Research Article

Gamma Radiation Effects on Dwarf Napier Grass Quality in Acidic Soil: A Study of Minerals and Rumen Fluids

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Abstract | This study investigated the potential of gamma radiation to enhance the quality of dwarf napier grass (*Pennisetum purpureum* cv. Mot) cultivated in acidic soil, with a focus on its macro-mineral content and rumen fluid characteristics. The research findings focus on the impact of gamma radiation solely on macro minerals and rumen fluids, enhancing our insights into innovative approaches for improving livestock nutrition in regions with prevalent acidic soils. The experiment involved the application of various gamma radiation doses (0, 5, 10, 15, 20, 25, and 30 Gy). Four replications were done using a randomized block design, with 25 *Pennisetum purpureum* cv. Mot seeds in each repetition, totalling 700 seeds. The plants were grown in acidic soil with a pH of approximately 4.5–5. After two months of growth, the plants were harvested, and various parameters were analyzed. The results of the research indicated that the application of a 15 Gy dosage significantly enhanced the absorption of P ($p<0.01$), N ($p<0.01$), and Ca ($p<0.01$) in the plant. Additionally, gamma irradiation at a 25 Gy dosage demonstrated a notable effect, resulting in the highest calcium (Ca) content ($p<0.01$). However, the treatment did not exhibit a significant impact on pH ($p > 0.05$) in the rumen fluid, while NH3 ($p<0.01$) and VFA ($p<0.01$) parameters in the rumen fluid were significantly affected. The optimal dosage for the rumen fluid parameters NH3 and VFA was found to be 15 Gy. Overall, it can be concluded from this study that gamma irradiation doses of 15 Gy can enhance the nutritional content of Pennisetum purpureum cv. Mot cultivated on acidic soil, particularly when evaluated based on mineral content and rumen fluid parameters.

Keywords | Acidic soil, Digestibility, Gamma radiation, Macro mineral, *Pennisetum purpureum* cv. Mott, Rumen fluids

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INTRODUCTION

Gamma radiation, a form of radiation, has been extensively employed in diverse domains such as agriculture and food preservation (Venugopalan and Suprasanna, 2022). It has been utilized to improve the quality and safety of agricultural goods and to investigate its impact on plant biology (Aly *et al*., 2021), such as plant breeding (Kiani *et al*., 2022; Hassine *et al*., 2023), pest control (Soufbaf and Abedi, 2023), and food preservation (Mshelia *et al*., 2023). The impact of gamma radiation on living species, including plants, has been extensively studied and documented, revealing its ability to cause biological, chemical, and physical alterations (Sawarkar and Mansoori, 2023). Prior studies have demonstrated that gamma radiation can augment the growth and nutritional quality of specific crops by modifying their chemical composition (El-Beltagi *et al.*, 2022), disintegrating anti-nutritional components (Naebi *et al.*, 2023), and enhancing their resilience against pests and diseases (Katiyar *et al.*, 2022).

Soil pH is a critical determinant of crop productivity and quality in the field of agriculture (Zhao *et al.*, 2022). Soil with a low pH, known as acidic soil, can have a major impact on the growth and development of plants, as well as the nutritional quality of the crops it yields (Al-Huqail *et al.*, 2022). Acidic soils pose a prevalent issue in tropical regions (Hartemink and Barrow, 2023), which hinders the growth of different crops due to their detrimental effects on soil health and plant nutrition (Cárceles Rodríguez *et al.*, 2022; Tahat *et al.*, 2020).

Dwarf napier grass, a tropical forage grass, is extensively utilized as cattle feed (Mapato and Wanapat, 2018), particularly in areas characterized by a tropical environment (Jørgensen *et al.*, 2010). Its high biomass production, nutritional value, and adaptability to diverse soil and climatic conditions make it highly esteemed (Maleko *et al.*, 2019). However, the plant's development may be significantly impeded when cultivated in acidic soils due to reduced accessibility of essential nutrients. For instance, it is essential to specify the particular nutrient, the acidity level of the soil, and the growth stage at which the plant may face challenges (Putra *et al.*, 2022b; Ribeiro *et al.*, 2023). This constraint has prompted the exploration of innovative methods aimed at enhancing its quality and specific nutritional composition (Putra *et al.*, 2022a).

The research on the gamma radiation effects on dwarf napier grass quality in acidic soil, with a focus on minerals and rumen fluids, holds significant importance in understanding the potential applications of radiation technology in enhancing forage quality. This study contributes to the broader knowledge on innovative approaches for improving livestock nutrition, especially in regions with prevalent acidic soils, by exploring the specific impacts of gamma radiation on essential components such as minerals and rumen fluids. The findings are expected to provide valuable insights for agricultural practices, aiding in the development of strategies to optimize forage quality and subsequently enhance animal health and productivity.

MATERIALS AND METHODS

Study area

The research was conducted in Kota Baru Santan, Tubei, Lebong Regency, Bengkulu, Indonesia, situated at a latitude of -3.1667240 and a longitude of 102.1432690, with an elevation of 97 meters above sea level. For a more detailed location, you can refer to the following Map (Figure 1).

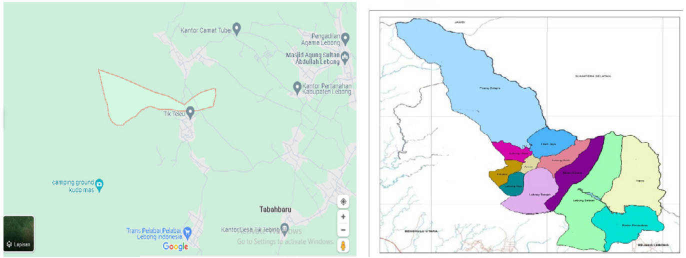

Figure 1: The research was conducted at coordinates Lat -3.1667240 and Long 102.1432690, at 97 meters above sea level.

Procedures

Irradiation process

The radiation treatment was administered at BATAN (National Nuclear Energy Agency). The seeds of *Pennisetum* purpureum cv. Mott were exposed to several amounts of gamma radiation, ranging from 5 Gy to 30 Gy, as well as a control group. The Cobalt 60 gamma radiation source was delivered using a gamma chamber irradiator type 4000A at a dose rate of approximately 0.0775 rad/second. A radiation dose was administered to 100 plant stems, resulting in a total of 1100 stems being exposed to radiation. An additional 100 stems were used as the control group.

Land preparation

The field research was carried out on marginal land where the pH range at the research location was 4.5 to 5.6, and the concentration of Aldd was 2.26 parts per million. Additionally, 10.68% of the soil is saturated with aluminium. The experimental design utilized a randomised complete block design (RCBD) consisting of four replications. Each experimental plot consisted of four rows, each with dimensions of 5 meters in length and 3 meters in width. Seeds that were not exposed to radiation and seeds that were exposed to radiation were planted, with a distance of 75 cm between each seed on the upper part of the row.The plants were collected two months later. The plants efficiently controlled the presence of weeds and insects, so mitigating their potential to impede their growth in the long run. After a period of two months of increasing in size, the plants were gathered and the branches were separated from the roots. Subsequently, the observations were conducted in accordance with the predetermined test criteria.

Calcium, phospourus, and nitrogen content

Leaves and stems of *Pennisetum purpureum* cv. Mot plants previously grown in the experimental field were collected for combined calcium, phosphorus, and nitrogen analysis.

The collected samples, consisting of both leaves and stems, were washed thoroughly with deionized water to remove any surface contaminants. Finally, a portion was oven-dried at 65 °C until constant weight. The dehydrated material was ground, passed through a 40 mesh sieve, and subsequently used to determine minerals, as reported by (Kusvuran, 2021; Altuntas and Dasgan, 2019). Three macromineral elements N, P, and Ca were examined in this investigation. A muffle furnace was used to mineralize around 0.1 g of the oven-dried material for six hours at 550 °C. Hydrochloric acid (HCl) was used to dissolve the resultant ash once it cooled. The nitrogen content was analysed by Kjeldahl digestion according to the procedure described by (Sáez-Plaza *et al.*, 2013). The concentrations of calcium and phosphorus were determined utilizing Atomic Absorption Spectroscopy (AAS) with reference to (Coşkun and Akman, 2005). In calcium analysis, the plant samples were ashed, and the resulting ash was dissolved in acid before being subjected to AAS. Phosphorus analysis involved digestion of the plant material with an appropriate acid, followed by AAS measurement.

Rumen fluid collection and incubation

Rumen fluid was obtained from cows fitted with fistulas and located at the University of Andalas barn in Padang. The Rumen fluid was collected, transported, pooled, and filtered according to the procedure described by (Gonzalez-Rivas *et al.*, 2017). Care and management the care of surgically modified animals was consistent with the guidelines (Bayne, 1998). The collection and preparation of rumen inoculum and buffer was described in (Aguerre *et al.*, 2023).

The substrates were ground to pass through a 1 mm sieve, and 1 g was placed in 250 mL ANKOM bottles with 75 mL of buffer solution dispensed to the bottles using a liquid dispenser based on the (Leon *et al.*, 2023). it was done according to a modification of the (Tilley and Terry, 1963) procedure. The Kansas buffer solution with a 6.8 pH value was used. The Rumen fluid underwent a thawing process consisting of three phases. Initially, the Rumen fluid was stored in a refrigerator set at a temperature of 4 °C for a duration of 30 minutes. Subsequently, it was transferred to a cold-water bath with a temperature of around 15 °C for another 30 minutes. Finally, the water bath temperature was progressively increased to 39 °C, allowing the Rumen fluid to thaw over the course of an additional hour. A volume of 25 ml of rumen fluid was introduced into the mixture of substrate and buffer. The bottles were sealed with pressure sensor modules from the ANKOM system, and carbon dioxide was injected into the bottles before they were placed in pre-heated water baths (20-L Analogue Waterbath, WB20; Ratek Instruments Pty Ltd., Boronia, VIC, Australia) set at a temperature of 39 °C. Additionally, four empty bottles were subjected to incubation with buffer and RF as a control. The incubation was conducted in two separate sessions of 24 hours each, with a total of eight replicates per treatment. The incubations employing RF stored at -80°C and -20°C were conducted concurrently using identical sources of Rumen fluid.

Thermo Fisher Scientific, USA, used a gas chromatography mass spectrometer (GC-MS; Thermo TRACE 1310-ISQ) to evaluate the supernatant for specific volatile fatty acids (VFA). the findings of a preliminary investigation was out at Andalas University's Faculty of Animal Husbandry's Ruminant Nutrition Laboratory.

Data analysis

The research data was analyzed for variance based on a randomized complete block design with seven treatments and four replications. Further, Duncan's multiple range test was used to determine the differences among the treatments.

RESULTS AND DISCUSSION

Effect of gamma radiation on calcium and, phosphorus, and nitrogen content

Gamma radiation is a powerful tool in various fields, including agriculture and food science. In this study, we investigate the impact of gamma radiation at different doses on the content of essential elements Calcium (Ca), Phosphorus (P), and nitrogen (N), in experimental samples. The variations in these elemental contents under different radiation exposures can provide valuable insights into the potential effects of gamma radiation on the nutritional quality of materials (Table 1).

Table 1: Calcium (Ca), phosphorus (P) , and nitrogen (N) content under gamma radiation exposure.

Treatment	Ca%	P%	N%
IR 0	0.5857 ± 0.08^{a}	0.2423 ± 0.03^{a}	0.83 ± 0.104^{a}
IR 5	0.5933 ± 0.08^{a}	0.1957 ± 0.03^{b}	1.07 ± 0.0289^{b}
IR 10	0.5973 ± 0.01^{a}	0.2460 ± 0.03^{ac}	1.25 ± 0.091^{c}
IR 15	0.6393 ± 0.01^{b}	0.2667 ± 0.03^{c}	1.26 ± 0.0104^{c}
IR 20	0.6387 ± 0.06^{b}	0.2113 ± 0.02^{b}	1.23 ± 0.029^{c}
IR 25	0.7680 ± 0.06^{c}	0.2393 ± 0.01^{a}	0.83 ± 0.0104^{a}
IR 30	0.7650 ± 0.08^{c}	0.2113 ± 0.02^{b}	0.72 ± 0.003^{a}

The results of the gamma radiation effect on the Calcium (Ca), Phosphorus (P), and Nitrogen (N) content in experimental samples at various doses. Data is displayed as means with corresponding standard deviations. This Table illustrates significant differences in Ca, P, and N content among treatment groups, denoted by different letters (a, b, c) for each element.

Table 1 reveals a positive correlation between the dose of gamma radiation and the Ca content of the dwarf napier grass. These findings indicate that gamma radiation can enhance the accessibility of Ca in the dwarf napier grass. The Ca concentration in the unirradiated Napier grass (IR 0) is 0.5857%. The calcium (Ca) level rises to 0.6393% in IR 15 and 0.7680% in IR 25. The rise in calcium concentration is substantial, specifically, 19.3% in the IR 15 and 32.2% in the IR 25.

The P content in dwarf napier grass increases with the rising gamma irradiation dosage, reaching its peak at 15 Gy. This suggests that gamma radiation positively influences the availability of P in dwarf napier grass. Specifically, the P content in non-irradiated dwarf napier grass (IR 0) is 0.2423%, and this value increases significantly to 0.2667% at IR 15, reflecting a notable 10.3% rise.

Subsequently, at a radiation dosage of 25 Gy, the P content decreases slightly to 0.2393%, indicating a decline compared to the 15 Gy dosage. Nevertheless, it is noteworthy that this value is higher than the P content observed at a radiation dosage of 30 Gy. At 30 Gy, the P content in dwarf napier grass decreases further to 0.2113%, demonstrating a significant difference from the non-irradiated samples. This decline suggests that a radiation dosage of 30 Gy may induce damage to the plants, resulting in suboptimal P absorption.

To justify whether increasing gamma radiation causes damage or provides benefits, it is crucial to consider the overall trend in phosphorus content. The enhancement of phosphorus availability at lower doses implies a potential positive impact on plant growth and nutrition. Conversely, the decline at higher doses, such as 30 Gy, suggests that excessive radiation can have damaging effects on the plants, leading to suboptimal nutrient absorption.

The N content in dwarf napier grass increases with the increasing dosage of gamma irradiation up to 15 Gy, then decreases at doses of 25 Gy and 30 Gy. This indicates that gamma radiation can enhance the availability of N in dwarf napier grass, but excessively high doses can cause damage to the plants, leading to a reduction in the N content. The N content in non-irradiated dwarf napier grass (IR 0) is 0.83%. This N content increases to 1.26% at IR 15. This increase in N content is quite significant, at 51.8%. However, the N content in dwarf napier grass decreases at radiation doses of 25 Gy and 30 Gy. This suggests that radiation doses of 25 Gy and 30 Gy can cause damage to the plants, resulting in suboptimal N absorption.

The rise in mineral content (calcium, phosphorus, and nitrogen) in gamma-irradiated dwarf napier grass can be ascribed to various mechanisms, including the stimulation of soil microorganism activity, which aids in the mineralisation process (Khan, 2005; Li *et al*., 2021; Chen *et al*., 2020). Acidic soils have a low pH, which causes rainwater to wash away minerals, making them inaccessible for plants to absorb (Gurmessa, 2021; Yadav *et al*., 2020).

The results of this investigation align with the conclusions of a prior study (El-Beltagi *et al*., 2022), suggesting that exposure to radiation up to 20 Gy can augment the mineral composition, specifically nitrogen (N) and magnesium (Mg), in plants. Nevertheless, there is a distinction when it comes to the levels of P and Ca found in plants. The study conducted by (El-Beltagi *et al*., 2022) found that the greatest levels of phosphorus (P) and calcium (Ca) were detected when a dosage of 80 Gy was used.

Gamma radiation has been reported to have a stimulating effect on the activity of enzymes responsible for transporting minerals into plant tissues (Singh *et al*., 2013). Essential for the growth and development of plants, minerals, including calcium (Ca), phosphorus (P), and nitrogen (N), contribute to vital processes such as photosynthesis, nutrient transport, and the fortification of plant cell walls (Bhatla *et al*., 2018).

The enhanced activity of enzymes involved in mineral transportation, specifically Ca, P, and N, in response to gamma radiation has been documented (Jan *et al*., 2012). This increase in enzyme activity results in a heightened availability of minerals within the plant tissues. The subsequent rise in mineral content, encompassing Ca, P, and N, within dwarf napier grass offers various advantages, notably in augmenting its nutritional value as animal fodder. Livestock, particularly in terms of bone and teeth development, require these essential minerals (Suttle, 2022). Consequently, the elevation in mineral content in dwarf napier grass can significantly enhance its suitability as a nutritionally enriched feed for animals.

Effect of gamma radiation on rumen fluid

Rumen fluid constitutes a vital component of the gastrointestinal system in ruminant species, encompassing cattle, goats, and sheep (Kamra, 2005). This fluid plays a crucial role in the breakdown and digestion of fibrous materials present in the ingested food of these animals. Numerous studies have been conducted to deepen our comprehension of the characteristics of rumen fluid, aiming to enhance both feed efficiency and animal health (Khiaosa-ard and Zebeli, 2014).

According to the data presented in Table 2 the research findings indicate that exposing dwarf napier grass seeds to gamma irradiation and planting them in acidic soil did not result in a notable impact on the pH of rumen fluid *in vitro*. The pH of rumen fluid is a crucial determinant in the process of ruminant digestion. Extreme deviations in pH levels can disturb the digestive process (Dijkstra *et al*., 2020). The rumen fluid pH did not exhibit any significant differences across the treatments in this investigation. These findings suggest that exposing dwarf napier grass seeds to gamma irradiation does not cause a substantial alteration in the pH of rumen fluid. The research findings are consistent with those of (Wahyono *et al*., 2018), indicating that different dosages of gamma irradiation do not directly impact the pH of rumen fluid. Gamma radiation has the potential to alter the nutritional composition of dwarf napier grass, although it does not have a direct impact on the pH of rumen fluid. The radiation doses administered in this trial were 5, 10, 15, 20, 25, and 30 Gy. These doses may not be sufficiently potent to affect the pH of rumen fluid.

Table 2: Caracteritic of rumen fluid under gamma radiation exposure.

Treatment	pH	NH_3 (Mg/100ml)	VFA (mM)
IR 0	6.92±0.19	13.87±0.20[a]	118.33±2.08[a]
IR 5	6.92±0.024	14.03±0.45[b]	123.0±2.09[b]
IR 10	6.92±0.016	17.00±0.38[cd]	125.67±1.41[bc]
IR 15	6.89±0.023	17.20±0.57[c]	128.33±1.53[c]
IR 20	6.88±0.025	16.9±0.78[d]	125.33±1.52[b]
IR 25	6.9±0.027	12.83±1.09[a]	119.33±1.41[a]
IR 30	6.89±0.021	10.37±0.92[a]	107.67±2.64[d]

The impact of gamma radiation on the characteristics of Rumen fluids (pH, NH3, and VFA) was assessed in experimental samples exposed to different doses. The data is presented in the form of means accompanied by their respective standard deviations. The table displays notable distinctions across treatment groups, indicated by distinct letters (a, b, and c) for each factor.

The gamma irradiation of dwarf napier grass seeds planted in acidic soil has been shown to impact the NH_3 content in *in vitro* rumen fluid. Specifically, Wahyono *et al*. (2018) demonstrated that gamma irradiation, administered at a dosage of 100 Gy, significantly enhances gas production under *in vitro* conditions.

In the context of our study, the initial NH_3 content in rumen fluid for the non-irradiated treatment (IR 0) was measured at 13.87 mg/100ml. Following gamma irradiation at a dosage of 15 Gy (IR 15), there was a substantial increase in NH_3 content, reaching 17.20 mg/100ml. This observed increment represents a noteworthy 23.1% rise at IR 15. The findings from our study align with Wahyono *et al*. (2018), supporting the notion that gamma irradiation can indeed influence gas production, as evidenced by the increased NH_3 content in *in vitro* rumen fluid.

The rise in NH_3 concentration in gamma-irradiated dwarf napier grass can be ascribed to various reasons, which include: Gamma radiation can improve the breakdown of fibrous material, resulting in an elevation of NH_3 levels. The study conducted by (Ahmed *et al*., 2023) found that the enhanced breakdown of roughage can be due to the elevated content of NH_3, which serves as a nitrogen source for the proliferation of cellulolytic bacteria.

Gamma irradiation at a dose of 15 Gy can increase the NH_3 content in in vitro rumen fluid. The elevation of NH_3 content can be beneficial for ruminant animals as NH_3 serves as a crucial nitrogen source for the growth and development of rumen microorganisms (Mahmoudi-Abyane *et al*., 2020).

The research results indicates that subjecting dwarf napier grass seeds sown in acidic soil to gamma irradiation can enhance the VFA content of *in vitro* rumen fluid. The concentration of volatile fatty acids (VFA) in the rumen fluid for the non-irradiated treatment (IR 0) was 118.33 millimolar (mM). The concentration of VFA content increased to 128.33 millimolar (mM) in the IR 15 treatment. The rise in VFA content is substantial, showing an increase of 8.1%. The rise in volatile fatty acid (VFA) concentration in gamma-irradiated dwarf napier grass can be ascribed to various factors, such as: Gamma radiation can stimulate the activity of rumen microbes, leading to the production of volatile fatty acids (VFAs).

By deepening our comprehension of the influence of gamma radiation on the volatile fatty acid (VFA) content of rumen fluid, we can devise more efficient approaches to enhance the nutritional quality of feed for ruminant animals (Pourbayramian *et al*., 2021). The research findings indicate a noteworthy increase of 8.1% in VFA content at a dosage of 15 Gy, which is of major value. These findings indicate that exposing rumen fluid to gamma irradiation at a dosage of 15 Gy can effectively increase the concentration of volatile fatty acids (VFAs) *in vitro*.

Multivariate analysis of mineral and rumen fluids characteristic

Prior to examining the correlation heatmap, it is crucial to acknowledge the importance of comprehending the connections between different mineral macrocomponents and the characteristics of rumen fluids in *Pennisetum purpureum* cv. Mot. The heatmap visually (Figure 2) represents the magnitude and orientation of relationships between various characteristics, enabling us to detect patterns and connections that might inform future investigations and practical implementations in the domain of forage and biomass utilisation. An essential aspect of fully utilising *Pennisetum purpureum* cv Mot potential for agricultural and industrial applications is to thoroughly investigate these relationships.

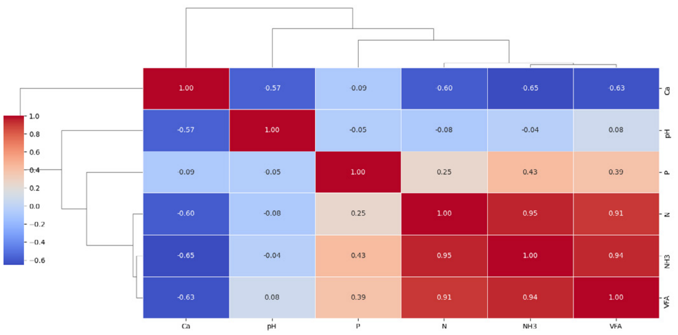

Figure 2: Hierarchical correlation analysis of gamma radiation effects on multiple parameters.
The correlation heatmap visually displays the connections between certain mineral elements and rumen fluid characteristics, such as Calcium (Ca), pH, Phosphorus (P), Nitrogen (N), Nitrate (NH_3), and Volatile fatty acid (VFA) in *Pennisetum purpureum* cv. Mot. Each square in the heatmap represents the magnitude and orientation of the correlation between two attributes. The colour gradient, which spans from blue (representing negative correlation) to red (representing positive correlation), visually depicts the strength and direction of these interactions. A darker hue of blue or red signifies a more pronounced link, whereas a lighter hue signifies a weaker or insignificant correlation.

The impact of gamma irradiation on dwarf napier grass seeds cultivated in acidic soil on the relationship between the levels of calcium (Ca), phosphorus (P), nitrogen (N), ammonia (NH3), and volatile fatty acids (VFA). The research findings presented in Figure 2 demonstrate that subjecting dwarf napier grass seeds sown in acidic soil to gamma irradiation has a notable impact on the relationship between the levels of Ca, P, N, NH3, and VFA. The element Ca demonstrates a robust inverse relationship with NH3 and VFA. This suggests that elevated calcium levels have a tendency to decrease the concentrations of NH3 and VFA in the rumen fluid. The study conducted by (Figueiredo de Almeida Gomes *et al*., 2006) revealed that calcium has the ability to suppress the activity of microorganisms. Rumen microorganisms contribute to the production of NH3 and VFA, which are vital sources of energy and nutrients for the growth and development of ruminant animals.

Phosphorus (P) shows a negligible association with the other parameters, suggesting that gamma irradiation does not have a substantial impact on the link between P concentration and NH_3 and VFA. There is a significant positive relationship between the Nitrogen (N) levels in dwarf napier grass and the presence of NH_3 and VFA in rumen fluid. These findings indicate that a higher concentration of nitrogen in dwarf napier grass can elevate the levels of ammonia (NH_3) and volatile fatty acids (VFA) in the fluid of the rumen. Nitrogen is a crucial nutrient necessary for the growth and development of rumen bacteria (Pfau *et al*., 2023). The bacteria in the rumen contribute to the production of NH_3 and VFA (Daning *et al*., 2022), which serve as significant sources of energy and nutrition for the growth and development of ruminant (Guo *et al*., 2020). The elevation of nitrogen (N) levels in dwarf napier grass can augment the concentrations of ammonia (NH_3) and volatile fatty acids (VFA) in rumen fluid. This is due to the fact that N is a vital constituent of protein, which acts as a fundamental source of energy and nourishment for microorganisms in the rumen.

The concentration of NH3 in rumen fluid shows a significant positive connection with the concentration of VFA. According to (Abbas *et al*., 2023), an elevated NH3 concentration in rumen fluid leads to an augmentation in VFA content in rumen fluid. Ammonia (NH3) is produced as a result of the cellulose fermentation process carried out by microorganisms in the rumen (Zanine *et al*., 2022).

From the above discussion, it can be inferred that subjecting dwarf napier grass seeds sown in acidic soil to gamma irradiation has a notable effect on the relationship between the levels of Ca, P, N, NH_3, and VFA. Gamma irradiation typically strengthens the inverse relationship between calcium (Ca) levels and ammonia (NH_3) and volatile fatty acids (VFA), while also reinforcing the positive relationship between nitrogen (N) levels and NH_3 and VFA. Augmenting the levels of calcium (Ca) and nitrogen (N) might diminish the concentration of ammonia (NH_3) in rumen fluid and enhance the concentration of volatile fatty acids (VFA) in rumen fluid.

CONCLUSIONS AND RECOMMENDATIONS

In conclusion, the outcomes of this study reveal a consistent trend of decreasing nitrogen (N) and phosphorus (P) levels with increasing gamma irradiation doses. Specifically, the study indicates that the optimal irradiation dose for enhancing calcium (Ca) content in dwarf napier grass is 25 Gy. Conversely, for phosphorus (P) and nitrogen (N), the most effective dose is 15 Gy. Highlighting the quality parameters of dwarf napier grass that exhibit improvement, it is noteworthy that certain irradiation doses contribute to enhanced nutritional quality and health. The findings emphasize a substantial decrease in nitrogen and phosphorus levels with increasing gamma irradiation, suggesting a dose-dependent impact on these essential elements.

Focusing on rumen fluid parameters, it is evident that irradiation at a dose of 15 Gy yields the most favorable outcomes. This is manifested by a significant increase in ammonia (NH_3) and volatile fatty acids (VFA) content. This enhancement implies a positive influence on gas production and volatile fatty acid composition in rumen fluid, ultimately contributing to the overall health and feed efficiency for livestock. Therefore, the careful selection of specific irradiation doses becomes a crucial consideration in endeavors to improve the nutritional quality and health of dwarf napier grass, while simultaneously enhancing the quality of rumen fluid as a livestock feed source.

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NOVELTY STATEMENT

This research investigates the innovative application of gamma radiation to enhance the nutritional quality of dwarf napier grass (*Pennisetum purpureum* cv. Mot) cultivated in acidic soil, addressing a critical challenge faced by livestock farmers in many regions. Unlike conventional research on gamma radiation and plants, this study uniquely focuses on its impact on macro-mineral uptake and rumen fluid characteristics, providing valuable insights into animal nutrition and digestive health.

AUTHOR'S CONTRIBUTION

BP originated and formulated the study, performed experiments, analysed data, and composed the report. Additionally, functioned as the corresponding author, supervising all communication pertaining to the research. BP offered valuable perspectives, contributed to the analysis of data, and examined the manuscript.

Declaration of competing interest

The authors state that they don't have any identifiable conflicting financial interests or personal relationships that may have potentially influenced the findings presented in this research article.

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