Revista *Ambientale*
Revista da Universidade Estadual de Alagoas/UNEAL
e-ISSN 2318-454X, Ano 17 Vol. 17 (nº 3), julho-outubro (2025)
https://doi.org/10.48180/ambientale.v17i3.648

Do pasto à horta: urina bovina como alternativa ecológica de fornecimento de nitrogênio para produção de alface

From pasture to garden: bovine urine as an ecological alternative for supplying nitrogen for lettuce production

De la pastorea al huerto: la orina bovina como alternativa ecológica para el suministro de nitrógeno para la producción de lechuga

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RESUMO - O uso intensivo de fertilizantes sintéticos de elevada solubilidade causa vários impactos negativos no meio ambiente, como acidificação do solo, contaminação dos recursos hídricos, aumento das emissões de óxido nitroso, entre outros. Sendo assim, o biofertilizante produzido a partir de urina bovina surge como uma alternativa que pode aumentar a autossuficiência do agricultor, pois contém alta concentração de nutrientes, como o nitrogênio, e também promove a conservação da biodiversidade e das atividades biológicas do solo. Assim, o presente trabalho foi realizado com o objetivo de identificar e caracterizar as diferenças na resposta de crescimento de plantas de alface (*Lactuca sativa L.*), expostas a diferentes concentrações de urina bovina. O delineamento experimental adotado foi blocos ao acaso, divididos em dois experimentos, com seis tratamentos (T), três repetições com duas plantas por repetição em cada experimento. Os experimentos foram realizados cultivando-se a alface em vasos mantidos dentro de casa de vegetação. A urina de vaca proporcionou um aumento nos níveis de massa fresca e massa seca da parte aérea e raízes, bem como para as outras variáveis: altura da folha, comprimento da folha e diâmetro do caule. Consequentemente, é recomendado o uso de urina bovina na dose de 1,5 mL/planta/semana via solo, pois foram os melhores resultados encontrados neste estudo.

Palavras-chave: Biofertilizante. Manejo orgânico. *Lactuca sativa L.*

ABSTRACT -The intensive use of synthetic fertilizers with high solubility causes several negative impacts on the environment, such as soil acidification, contamination of water resources, increased nitrous oxide emissions, among others. Therefore, the biofertilizer produced from bovine urine appears as an alternative that can increase the self-sufficiency of the farmer, as it contains a high concentration of nutrients, such as nitrogen, and also promotes the conservation of biodiversity and soil biological activities. Thus, the present work was carried out with the objective of identifying and characterizing the differences in the growth response of lettuce plants (*Lactuca sativa L.*), exposed to different concentrations of bovine

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urine. The experimental design adopted was randomized blocks, divided into two experiments, with six treatments (T), three replications with two plants per replication in each experiment. The experiments were carried out by cultivating lettuce in vases kept in a greenhouse. Cow urine provided an increase in the levels of fresh mass and dry mass of shoots and roots, as well as for the other variables: leaf height, leaf length and stem diameter. Consequently, the use of bovine urine at a dose of 1.5 mL/plant/week via soil is recommended, as these were the best results found in this study.

Keywords: Biofertilizer. Organic handling. *Lactuca sativa L.*

RESUMEN - El uso intensivo de fertilizantes sintéticos altamente solubles causa varios impactos ambientales negativos, como la acidificación del suelo, la contaminación del agua y al aumento de las emisiones de óxido nitroso. Por lo tanto, el biofertilizante producido a partir de orina bovina surge como una alternativa que puede aumentar la autosuficiencia de los agricultores, ya que contiene una alta concentración de nutrientes, como el nitrógeno, y también promueve la conservación de la biodiversidad y las actividades biológicas del suelo. Por lo tanto, este estudio tuvo como objetivo identificar y caracterizar las diferencias en la respuesta de crecimiento de las plantas de lechuga (*Lactuca sativa L.*) expuestas a diferentes concentraciones de orina bovina. El diseño experimental fue un diseño de bloques completos al azar, dividido en dos experimentos, con seis tratamientos (T) y tres réplicas, con dos plantas por réplica en cada experimento. Los experimentos se llevaron a cabo cultivando lechuga en macetas mantenidas en el interior de un invernadero. La orina de vaca aumentó la materia fresca y seca de los brotes y las raíces, así como otras variables: altura de la hoja, largo de la hoja y diámetro del tallo. Por lo tanto, se recomienda el uso de orina bovina en dosis de 1,5 mL/planta/semana en suelo, ya que fue la que arrojó mejores resultados en este estudio.

Palabras clave: Biofertilizante. Manejo orgánico. *Lactuca sativa L.*

INTRODUÇÃO

The advancement of technologies and management practices has brought many benefits to agricultural production. However, linked to these advances, there is the intensive use of chemical fertilizers, which directly affect the quality of the soil and the environment, due to the reduction between application intervals and/or replacement and removal of nutrients by plants (Jesus, 2019). Besides, chemical fertilizers, in addition to having a high cost, especially for the family-based farmer, when applied intensively, cause a number of negative impacts on the environment and can harm sustainable agriculture (Brito, 2021). That brings forth effects such as soil acidification, contamination of water resources, increased nitrous oxide emissions, among others (Macêdo, 2019).

Organic agriculture then emerges as a viable alternative to circumvent these problems, especially when related to the family-based farmer (Oliveira *et al*., 2010). Given it is an unconventional system, which intends to promote the conservation of biodiversity and soil biological activities (Moraes; Oliveira, 2017). Therefore, organic agriculture aims to use natural resources in a sustainable and rational way, using traditional methods and ecological technologies for land exploitation, without the use of synthetic chemicals or genetically modified foods (Cruz *et al.*, 2021). Currently, the market for organic products shows constant

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and significant growth (Madail; Belarmino; Bini, 2011), in several countries, due to changes in consumer preferences, as well as to the belief that this is the path that can lead to sustainable survival between humankind and nature, focusing on current and future generations' food needs (Lemes; Oikawa; Michellon, 2018).

One of the practices widely used in organic agriculture is the use of biofertilizers. A biofertilizer is a product obtained from the decomposition of organic matter, which occurs through physical, chemical and biological phenomena, promoting a fertilizer that can be applied in liquid, foliar and/or solid form, widely used in organic food production (Alves, 2019). Its incorporation in food production is mainly due to its low cost compared to chemical fertilizer; to it having a high concentration of nutrients, such as nitrogen and phosphorus, and to the fact that it provides greater resistance to pests and diseases, as a consequence promoting plant development and production (Jesus, 2019). Furthermore, according to Brito (2021), aside from providing the main nutrients for plants, biofertilizers also release phytohormones and microorganisms that bring beneficial actions to the soil, promoting high plant development and product quality. In this context, one of the alternative raw materials that has been highlighted, due to its great potential to help in the production of vegetables, is the incorporation of bovine urine as a natural biofertilizer, since it has high levels of nitrogen (Oliveira *et al.,* 2010).

Bovine urine is considered an agricultural biofertilizer that can replace the use of external products, being that it is easily found in small properties, allowing an integration between cattle raising and horticulture, reducing costs and serving as a source of nutrients of short-, medium- and long-term efficiency (Alves, 2019). In this way, several studies are currently incorporating bovine urine in organic agriculture. Marangon *et al*. (2021), analyzed and found satisfactory results in the growth of lettuce seedlings in southeastern Paraná when applying bovine urine in foliar form. Cruz *et al.* (2021), also found positive results when analyzing arugula production through organic fertilization and doses of bovine urine. The aforementioned authors also zeroed in on the find that the application of doses of bovine urine provided an increase in the production of dry mass of the aerial part and in the number of leaves of arugula seedlings.

Similar results were also found in a study that aimed to evaluate the effect of bovine urine on the nutritional status of lettuce (Oliveira *et al*., 2010), where urine applied via soil or foliar had an effect on the levels of mineral elements in the plants aerial parts and provided an increase in the dry matter mass of the plants. Similarly, Pereira (2016), while researching, confirmed that bovine urine has great potential to be used as an alternative raw material in organic agriculture, since cow urine solutions positively interfered with the germination and growth of lettuce and tomato seedlings. Even Arya (2018), in a study carried out in the city of Kanpur in India, found that spraying bovine urine on the cabbage leaf reduces the incidence of insect pests, especially aphids, and reported that, dipping the cabbage seed in the urine, about 60-80% of germination occurred.

Thus, it is observed that the application of bovine urine in the production of seedlings, despite being an ancient technique, has been extremely widespread and put to use, bringing in addition to benefits for the environment, agricultural productivity and consequently greater income, mainly for small farmers (Rodrigues *et al.*, 2023). Thus, this work aimed to identify and characterize the difference in the growth response of lettuce seedlings (*Lactuca sativa L.*) exposed to different concentrations of bovine urine, through two different experiments.

MATERIAIS E MÉTODOS

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The experiment was conducted in a greenhouse on a rural property in the municipality of Pelotas. Said place is located in the southern region of the State of Rio Grande do Sul, whose geographic coordinates are: 31° 46' 19" South latitude and 52° 20' 34" West longitude. The climate of the municipality, according to the Köppen classification, is subtropical (Cfa), humid, and summers are warm or occasionally hot, with regular precipitation (Embrapa Clima Temperado, 2022). In this period, the absolute maximum temperatures of the year are between 29°C and 34°C, approximately, while winters are relatively cool, but cold for a Brazilian coastal city, according to the climatological bulletin of the agrometeorology laboratory of Embrapa Clima Temperado. To carry out the experiment, a greenhouse was utilized, produced by hand, with bamboo and transparent polyethylene plastic film of 0.05mm, and the management of the greenhouse environment was done only by natural ventilation, daily, by opening the sides.

The lettuce seedlings (*Lactuca sativa L.*) were acquired through the union of rural workers of Pelotas, local to the municipality of Pelotas/RS, using the cultivar Pira 63® (purple), its main characteristic being the curly and purple leaves. The acquired seedlings were 20 days old. The complete cycle of the cultivar is 35 to 45 days after transplanting (Sanches, 2007). For the cultivation of lettuce, vases with a capacity of 2.0 kg were used, filled with a weight of 1.2 kg of commercial substrate purchased directly from the composting center for organic agro-industrial waste, located in Pelotas/RS. The physical-chemical characterization of the commercial substrate used for seedling cultivation was carried out, based on pH, total nitrogen, organic carbon, calcium, density, sulfur, total phosphorus, magnesium, manganese, molybdenum, potassium and humidity at 65ºC, adopting the methodology recommended by Tedesco (1995).

Ergo, the results obtained were: pH 8.2, total nitrogen 0,8%, total organic carbon 12,0%, calcium 7,44%, density 0,5334 g/cm3, sulfur 0,24%, total phosphorus 2,13%, magnesium 0,68%, manganese 0,28%, molybdenum <0,01%, potassium 0,99%. The seedlings were irrigated after identifying the field capacity of the substrate used for production. In this way, the amount of water needed was 140mL applied within 2 days. Irrigation was conducted so that the pots were always moist and not soaked. The water used for irrigation was provided by the Autonomous Sanitation Service of Pelotas – SANEP.

The cow urine used in the experiment was collected from lactating cows, from a dairy herd, belonging to the same rural property in the municipality of Pelotas/RS where the experiment took place. The herd consists of Holstein cows that normally feed on millet pastures and native grassland, and during the milking period they receive corn silage and feed (composed of corn, soybean bran, soybean hulls, wheat bran and mineral salt). The collection was carried out in 6 cows that were between 2 and 5 years old, using a clean sterilized bucket in brand new condition, then stored in 5L sterilized gallons. The urine underwent a 4-day maturation treatment, according to the study by Oliveira (2007). Past this period, a 5L urine sample was sent to a private laboratory for water and effluent analysis, registered at FEPAM for analysis of chlorides, biochemical oxygen demand (BOD), phosphorus, total nitrogen and pH. The results obtained from the urine analysis were as follows: Chlorides 10.462,00 mg Cl^-/L, BOD 9.450,00 mgO^2/L, phosphorus 6,84 mg P/L, total nitrogen 8.148,00 mg N(NTK)/L, pH 8,95.

Two experiments were carried out in a randomized block design. Each experiment with six treatments, three replications with two plants per replication. The nutrient recommendation for the lettuce crop used was that recommended by the Fertilization and Liming manual of Rio Grande do Sul, in which, according to calculations based on the characteristics of the substrate of choice, it was 80 kg. ha-1 for nitrogen, 70 $Kg.ha^{-1}$ for phosphorus and 160 Kg.ha-1 for potassium (CQFS, RS/SC, 2016). For experiments 1 and 2 it was considered: T0 as a control,

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T1 25% of the recommended dosage, T2 50% of the recommended dosage, T3 100% of the recommended dosage, T4 200% of the recommended dosage and T5 400% of the recommended dosage.The experiments differ in that, for experiment 1, the dosages were divided into six applications, while for experiment 2, the dosages were tripled and applied weekly.

Experiment 1 consisted of studying the effects of six dosages of bovine urine, they are: T0=0 mL (control), T1=0,25 mL, T2= 0,5 mL, T3= 1 mL, T4= 2 mL and T5= 4 mL. These dosages of each treatment were applied directly to the substrate once a week for six weeks to complete the 42-day cycle of growing lettuce after transplanting. In experiment 2, the effects of the following bovine urine dosages were studied, according to the treatments: T0= 0 mL (control), T1= 0,75 mL, T2=1,5 mL, T3= 3 mL, T4= 6 mL and T5= 12 mL, applied directly via substrate once a week during the six weeks. Treatments with bovine urine began 5 days after transplanting the seedlings into the pots, with the application of different dosages for six weeks, according to experiments 1 and 2.

At 45 days after transplanting, the plants were carefully extracted from the polyethylene pots, for determination of the variables: AH - average height of the seedlings (cm), MFMAP - mass of the fresh matter of the aerial part of the plants (g), MDMAP - mass of the dry matter of the aerial part of the plants (g), FMR – fresh mass of the roots of the plants (g) and DMR – dry mass of the roots of the plants (g) and diameter of the plants (cm). The plants were carefully washed with distilled water in order to remove aggregated substrate particles. After that step, the seedlings were separated into two vegetative fractions: root and aerial part (shoot). The aerial part and roots of the plants were weighed in an analytical balance to determine the FM. Subsequently, they were dried in an oven at 65ºC until constant weight for posterior determination of DM, by weighing on an analytical balance.

The diameter of the plants was obtained by measuring using a caliper and the height of the plants was measured with a ruler. Later on, the data were analyzed and interpreted from the analysis of variance (Test F), through the use of Software R.

RESULTADOS E DISCUSSÃO

EXPERIMENT 1

The results of the t Student test of experiment 1 using smaller doses of bovine urine in lettuce seedlings are shown in Table 1. As described in the material and methods, experiment 1 received fractional urine dosages, namely: T0=0 mL, T1 =0.25 ml, T2= 0.5 ml, T3= 1 ml, T4= 2 ml and T5=4 ml. According to the data shown in Table 1, differences can be observed in the treatments tested in relation to the variables fresh mass of the root and aerial part, dry mass of the root and aerial part, seedling height, leaf height, root length and neck diameter.

Table 1. Fresh mass and dry mass of shoots and roots, plant height, root length and stem diameter of lettuce seedlings cultivated under different dosages of bovine urine. T0=0 mL, T1=0,25 mL, T2= 0,5 mL, T3= 1 mL, T4= 2 mL e T5=4 mL. Means followed by letters in the columns differ from each other at the indicated significance level.

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Treatments	Fresh mass (g)		Dry mass(g)		Leaf height (cm)	Root length (cm)	Stem Diameter (cm)
	Aereal part (shoot)	Root	Aerial part (shoot)	Root			
Exp 1-T0	65,10 ab	6,59 a	3,83 a	0,36 a	19,25 a	23,83 a	0,90 a
Exp 1-T1	58,21 b	6,59 a	2,78 a	0,36 a	19,33 a	26,00 a	0,88 a
Exp 1-T2	74,30 ab	10,92 a	5,08 a	0,72 a	19,50 a	23,66 a	0,96 a
Exp 1-T3	71,94 ab	9,69 a	4,09 a	0,67 a	21,50 a	24,66 a	1,00 a
Exp 1-T4	75,13 ab	8,40 a	3,20 a	0,51 a	19,00 a	21,66 a	0,91 a
Exp 1-T5	91,24 a	9,56 a	3,56 a	0,64 a	20,16 a	19,00 a	0,91 a

T0=0 mL, T1=0,25 mL, T2= 0,5 mL, T3= 1 mL, T4= 2 mL e T5=4 mL. Means followed by letters in the columns differ from each other at the indicated significance level.
Source: Authors.

Thus, it was noticed that the T5 was superior to the other treatments in the parameter fresh mass of the aerial part. In the other parameters, no statistical difference was an increase in the parameters fresh mass of the root and dry mass of the aerial part and root.

The data in Table 1 demonstrate that as the bovine urine dose increases from 0,25 mL to 4 mL/prant/week, there was a tendency for shoot fresh mass to increase, with the T5 treatment presenting a significantly higher value than the others. This behavior may indicate that the greater supply of nitrogen and other nutrients from urine may stimulate greater accumulation of water and biomolecules in the leaves, resulting in greater turgidity and initial vigor. Howerer, when analyzing dry mass, peaks occur at T2 (0,5 mL), suggesting the existence of an ideal threshold at which nutrition is sufficient to promote the synthesis of organic compounds without resulting in excess salts or osmotic imbalance that could impair dry matter fixation.

This result is similar to the study by Marangon *et al*. (2021), analyzing the effects of seven concentrations of bovine urine on lettuce seedlings, observed that there was an increase in plant height with the maximum concentration of 5%. This fact may possibly have happened due to the chemical properties of cow urine, such as potassium, nitrogen, phosphorus, etc., which can cause an increase in fresh matter levels (Marangon *et al.*, 2021). However, the results found here differ from the study by Freire *et al.* (2019), who did not find significant effects of the applications of six different concentrations of cow urine on the production of kale seedlings. With the exception of the 15% concentration of cow urine diluted in water, which provided greater leaf expansion in the produced seedlings.

Despite the increase in biomass, variables such as leaf height, root length, and stem diameter did not show clear statistical differences between treatments, which can be explained by the preferential allocation of nutrients to leaf expansion rather than longitudinal or radial stem growth. Furthermore, the high pH of the matured urine and the buffering capacity of the substrate may have limited morphometric changes in structural organs, concentrating the effect

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on increased leaf cell volume rather than stem elongation or thickness. These results reinforce the need to balance biofertilizer doses so that improvements in one growth variable do not come at the expense of overall plant development uniformity. Unlike Marangon *et al*. (2021) and Oliveira *et al.* (2009), who found that as urine concentration increased, stem diameter increased. This factor, according to Oliveira *et al.* (2009), is not due only to the nutritional factor, but also to other factors, such as hormonal effects on cell elongation.

In summary, the randomized block design and cultivation in 1,2 kg pots of standardized substrate ensured environmental control, but may also have accentuated nutrient saturation effects at higher doses, since water availability and solute runoff are restricted in confined environments. Future work could explore even smaller application rates, investigate soil nitrogen dynamics, and measure rhizospheric microbiota parameters to understand how to optimize the use of bovine urine while maintaining balanced growth of all parts of the lettuce.

EXPERIMENT 2

The results of the t Student test of experiment 2 using triple the dosages of experiment 1, of bovine urine in lettuce seedlings are presented in Table 2. As described in the material and methods, the experiment received triple the dosages of treatment 1, of urine, they are: T0= 0 mL, T1= 0.75 mL, T2=1.5 mL, T3= 3 mL, T4= 6 mL and T5= 12 mL. According to the data shown in Table 2, the tested treatments showed statistically significant differences for the variables fresh mass of root and shoot, dry mass of root and shoot, leaf height, root length and stem diameter.

Table 2. Fresh and dry mass of shoots and roots, plant height, root length and stem diameter of lettuce seedlings cultivated under different dosages of bovine urine.

Treatments	Fresh mass (g)		Dry mass(g)		Leaf height (cm)	Root length (cm)	Stem Diameter (cm)
	Aereal part (shoot)	Root	Aerial part (shoot)	Root			
Exp 2-T0	118,86 ab	21,94 a	11,37 a	1,56 a	39,33 a	51,16 a	1,90 ab
Exp 2-T1	141,69 ab	19,14 a	11,42 a	1,22 a	44,00 a	52,66 a	1,93 ab
Exp 2-T2	170,13 a	23,08 a	6,89 ab	1,37 a	41,83 a	52,00 a	2,23 a
Exp 2-T3	160,12 ab	24,19 a	8,13 ab	1,65 a	36,66 a	42,00 ab	2,33 a
Exp 2-T4	85,79 b	6,63 b	3,53 bc	0,31 b	28,0 a	20,33 bc	1,20 b
Exp 2-T5	0,00 c	0,00 b	0,00 c	0,00 b	0,00 b	0,00 c	0,00 c

T0= 0 mL, T1= 0,75 mL, T2=1,5 mL, T3= 3 mL, T4= 6 mL e T5= 12 mL. Means followed by letters in the columns differ from each other at the indicated significance level.
Source: Authors (2025).

In this way, it was noticed that T2 was superior to the other treatments in the aerial part of the fresh mass, already in the root of the fresh mass, T3 stood out. Treatments T2 and T3 did not differ from each other in the collar diameter parameter. Treatments T1 and T2 also did not

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differ statistically in the root length parameter. The T1 treatment did not differ statistically from the control in terms of shoot dry mass and stem diameter.

It was observed that the T5 treatment had zero as a result in all parameters, because the lettuce seedlings did not support the high dose of bovine urine, T5=12mL causing the death of all seedlings of this treatment. Similarly, the T4 treatment, with 6mL, caused a sharp decline in growth parameters and, at extreme levels, plant death. This adverse effect can be explained by the accumulation of salts and the high pH of the matured urine (pH 8,9), factors that can lead to phytotoxicity, inhibition of beneficial microbial activity in the rhizosphere, and osmotic imbalance, limiting the absorption of water and essential nutrients.

A more in-depth analysis of the results reveals a clear dose-dependent effect of bovine urine on the development of lettuce seedlings. With more moderate applications, especially at a dose of 1,5 mL per plant per week, a significant increase in fresh and dry matter of both shoots and roots was observed, as well as an increase in morphometric variables (leaf height and length, and stem diameter). This behavior suggests that the concentration of nutrients present in urine, especially the nitrogenous fraction, was sufficient to meet vegetative demands without causing physiological imbalances.

Regarding the fresh mass of shoots and roots, the increase in bovine urine dosage generated an increase in fresh matter levels, similar to the study by Oliveira (2007), where he applied cow urine in lettuce production, by soil and foliar, in different concentrations of 0,0, 0,25, 0,50, 0,75, 1,00 and 1,25%, but he found that the plants that received applications of cow urine on the leaves showed higher values, compared to those obtained with soil application.

It can be seen that in most treatments there was a decrease in dry mass compared to the control, this effect can be explained by the nutritional imbalance caused by the alkalinity of cow urine (pH 8,9), which possibly has delayed growth of lettuce roots, reducing the allocation of dry biomass in this organ (Silva, 2020). In contrast, Santos *et al.* (2019), in their study with lettuce submitted to doses of bovine urine, found positive results in relation to the dry and fresh matter of the aerial part with the increase of doses of cow urine, using doses (0mL, 5mL, 10mL and 15mL) applied directly to the soil. The results obtained in this research are similar to those of Cruz *et al*. (2021) who studied the use of bovine urine doses as a source of low-cost fertilization and found that it provides nutrients, increasing the fresh mass of the aerial part and height in arugula production.

Nutrient saturation in confined vessels may explain why high doses, despite providing more nitrogen, end up creating osmotic stress and limiting water uptake. While in experiment 1, fractional applications in smaller doses produced moderate and gradual gains, experiment 2 showed that higher concentrations administered weekly enhance the nutritional effect up to the toxicity threshold, highlighting the importance of adjusting the frequency to the applied volume to maximize growth without exceeding the critical tolerance point.

From an agronomic and economic standpoint, applying 1,5 mL emerges as the most advantageous alternative. Reducing the required urine volume means less work in collecting, storing, and preparing the solution, in addition to lowering operational costs and the risk of nutrient leaching. All this without compromising high fresh weight yield, ensuring consistent and market-attractive lettuce leaves. To further explore these findings, future work could investigate soil nitrogen dynamics and map changes in the rhizosphere microbiota. Assessing postharvest parameters, such as nitrite content, soluble solids, and sensory characteristics, will help confirm the safety and nutritional value of leaves produced with 1,5 mL of bovine urine. In summary, although 4 mL can boost growth under certain conditions, the 1,5 mL dose presents

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a more balanced and efficient strategy, maintaining high fresh mass yield with lower input and labor consumption, benefiting both farmers and the environment.

Therefore, the use of bovine urine as a biofertilizer presents a low-cost and easy-to-implement strategy in family systems, favoring the circularity. However, commercial-scale applicability requires standardization of collection, maturation, and dosage protocols, as well as frequent monitoring of soil and plants to avoid saline accumulation and potential phytotoxic effects.

CONCLUSION

Based on the data presented, one can conclude that bovine urine as a biofertilizer for the production of lettuce seedlings is viable, presenting itself as a low-cost, accessible fertilizer, even for small farmers. Furthermore, cow urine provided an increase in the levels of fresh mass of shoots and roots and dry mass of shoots and roots, as well as for the other variables, leaf height, leaf length and stem diameter. Accordingly, the use of bovine urine at a dose of 1,5 mL/week/plant via soil is recommended, as these were the best results found in this study. Although, in high doses it can harm plant growth. Therefore, we suggest that future studies expand the evaluation to field conditions, compare soil and foliar applications in different seasons, and investigate postharvest quality parameters (nitrate content, sensory quality, and shelf life) to establish bovine urine as a viable and sustainable alternative for fertilizing hardwoods.

CONFLICTS OF INTEREST

Os autores declaram que o trabalho não possui conflito de interesses.

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