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RESEARCH ARTICLE
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Investigating the Characteristics of Pakchong Fodder Using Struvite Containing Compost Comparing with Chemical Fertilizer

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ABSTRACT

Struvite containing compost produced from layer litter is a rich source of nitrogen, phosphorus and other micronutrients. The performance of Pakchong fodder was studied by utilizing struvite containing compost to identify its application rate on fodder growth. For this purpose, a field study of Pakchong fodder growth was undertaken in the fodder production area at goat, sheep and horse farm of Bangladesh Agricultural University (BAU). A total five treatments such as T_0 (no compost and no chemical fertilizer at all), T_1 (2-ton struvite containing compost/ha), T_2 (4-ton struvite containing compost/ha), T_3 (6-tons struvite containing compost/ha) and T_4 (150kg urea/ha and other macro- and micro-nutrients) with three replications were studied. Parameters studied were yield, height and circumference of Pakchong fodder along with its nutrient content such as dry matter, crude protein, crude fiber, ether extract, pH, phosphorus and potassium content. The result showed that T_2 produced significantly higher yield (96.67 tons/ha), plant height (257.67cm) and stem circumference (6.63cm) compared to other treatments. In case of nutrient content, a significantly higher crude protein (15.07%), ether extract (6.78%), ash (1.77%), phosphorus (0.28%) and potassium (0.98%) contents were found in T_2 treatment also, compared to other treatments. Higher CP and P content in the produced Pakchong fodder might be due to nitrogen and phosphorus assimilation from struvite. Therefore, it might be concluded from the experiment that 4-ton/ha (T_2) struvite containing compost will be the suitable application rate for Pakchong fodder growth.

Keywords: Struvite, Pakchong fodder, Fodder yield, Nutrient content

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INTRODUCTION

The availability of fodder in Bangladesh can vary depending on several factors, including the region, climate, and agricultural practices. Bangladesh has limited natural pastures, and they are often under grazed (Rahman et al., 1998; Kobir et al., 2022). As a result, the availability of natural grazing land is relatively low, which can put pressure on these fragile ecosystems (Ahmed et al., 2021). To meet the demand for animal feed, many farmers in Bangladesh cultivate fodder crops. Common fodder crops grown in the country include rice straw, maize, sorghum, and Napier grass (Pakchong fodder). The amount of cultivated fodder crops depends on the agricultural practices in different regions. The availability of fodder can vary seasonally. During the monsoon season, when there is abundant rainfall, the growth of natural and cultivated fodder is typically more favorable. However, during the dry season, there may be challenges in providing adequate fodder for livestock. The fodder production is closely linked to the livestock population in Bangladesh (Rahman et al., 1997; Baset et al., 2003; Rahman et al., 2008; Islam et al., 2010; Hashem et al., 2020). The demand for fodder is higher in areas with a significant concentration of livestock,

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such as dairy farms. The cultivation of fodder in Bangladesh is influenced by a combination of natural factors, agricultural practices, and government interventions. Efforts to promote the cultivation of high-yield fodder crops like Napier grass and the adoption of sustainable fodder management practices can help ensure a more consistent and reliable supply of animal feed for the country's growing livestock population (Baset et al., 2003).

Pakchong fodder, also known as Napier grass (*Pennisetum purpureum*), is a vital agricultural resource that plays a significant role in the livestock industry, particularly in regions with warm and tropical climates (Sarker et al., 2021; Liman et al., 2022; Mohamad et al., 2022). This versatile forage crop holds great importance for farmers and animal husbandry for several reasons. This fodder is prized for its high nutritional value. It is rich in essential nutrients such as proteins, carbohydrates, and fiber, making it an ideal feed for various livestock, including cattle, goats, and buffaloes. This nutrient density helps ensure the health and productivity of these animals. Pakchong fodder can be harvested several times a year, providing a consistent and abundant source of feed for livestock. This makes it a sustainable option for farmers who need a reliable source of animal nutrition. One of the remarkable features of Napier grass is its ability to withstand drought conditions. This resilience to water scarcity is especially valuable in regions prone to erratic rainfall patterns. It ensures that livestock can be fed even during dry spells when other forage crops may not be available. Growing Pakchong fodder can have positive effects on soil quality. Its deep root system helps prevent soil erosion, enhances soil structure, and promotes nutrient cycling. This can benefit the overall health of the agricultural ecosystem. Pakchong fodder is relatively inexpensive to cultivate and maintain. It requires minimal inputs in terms of fertilizers and pesticides, making it a cost-effective choice for farmers. Additionally, its high yield per unit area further contributes to its cost-efficiency. The cultivation of Napier grass can help reduce the pressure on natural pastures and rangelands, which are often overgrazed. By providing a reliable source of animal feed, it allows these fragile ecosystems to recover and regenerate. In conclusion, Pakchong fodder is a crucial component of sustainable agriculture, especially in tropical and subtropical regions. Its nutritional value, high yield, drought resistance, and soil improvement properties make it an asset for livestock farmers. By integrating Napier grass into their farming practices, farmers can enhance the health and productivity of their livestock while also promoting environmental sustainability (Maleko et al., 2019).

Struvite-containing compost, often referred to as "struvite-enriched compost" or "MAP enriched compost," holds significant importance in the fields of agriculture, environmental sustainability, and waste management due to several key reasons. Struvite is a crystalline compound that contains phosphorus, which is a vital nutrient for plant growth (Rahman et al., 2011, 2013 and 2014; Hertzberger et al., 2020). In agricultural systems, phosphorus is often a limiting factor, and its availability can influence crop yields. Struvite-containing compost serves as a valuable source of phosphorus, reducing the need for chemical fertilizers and supporting sustainable farming practices (Lee et al., 2009; Liu et al., 2011). Phosphorus is one of the essential macronutrients required for plant development. By incorporating struvite-enriched compost into agricultural soils, farmers can enhance soil fertility and improve crop yields. Struvite, with its high phosphorus and magnesium content, perfectly complements the nutrient requirements of livestock and the growth of this versatile forage crop. The slow-release properties of struvite ensure a consistent and sustainable nutrient supply, reducing the dependence on synthetic fertilizers and minimizing environmental risks. This practice promotes sustainable agriculture by reducing the environmental impact associated with excessive fertilizer use (Rothbaum and Rohde, 1976; Shu et al., 2006; Poncer and Garcialopez, 2007). Struvite-containing compost is often derived from organic waste materials, such as wastewater sludge or organic kitchen waste. Recycling these waste streams into struvite-enriched compost diverts organic materials from landfills, mitigating the environmental issues associated with waste disposal and contributing to a circular economy. Moreover, struvite-containing compost plays a crucial role in sustainable agriculture, waste management, and environmental conservation by recovering phosphorus from organic waste streams and using it to enhance soil fertility and crop production (Rahman et al., 2014). This approach helps address multiple challenges, including resource scarcity, pollution prevention, and the promotion of circular economy principles. It needs research activities for optimizing the biomass yield of Pakchong fodder with standard application rate. In our knowledge, there is no research work regarding the optimum application rate of struvite containing compost to produce Pakchong fodder in Bangladesh. So, the study was carried out to identify the biomass yield, height, circumference of Pakchong fodder along with its nutrient contents at different application rate of struvite containing compost.

MATERIALS & METHODS

Research Site and Period

The fodder production research was executed in the fodder plot of Goat and Sheep Farm of Bangladesh Agricultural University, Mymensingh with different application rate of struvite containing compost. The experiment was conducted during the period of 8th March to 8th July, 2023. Nutrient contents of the produced fodder were analyzed in the laboratory.

Layout and Design of the Experiment

There were five total five treatments such as three struvite containing compost, one chemical fertilizer and one control along with three replications randomly designed in the fodder production plot. The layout of the experiment is shown in Table 1.

Land Preparation and Management

The study comprised two phases: the initial phase focused on cultivating Pakchong fodder, while the subsequent phase involved analyzing the fodder in laboratory. Throughout the experiment, temperatures fluctuated between 30 to 35°C for maximums and 23 to

26°C for minimums, while relative humidity ranged from 76.5 to 85.4%, with an average rainfall of 201 mm. The experimental site featured silt loam soil with compositions of 0.14% nitrogen, 0.11% phosphorus, 0.31% potassium, and 0.11% sulphur. The terrain was flat, adequately drained, and situated above flood levels. Land preparation involved meticulous ploughing and cross ploughing with a power tiller, followed by levelling and division into 15 plots measuring 10 m^2 each. Removal of weeds and remnants from the prior crop was conducted before levelling. Struvite-containing compost, sourced from the composting facility at the Sheep, Goat, and Horse Farm of BAU, was applied during the final land preparation stage, serving as organic fertilizer. The compost application rate was determined based on nitrogen availability and standard nitrogen requirements for Pakchong fodder cultivation. Samples of the compost, soil, and fodder plants underwent chemical analysis for nitrogen, phosphorus and potassium at the Laboratory of Animal Science, Bangladesh Agricultural University, Mymensingh. The percentages of nitrogen (N), phosphorus (P), and potassium (K) are detailed in Table 2. Struvite containing compost and isolated struvite were presented in Fig. 1.

Table 1: Layout and design of the experiment

Replication	Treatment				
	T_0	T_1	T_2	T_3	T_4
R_1	T_0R_1	T_2R_2	T_3R_2	T_1R_2	T_4R_3
R_2	T_1R_1	T_4R_1	T_0R_2	T_3R_3	T_2R_3
R_3	T_2R_1	T_3R_1	T_1R_3	T_4R_2	T_0R_3

Here, T_0 = no compost and no chemical fertilizer at all, T_1 = 2-ton struvite containing compost/ha, T_2 = 4-ton struvite containing compost/ha), T_3 = 6-ton struvite containing compost/ha, and T_4 = 150 kg urea/ha and other macro- and micro-nutrients.

Table 2: Chemical analysis of MAP containing compost

Parameters	Struvite containing compost
pH	8.50±1.25
Dry Matter (%)	75.00±2.12
Total Organic Carbon (%)	57.50±2.11
Ash (%)	2.76±0.50
Ether Extract (%)	2.85±0.5
Crude Fiber (%)	15.3±0.5
Nitrogen (%)	1.88±0.20
Phosphorus (%)	0.25±0.01
Potassium (%)	0.39±0.01

Fig. 1: Struvite containing compost and the isolated struvite.

Application of Compost on the Plot and Implant the Fodder Cut

The experiment was executed in a Completely Randomized Design (CRD) along with control, three levels of struvite containing compost, and solely on chemical fertilizer added treatments. The treatments were T_0 (no compost and no chemical fertilizer at all), T_1 (2-ton struvite containing compost/ha), T_2 (4-ton struvite containing compost/ha), T_3 (6-ton struvite containing compost/ha) and T_4 (150kg urea/ha and other macro- and micro-nutrients). For the implantation of the cutting of Pakchong fodder stem, the line-to-line distance was 75cm, plant to plant distance was 45cm and the harvesting time was 50 days from implantation of the cutting. During the harvesting period, Pakchong fodder plants were succulent enough and contain sufficient nutrients.

Parameters Studied

The Pakchong fodder production research was planned to assess the result of application rate of struvite containing compost compared with the standard dose of chemical fertilizer. The parameters studied were yield, height and circumference of Pakchong fodder. Nutrient content such as dry matter (DM), crude protein (CP), crude fiber (CF), ether extract (EE), ash, phosphorus (P) and potassium (K) concentrations of Pakchong fodder also. All parameters of Pakchong fodder were analyzed in standard methods (AOAC, 2005).

Statistical Analysis

The data underwent analysis using a Completely Randomized Design (CRD) via SAS statistical software. Significant mean values were assessed using DMRT (Duncan's Multiple Range Test). All data were expressed as Mean±SD.

RESULTS AND DISCUSSION

Yield, Height and Circumference of Pakchong Fodder

The yield, height and circumference of cultivated Pakchong fodder at different treatments were given in Table 3. An important alteration was found in Pakchong fodder yield, plant height and stem circumference among the groups during the whole experimental period (50 days). But there was no noteworthy alteration between T_1 and T_4 treated groups. These results might indicate that the struvite containing compost had significantly different effects ($P<0.01$) on Pakchong fodder growth. The highest yield was observed in T_2 (96.67ton/ha) and the lowest yield was observed in T_0 (34.33ton/ha). The height of cultivated Pakchong fodder at different treatments were significantly varied ($P<0.01$) at different treatments. The highest height was observed in T_2 (257.67cm), it was very much similar with T_3 (255.00cm) and the lowest height was observed in T0 (170.00cm). The circumference of cultivated Pakchong fodder stem at different treatments were significantly varied ($P<0.01$) at different treatments. The highest stem circumference was observed in T_2 (6.63cm) and it was very much similar with T_4 (6.36cm) and the lowest circumference was observed in T_0 (3.26cm).

Ahmed et al. (2021) investigated the effects of cultivar and cutting period on several parameters including plant height, basal circumference, tiller number and diameter, leaves per tiller, and diameter of the lowest node. They found that the BLRI Napier hybrid-3 cultivar exhibited greater plant height compared to Pakchong-1,

Table 3: Biomass yield and physical parameters of Pakchong fodder at different levels of struvite containing compost along with chemical fertilizer

Parameters	Treatments					SEM	Level of significance
	T_0	T_1	T_2	T_3	T_4		
Biomass Yield (ton/ha)	34.33±1.53^{d}	70.33±1.53^{c}	96.67±1.53^{a}	79.67±3.51^{b}	72.67±3.21^{c}	1.855	**
Height (cm)	170.00±20.00^{c}	230.00±10.00^{b}	257.67±8.74^{a}	255.00±13.23^{a}	241.67±9.07^{ab}	5.238	**
Circumference (cm)	3.27±0.25^{c}	3.77±0.25^{c}	6.63±0.32^{a}	5.50±0.50^{b}	6.37±0.32^{a}	0.185	**

T_0 = Pakchong fodder production without any compost and chemical fertilizer, T_1 = 2-ton struvite containing compost/ha, T_2 = 4-ton struvite containing compost/ha, T_3 = 6-ton struvite containing compost/ha, T_4 = 150kg urea/ha and other macro- and micro- nutrients. Values (mean±SD) bearing different alphabets in a row differ significantly (P<0.01).

Table 4: Nutrient composition of Pakchong fodder at different levels of MAP containing compost along with chemical fertilizer

Parameters	Treatments					SEM	Level of significance
	T_0	T_1	T_2	T_3	T_4		
DM (%)	16.43±0.78^{b}	18.87±0.31^{a}	19.03±0.54^{a}	17.44±1.08^{b}	20.09±0.20^{a}	0.116	**
CP (%)	8.21±0.97^{d}	11.19±0.28^{c}	15.06±0.52^{a}	11.63±0.57^{c}	13.31±0.80^{b}	0.462	**
CF (%)	33.27±1.07	32.98±1.64	32.15±1.07	31.61±0.87	32.47±1.06	0.614	NS
EE (%)	4.20±0.40^{b}	5.86±0.93^{a}	6.78±0.25^{a}	6.05±0.23^{a}	6.07±0.25^{a}	0.145	**
Ash (%)	1.55±0.11	1.55±0.21	1.77±0.17	1.54±0.13	1.56±0.21	0.121	NS
pH	6.26±0.27^{b}	6.69±0.17^{a}	6.62±0.17^{ab}	6.39±0.24^{ab}	6.48±0.19^{ab}	0.109	*
P (%)	0.17±0.02^{c}	0.23±0.04^{abc}	0.28±0.03^{a}	0.26±0.02^{ab}	0.22±0.04^{bc}	0.023	*
K (%)	0.70±0.07^{c}	0.78±0.06^{bc}	0.98±0.06^{a}	0.89±0.06^{ab}	0.78±0.05^{bc}	0.029	*

T_0 = Pakchong fodder production without any compost and chemical fertilizer, T_1 = 2-ton struvite containing compost/ha, T_2 = 4-ton struvite containing compost/ha, T_3 = 6-ton struvite containing compost/ha, T_4 = 150kg urea/ha and other macro- and micro- nutrients. Same superscripts in different treatments groups did not differ significantly. ** P<0.01); *P<0.05) and NS=Not significant.

while basal circumference and tiller number were similar for both cultivars. However, tiller diameter and diameter of the lowest node were significantly higher in Pakchong-1. Cultivar also influenced the number of leaves per tiller. Regarding cutting period, plant height and leaves per tiller increased progressively with longer cutting periods, while other parameters such as basal circumference, tiller number, tiller diameter, and diameter of the lowest node showed no significant variation. Tarvorasak et al. (2016) conducted a study on the growth of Pakchong fodder and found significant differences in yield among different nutrient-supplied groups. They observed that as cut stems gradually died after the development of new shoots, they were excluded from the determination of plant growth. Measurements included total biomass, plant height, new shoot number, root number, root length, and average leaf area. The harvested components were fractionated into roots, stems, and leaves, then dried to a constant weight. Shoot elongation rate was calculated as the total increase in shoot length divided by the number of days elapsed during the experiment. Liu et al. (2011) studied the maize fodder yield by applying struvite along with chemical fertilizer and found an important alteration in fodder yield, plant height and stem circumference between control and struvite containing compost treated groups.

Nutritional State of the Cultivated Pakchong Fodder

The nutritional state (DM, CP, CF, EE, ash, pH, P and K) of cultivated Pakchong fodder at different treatment levels are shown in Table 4. Application of struvite containing compost at different treatments on cultivated Pakchong fodder showed significantly differed (P<0.01) on dry matter, crude protein and ether extract. The highest DM was observed in T_4 (20.09%), it was very much closer with T_2 (19.03%) and T_1 (18.87%) the lowest DM was observed in T_0 (16.43%). Similarly, the highest CP was observed in T_2 (15.06%), followed by T_4 (13.31%) and T_3 (11.63%) and the lowest CP was observed in T_0 (8.21%). In case of EE, the highest EE was observed in T_2 (6.78%), followed by T_4 (6.07%) and T_3 (6.05%) and the lowest EE was observed in T_0 (4.20%). Application of struvite containing compost at different treatments on cultivated Pakchong fodder showed significantly differed (P<0.05) pH, P and K content. The highest pH was observed in T_1 (6.69), followed by T_2 (6.63) and T_4 (6.48) and the lowest pH was observed in T_0 (6.26). Application of struvite containing compost at different treatments on cultivated Pakchong fodder showed significant differences (P<0.01) on P and K concentration. The highest P was observed in T_2 (0.28%), followed by T_3 (0.26%), T_1 (0.23%), T_4 (0.22%) and the lowest P was found in T_0 (0.17%). Similarly, the highest K was observed in T_2 (0.98%), followed by T_3 (0.89%), T_4 (0.78%), T_1 (0.77%) and the lowest P was found in T_0 (0.70%). There were no significant differences on the application of struvite containing compost on cultivated Pakchong fodder at different treatments in CF and ash content.

Liu et al. (2011) studied the maize fodder yield by applying struvite along with chemical fertilizer and found a significant difference in DM, CP, and ash content between control and struvite treated groups. Maize treated with struvite exhibited significantly higher levels of dry matter and ash compared to maize in the control group. Yetilmezsoy and Zengin (2009) found that struvite-treated garden grass yielded higher dry matter content compared to garden grass treated with P fertilizer, attributing this to the positive effects of struvite on dry matter content. Additionally, the crude protein (CP) content, a crucial quality indicator for forage, was significantly higher in the T_2 group (15.06%) compared to other groups. The P content ranges between 0.11 to 0.88% with the means of 0.26±0.04%. Differences in phosphorus (P) content observed in the present study compared to literature reports may be attributed in part to variations within and between species. Variability in P content could stem from differences among varieties and cultivars in factors influencing P accumulation in forages. Furthermore, fluctuations in available soil P and soil pH, along with the growth stage of forages, proportions of leaf and stem fractions, and the sampling season, may contribute to

these differences (Minson, 1990). Mineral contents, including P, typically decline as forage plants mature (McDowell and Valle, 2000). The k value varied from 0.09-1.27% and the mean was 0.699±0.086%. The potassium (K) content was determined to be higher than the required level, with all values falling below the maximum tolerable limit of 3% as per the National Research Council guidelines (NRC, 2001). Assumed to this, the likelihood of potassium toxicosis is low. Extensive research indicates that excess ingested potassium beyond requirements is rapidly eliminated through the renal system of dairy cattle, making potassium toxicity unlikely and not known to be a practical issue in dairy cattle. However, deficiencies in potassium can lead to reduced intake, weight loss, and stiffness in joints. Cattle subjected to stress from long-distance transportation may require elevated levels of potassium to replenish lost body reserves.

Conclusion

From this experiment, it was developed a remarkable innovation in the field of sustainable agriculture, i.e., the utilization of struvite-containing compost on Pakchong fodder. As we conclude this discussion, it is evident that this innovative approach holds immense promise for revolutionizing the way we nourish our livestock and manage agricultural resources. Pakchong fodder, has long been recognized for its nutritional value and resilience in tropical climates. Its ability to provide essential nutrients to livestock, particularly in regions with limited access to quality forage, makes it a crucial resource for the agricultural sector. However, to optimize its potential, we must address the challenges of nutrient management, sustainable practices, and environmental impact.

It was also found that maximum yield, plant height, stem circumference along with CP and EE contents were found in T_2 or 4-ton/ha application rate of struvite-containing compost. Lower application rate showed a lower yield as well as nutrient contents. On the other hand, a higher application rate (6-ton/ha) struvite-containing compost also showed comparatively lower yield and other nutrient properties. Therefore, it might be stated that 4-ton/ha struvite-containing compost would be a suitable application rate for better performance of Pakchong fodder. Finally, the utilization of struvite-containing compost on Pakchong fodder is a step towards a more resilient, productive, and sustainable agricultural future. It represents a harmonious synergy between technology, nature, and resource conservation. As we move forward, let us continue to explore innovative solutions that not only nourish our livestock but also protect our environment, secure our food supply, and foster the well-being of our communities.

Finally, we can transform our agricultural landscape into one that thrives on sustainability, innovation, and responsible stewardship of our precious resources. Therefore, the potential of struvite containing compost and Pakchong fodder to pave the way for a greener, more bountiful future in agriculture.

Competing Interests: Authors declare no competing interests exist.

Authors' Contribution: This work was carried out in collaboration among all the authors. Authors Md Mukhlesur Rahman and Md Abul Hashem has designed the study and drafted the experimental protocol. Authors Mustafizur Rahman, Md Murshed Hasan Mustafa and Yeadul Islam were executed the experiment as well as analyzed the data. Author Mahmud Hossain Sumon performed the statistical treatments and interpreted the study results. All authors read and approved the final manuscript.

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