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Effects of Biosullary Application on Soil Fertility Status and Corn (*Zea mays*) Production after Two Planting Periods

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ABSTRACT

Maize production in Indonesia faces challenges of climate change, affecting the deviation of planting seasons and overall yield stability. This study evaluates the impact of biosullary application on maize growth and yield across two planting periods using a Randomized Complete Block Design (RCBD). With twenty-one experimental units and treatments replicated three times, the study encompassed 252 plants and 63 sample plants. Findings indicate Treatment P6 consistently produced the tallest plants (199.67 cm), highest number of leaves (13.33 at planting period 1, 12.00 at planting period 2), and fastest flowering period (39.00 days at planting period 1, 45.00 days at planting period 2). P6 also showed notable cob length (11.67 cm in period 1), while Treatment P5 excelled in period 2 with 13.00 cm. Treatment P5 recorded the highest 100-seed weight (26.33 grams at planting period 1, 22.67 grams at planting period 2). To sustain maize productivity, increasing fertilizer dosage at the planting period 2 is recommended. Biosullary application not only enhances maize growth and yield but also improves soil physical properties, boosts microbial vitality, and stabilizes soil pH. These findings highlight biosullary potential as a sustainable approach to mitigate climate impacts and enhance maize production in Indonesia.

INTRODUCTION

Corn (*Zea mays*), one of the world's most widely grown cereal crops, is essential for agriculture and food production. It belongs to the grass family Poaceae and can be recognized by its tall stems with large ears full of seeds. Corn is a staple grain that can be used as human food, animal feed, and industrial activities in many parts of the world. Corn yields in Indonesia are at unpredictable levels due to climate change, which also impacts planting seasons and productivity (Herlina & Prasetyorini, 2020). Despite efforts to increase corn farming efficiency, Indonesia's low production levels are still not able to fulfil customer demand (Kholid et al., 2023).

The need for corn is expected to increase in the coming years so that it is necessary to increase productivity and land availability (Tobing et al., 2022). Soil contains good nutrients to obtain high corn yields economically. Chemical fertilizers can be misused to provide the nutrients plants need, which can endanger the environment and human health. Therefore, it is necessary to conduct research on sustainable and environmental friendly plant fertilization techniques. The Central Agricultural Statistics Agency estimates corn production in 2022 was 16.53 million tons; in 2023, the number fell to 14.77 million tons. This shows a decrease in production at 1.75 million tons according to BPS (2024).

The application of biosulllary is one viable alternative. One of the by-products of composting organic materials, such as agricultural waste and other organic waste, is biosullary. The beneficial bacteria contained in biosullary improve soil health

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and plant nutrient availability (Zone et al., 2020). Research has shown that applying potassium and phosphorus fertilizers to different crops only slightly increases their concentrations in leaf tissue, indicating the importance of nutrient management techniques (Parent et al., 2020). Notably, early plant development is not a reliable indicator of plant performance in all cases, highlighting the complexity of plant responses to nutrient provision.

Although biosullary has been studied extensively in agriculture, there is still less information regarding how it impacts to soil fertility, particularly those that were frequently planted with plants like corn. Furthermore, earlier research tended to focus on a single planting season. This study aims to bridge this gap by examining the effects of biosullary treatment on maize plants during two different planting seasons. When the impact of biosolids on soil fertility dynamics is assessed, the prospective for sustainable intensification via double cropping systems to enhance biomass and reduce nitrogen losses must be considered (West et al., 2020). Nevertheless, Sharma et al. (2020) stresses the linkage of plant growth by determining how zinc concentrations influence absorption of nutrient, soil fertility, and crop yield.

The impact of biosullary on the growth and maize yield in two planting periods is objective of this research. In detail, first and second planting periods are evaluated to determine the differences between treatments.

MATERIALS AND METHODS

From May to December 2023 on dry land in Marang Subdistrict, Pangkep Regency, South Sulawesi, the research experiment was conducted. Hybrid F1 Exotic Pertiwi maize seeds, *Gliricidia sepium*, and *Chromolaena odorata* L. were used, together with some tools such as a shovel, hand sprayer, measuring tape, watering can, bucket, analytical balance, labels, and office stationery.

The Randomized Complete Block Design (RCBD) was adopted into two planting periods. Six treatments and one control were applied and described namely the control group (P0) received no fertilizer, and the treatment groups. The treatment groups were varying doses of *Gliricidia sepium* and *Chromolaena odorata* L. with the same composition of both fertilizers, i.e. 50+50 (P1), 75+75 (P2), 100+100 (P3), 125+125 (P4), 150+150 (P5), and 175+175 (P6) kg/plot.

Each treatment was replicated three times, resulting in twenty-one experimental units. Each experimental unit consisted of twelve plants, with three sample plants per experimental unit, thus, the experiment had a total of 252 plants with 63 plant samples. The data were analyzed using analysis of variance (ANOVA) followed by mean comparison using Least Significant Difference (LSD) test at a 95% level of confident.

RESULTS AND DISCUSSION

Plant Height

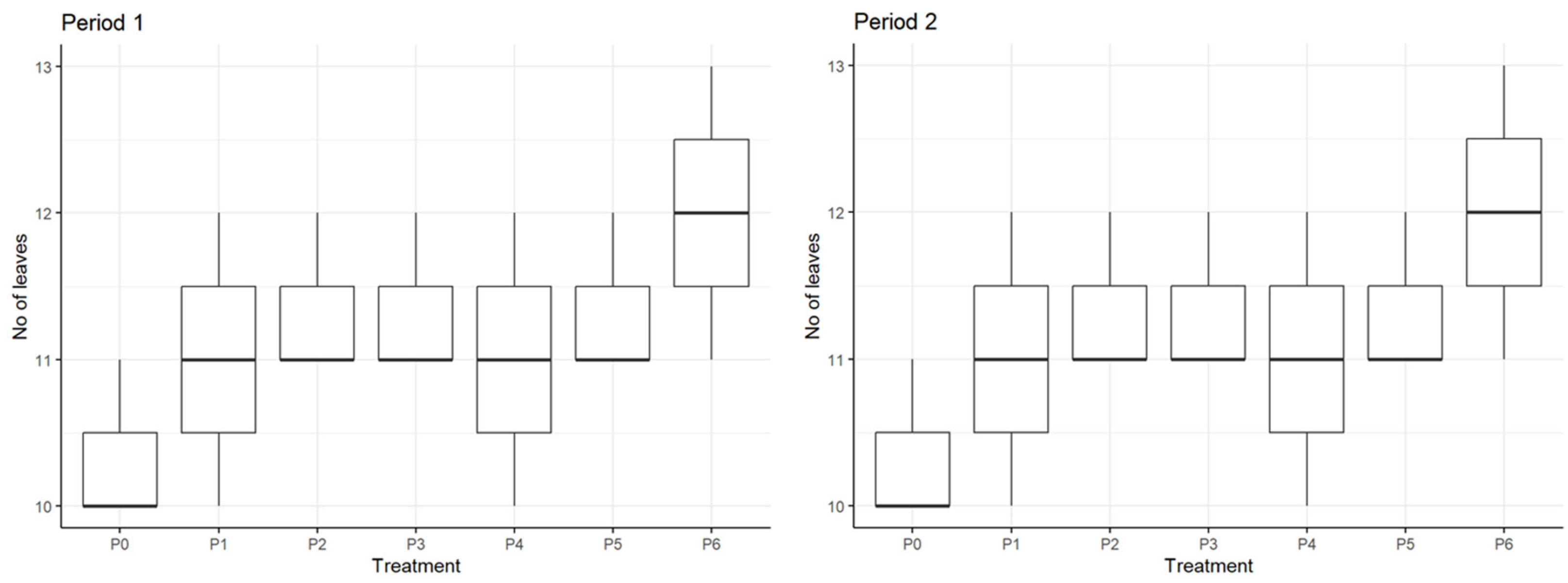
The height of maize plants was observed in two planting periods with the application of *Gliricidia sepium* and *Chromolaena odorata* L. fertilizers. The observation results are presented in Table 1. It can be seen that the height of maize plants varies within each treatment and planting period.

Table 1. Maize plant height (cm) in two planting periods with the application of *Gliricidia sepium* and *Chromolaena odorata* L. fertilizers

Treatment	Plant Height (cm)	
	Period 1	Period 2
P0	154.33±0.54a	144.33±2.42a
P1	172.33±0.98b	160.67±2.36c
P2	175.33±0.72c	168.67±0.54d
P3	170.00±0.47b	155.00±0.27b
P4	182.67±1.19d	171.00±0.94d
P5	191.33±1.52e	172.33±0.98d
P6	199.67±0.72f	176.67±0.72e

Remarks: Numbers followed by the different letters within the same column differ significantly based on LSD ($\alpha \leq 5\%$). P0 = Control; P1 included *G. sepium* fertilizer at a dose of 50 kg/plot and *C. odorata* fertilizer at a dose of 50 kg/plot; P2 applied *G. sepium* fertilizer at a dose of 75 kg/plot and *C. odorata* fertilizer at a dose of 75 kg/plot; P3 involved *G. sepium* fertilizer at a dose of 100 kg/plot and *C. odorata* fertilizer at a dose of 100 kg/plot; P4 comprised *G. sepium* fertilizer at a dose of 125 kg/plot and *C. odorata* fertilizer at a dose of 125 kg/plot; P5 included *G. sepium* fertilizer at a dose of 150 kg/plot and *C. odorata* fertilizer at a dose of 150 kg/plot; and P6 applied *G. sepium* fertilizer at a dose of 175 kg/plot and *C. odorata* fertilizer at a dose of 175 kg/plot

In the first planting period, the height of maize plants significantly increased from treatment P0 to P6. The tallest plants were recorded in treatment P6 with 199.67 cm, while the shortest plants were observed in treatment P0 with 154.33 cm. The differences of plant height among the treatments were statistically significant.



Remarks: P0 = Control; P1 included *G. sepium* fertilizer at a dose of 50 kg/plot and *C. odorata* fertilizer at a dose of 50 kg/plot; P2 applied *G. sepium* fertilizer at a dose of 75 kg/plot and *C. odorata* fertilizer at a dose of 75 kg/plot; P3 involved *G. sepium* fertilizer at a dose of 100 kg/plot and *C. odorata* fertilizer at a dose of 100 kg/plot; P4 comprised *G. sepium* fertilizer at a dose of 125 kg/plot and *C. odorata* fertilizer at a dose of 125 kg/plot; P5 included *G. sepium* fertilizer at a dose of 150 kg/plot and *C. odorata* fertilizer at a dose of 150 kg/plot; and P6 applied *G. sepium* fertilizer at a dose of 175 kg/plot and *C. odorata* fertilizer at a dose of 175 kg/plot

Fig. 1. Average number of corn leaves in two planting periods with the application of *Gliricidia sepium* and *Chromolaena odorata* L. fertilizers

Meanwhile, in the second planting period, a similar increase in maize plant height was observed from treatment P0 to P6. The tallest plants were recorded in treatment P6 with 176.67 cm, while the shortest plants were observed in treatment P0 with 144.33 cm. These differences were also statistically significant (LSD 0.05) among the treatments.

Comparison between the first and second planting periods shows a decrease in plant height in some treatments in the second planting period compared to the first planting period. However, overall, plant height tends to be higher in the first planting period. Exploring the growth response of maize plants to different fertilizers indicates significant differences in plant height based on the type of fertilizer used (Harini et al., 2021) signifying the potential impact of fertilizer choice on plant height. This is related to the use of *Gliricidia sepium* organic fertilizer that positively affects plant height (Illah, 2022).

Gliricidia sepium and *Chromolaena odorata* L. fertilizers positively induces the maize growth with best results on P6 on both planting periods. It recommends the potential effectiveness of these leaf-based fertilizers in improving maize production. In addition, the fertilizer dosage under specific planting system promotes taller plants, or plant height (Suwarti & Suwardi, 2020).

Number of Leaves (Strands)

The average number of leaves under various treatment of fertilizers at two different planting periods are presented in Fig. 1. The leaf number is a crucial indicator to be used to assess plant growth and health. Number of leaves is directly correlated with the photosynthetic leaf area that are actively conducting photosynthesis process to produce crop yield.

In period 1, there was variation in the average number of leaves among different treatments, with P6 showing the highest average number of leaves at (13.33 leaves per plant), while P0 had the lowest (11.33 leaves per plant). It's related to the role of identified treatments to stimulate leaf number of maize. Furthermore, at the second planting period, the average number of leaves per treatment decreased. However, these did not occur in all treatments. P6 shown the highest number of leaves, ca. 12.00 leaves at period 2, whereas P0 showed the lowest ca. 10.33 leaves. Pratiwi (2017) reported that *Gliricidia sepium* and *Chromolaena odorata* influences the number of leaves at different planting periods. In addition, Jjagwe et al. (2020) observed that the use of various organic fertilizers also influences yield development in maize.

Among the treatments, there were variations in the number of leaves between both periods. Buzo et al. (2022) stated the use of organic fertilizers increase the plant growth and soil health. In addition, the liquid organic vermicompost provides beneficial impacts on plant growth and yield (Muktamar et al., 2017).

Gliricidia sepium and *Chromolaena odorata* fertilizers stimulated the number of leaves in maize (Kefi et al., 2022). Additionally, the *G. sepium* in the liquid affected leaf growth (Hasan et al., 2021). Application of manure and NPK fertilizers on different soil types enhances plant growth, nutrient uptake, and maize performance as well as the organic leaf fertilizers (Sebetha & Mashele, 2019).

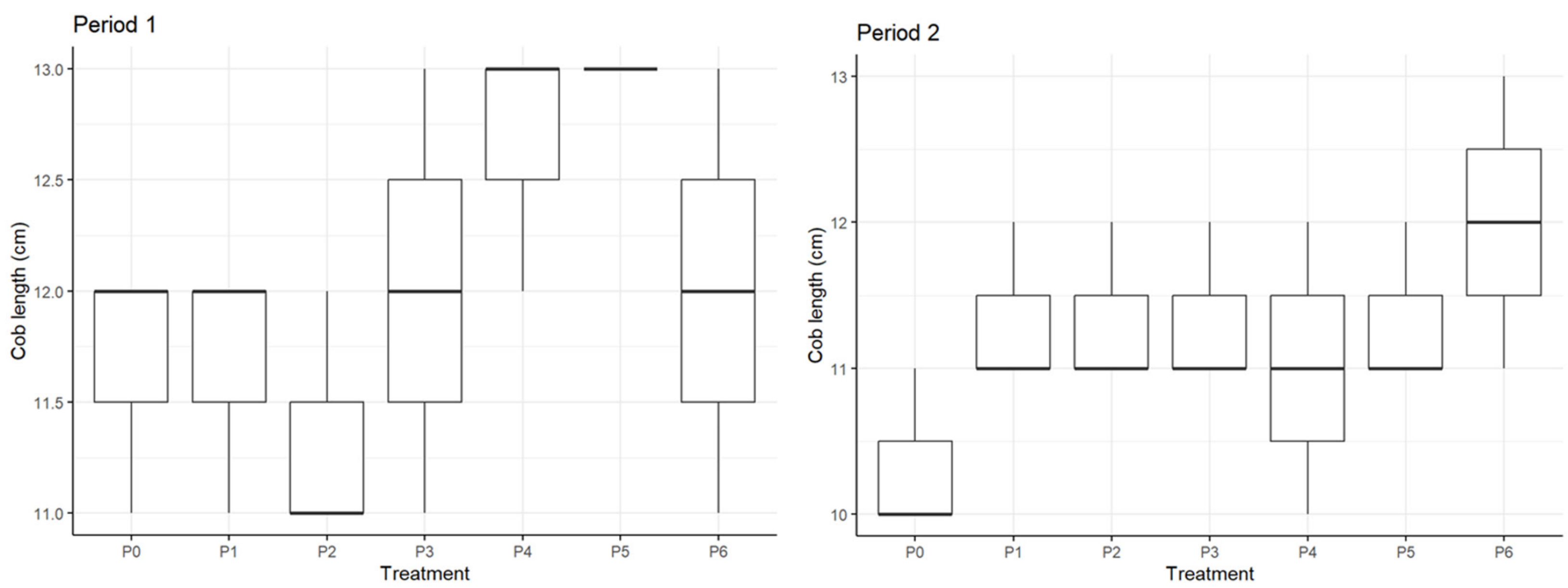
The period for 50% male flowering

The average age at which 50% of male flowering occurs at two planting periods with the application of *G. sepium* and *C. odorata* fertilizers was described in Table 2. The variations in the period of 50% male flowering were shown among the treatments and between planting periods.

At planting period 1, there were significant differences in the period for 50% male flowering among treatments, with the highest value recorded in P0 at 42.00 days and the lowest value was recorded in P6 at 39.00 days. Based on LSD, $\alpha=0.05$ (Table 2), the increasing of the period for 50% male flowering on mostly all treatments occured at the planting period 2. In these planting period, the longest period (49 DAP) was observed at P0 and the fastest (45 DAP) was observed at P6.

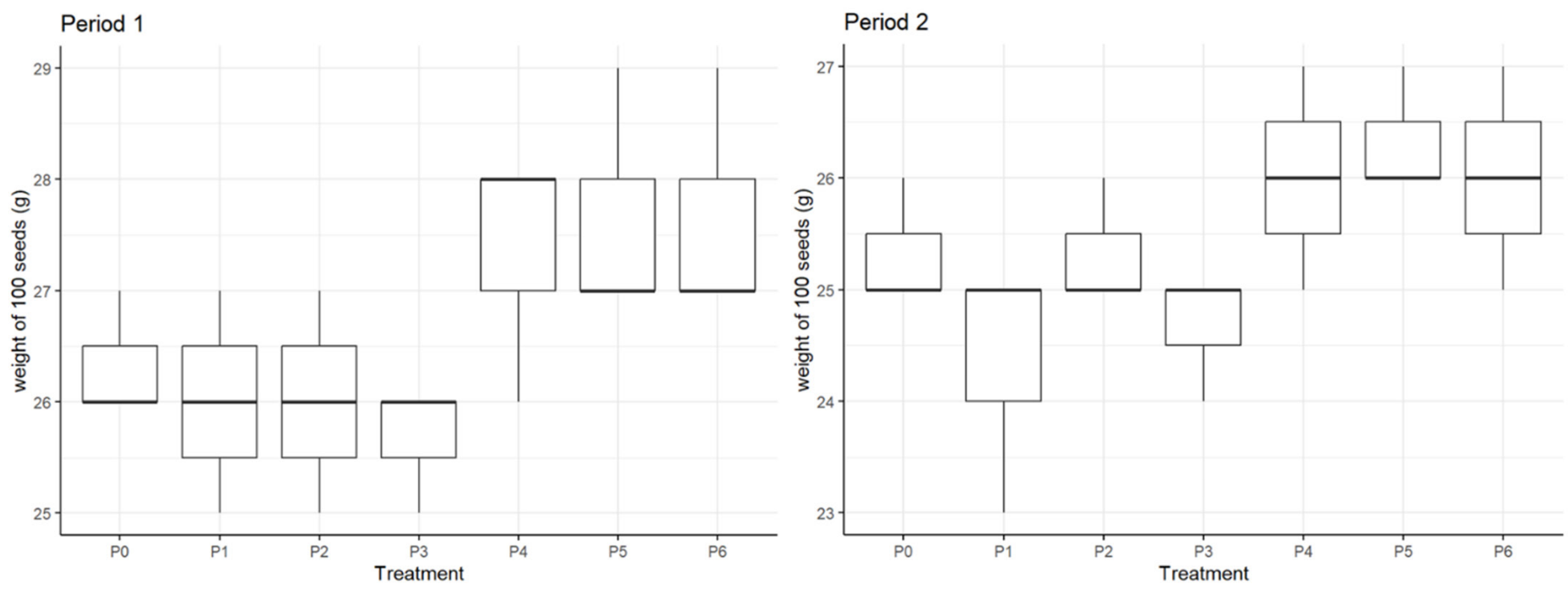
Based on Table 2, *Gliricidia sepium* and *C. odorata* leaves as an organic fertilizer provide the highest nitrogen content and increase phosphorus in maize leaves during flowering period. Galindo et al. (2016) stated that the nitrogen is important to stimulate the optimal plant development, and Karimuna et al. (2023) added that the use of green manure enriched with EM4 also promotes leaf area, dry weight, and the flowering period.

In addition, P6 stimulates the faster 50% male flowering than others. It concludes that the use of leaf fertilizers (*Gliricidia sepium* and *C. odorata*) in maize increases the flowering process. Triadiawarman et al. (2020) reported that leaf fertilizers and its dosages influence the average flowering time, and it is caused by genetic and environmental, their interactions (Purba & Hadiatry, 2022; Syafii & Ruswandi, 2019).



Remarks: P0 served as the control; P1 included *G. sepium* fertilizer at a dose of 50 kg/plot and *C. odorata* fertilizer at a dose of 50 kg/plot; P2 applied *G. sepium* fertilizer at a dose of 75 kg/plot and *C. odorata* fertilizer at a dose of 75 kg/plot; P3 involved *G. sepium* fertilizer at a dose of 100 kg/plot and *C. odorata* fertilizer at a dose of 100 kg/plot; P4 comprised *G. sepium* fertilizer at a dose of 125 kg/plot and *C. odorata* fertilizer at a dose of 125 kg/plot; P5 included *G. sepium* fertilizer at a dose of 150 kg/plot and *C. odorata* fertilizer at a dose of 150 kg/plot; and P6 applied *G. sepium* fertilizer at a dose of 175 kg/plot and *C. odorata* fertilizer at a dose of 175 kg/plot

Fig. 2. The average cob length in two planting periods was assessed with the application of *Gliricidia sepium* and *Chromolaena odorata* fertilizers



Remarks: P0 served as the control; P1 included *G. sepium* fertilizer at a dose of 50 kg/plot and *C. odorata* fertilizer at a dose of 50 kg/plot; P2 applied *G. sepium* fertilizer at a dose of 75 kg/plot and *C. odorata* fertilizer at a dose of 75 kg/plot; P3 involved *G. sepium* fertilizer at a dose of 100 kg/plot and *C. odorata* fertilizer at a dose of 100 kg/plot; P4 comprised *G. sepium* fertilizer at a dose of 125 kg/plot and *C. odorata* fertilizer at a dose of 125 kg/plot; P5 included *G. sepium* fertilizer at a dose of 150 kg/plot and *C. odorata* fertilizer at a dose of 150 kg/plot; and P6 applied *G. sepium* fertilizer at a dose of 175 kg/plot and *C. odorata* fertilizer at a dose of 175 kg/plot

Fig. 3. The average weight of 100 seeds (g) in two planting periods with the application of *Gliricidia sepium* and *Chromolaena odorata* fertilizers was examined

Table 2. Average age of 50% male flowering (DAP) under the use of *G. sepium* and *C. odorata* fertilizers at two planting periods

Treatment	Age of Flowering Male 50% (DAP)	
	Period1	Period2
P0	42.00±0.00d	49.00±0.00a
P1	41.00±0.47c	47.33±0.27b
P2	41.33±0.27c	47.00±0.00b
P3	40.67±0.27b	47.33±0.27b
P4	40.33±0.27b	46.33±0.27c
P5	40.00±0.00b	45.67±0.27c
P6	39.00±0.00a	45.00±0.00d

Remarks: Numbers followed by the different letters within the same column differ significantly based on LSD (α ≤ 5%). P0 = Control; P1 included *G. sepium* fertilizer at a dose of 50 kg/plot and *C. odorata* fertilizer at a dose of 50 kg/plot; P2 applied *G. sepium* fertilizer at a dose of 75 kg/plot and *C. odorata* fertilizer at a dose of 75 kg/plot; P3 involved *G. sepium* fertilizer at a dose of 100 kg/plot and *C. odorata* fertilizer at a dose of 100 kg/plot; P4 comprised *G. sepium* fertilizer at a dose of 125 kg/plot and *C. odorata* fertilizer at a dose of 125 kg/plot; P5 included *G. sepium* fertilizer at a dose of 150 kg/plot and *C. odorata* fertilizer at a dose of 150 kg/plot; and P6 applied *G. sepium* fertilizer at a dose of 175 kg/plot and *C. odorata* fertilizer at a dose of 175 kg/plot

Cob Length (cm)

Based on Fig. 2, at the planting period 1, P5 and P0 showed the highest and lowest cob length at 13.00 cm, and 11.67 cm respectively. At the planting period 2, P6 and P0 produce the highest and lowest one at 12.00 cm and 10.00 cm respectively. However, P5 produces 11.00 cm at planting period 2. Related to this evident, Raksun et al. (2019) mentioned that organic fertilizers influence various parameters of growth and development maize, such as cob length, the leaf number, cob length, cob diameter, and yield (Nurnawati et al., 2022).

Based on Fig. 2, the decreasing cob length at planting period 2 may be related to the fluctuations in environmental conditions, seasonal variations, or interactions with other experimental treatments. In addition, Dewanto et al. (2013) reported that organic fertilizer application provides the essential nutrients that induce the maize length cobs.

Weight of Hundred Seeds (g)

Based on Fig. 3, P5 and P6 produce higher average weights than other treatments in both planting periods, while P3 and P1 produced the lowest average weights. Related to the weight of hundred seeds, Maintang et al. (2022) stated that the proper fertilization management with suitable doses contributes to enhance maize production.

There are variations in the average weight of hundred maize kernels from the planting period 1 to the planting period 2 among the treatments. Generally, the decrease in weight of a hundred kernels was observed from planting period 1 to planting period 2, except in several treatments. Treatments P5 and P6, however, show an increase in average kernel weight from period 1 to period 2. Yuniarti et al. (2020) reported that organic fertilizer plays a significant role in influencing soil pH, phosphorus availability, phosphorus uptake, and maize yield. Related to maize growth and yield, liquid organic foliar and animal fertilizers specifically contribute to enhance maize cob length, diameter, and weight (Hasan et al., 2021; Sawen et al., 2022).

CONCLUSION

Our results show that the effect of biosullury on maize plant production is higher in the planting period 1 than the planting period 2. Therefore, it is suggested to consider the increasing of fertilization dosage at the planting period 2 to maintain the maize plant productivity. The use of biosullury could improve soil physical properties, enhance soil microbial activity, and maintain soil pH stability consistently over time. These benefits emphasize the potential of biosullury as a sustainable agricultural practice to support maize cultivation and overall soil health.

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