literature indicates that the effective fertilization of permanent grasslands should not aim solely at maximizing biomass production, but rather at balancing productivity, nutritional value, ruminant performance, and biodiversity conservation. The selection of fertilizer types and application rates should be tailored to local conditions, soil fertility, and management practices, while also taking into account the risk of nutrient losses, as highlighted by Ruz-Jerez, White and Ball, and Fuchs et al. Such an integrated approach provides the basis for the sustainable management of permanent grasslands and the efficient utilization of forage resources.

• Conclusions

- Fertilization is an important management practice for permanent grasslands, with the potential to increase dry matter yield and alter the nutritional value of forage.
- Nitrogen can stimulate vegetative growth and contribute to an increase in crude protein concentration; however, these effects do not necessarily translate into a proportional improvement in forage digestibility or the productive performance of ruminants.
- Organic and mineral fertilization can contribute to improving grassland productivity; however, the choice of fertilization strategy should be adapted to local conditions.
- High nutrient inputs may favor competitive plant species and reduce floristic richness. However, the effectiveness of these systems should be assessed in relation to grassland type, environmental conditions, and production and conservation objectives.
- Studies conducted in Romania provide relevant insights into the responses of mountain and semi-natural grasslands to fertilization. Their findings should be interpreted within the context of each study site, as differences in soil properties, climatic conditions, and floristic composition may lead to distinct responses.
- In conclusion, rational fertilization should be integrated into a management system that simultaneously aims to optimize forage production, nutritional value, animal performance, and environmental protection.