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Agronomic Performance of Sesame (Sesamum *indicum*) Under Different Fertilizer Management

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Abstract. The sesame crop is one of the earliest crops that is being grown for edible oil purposes. The production performance of this crop is often affected by different factors such as soil fertility, water, and climatic conditions. This study evaluated the performance of sesame under different fertilizer management like animal manure, guano, vermicast, inorganic fertilizer, and no fertilizer application as check plots. The study showed that applying guano fertilizer significantly improved plant height performance 30 to 60 days after planting compared to inorganic fertilizer, other organic fertilizers, and treatments without fertilizer application. The number of capsules per plant produced by sesame was significantly higher with guano fertilizer application compared to treatments without fertilizer application and other organic and inorganic fertilizer sources as treatments. Similarly, the yield performance of sesame under different fertilizer applications resulted in a significant performance over guano fertilizer, with the highest yield obtained compared to other fertilizer management. The different organic and inorganic fertilizers are good sources of essential nutrients for sesame production. Likewise, further study can be conducted using a fertilizer combination, both organic and inorganic, for a better fertilizer management recommendation.

Keywords: Sesame, Organic fertilizer, Inorganic fertilizer, Performance, Combination.

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INTRODUCTION

The sesame crop is scientifically known as *Sesamum indicum* L., of the family Pedaliaceae, and is considered one of the first oil crops humans use in their diet (Langyan et al., 2022). It is extensively grown and has a mellow flavor with high nutritional value, making it very popular in the diet. Sesame seeds are a rich source of protein and lipids and have many human health benefits (Wei et al., 2021). Globally, market demand for sesame consumption is increasing with increasing health awareness and the production scale is constantly expanding (Myint et al., 2019). The primary production area for sesame is Sudan, which ranks highest in sesame seed production with 1,119,026 metric tons, followed by India and Tanzania (FAO, 2022). Sesame is widely cultivated because of its highly aromatic odor and mellow flavor (Pathak et al., 2014). Sesame oil is one of the raw ingredients in manufacturing soaps, paints, perfumes, pharmaceuticals, and insecticides (Dossa et al., 2023). In general, sesame is used in various aspects of daily life, such as food, feed, and cosmetics, and it is safe for humans and animals (Wei et al., 2021).

Production of sesame requires essential nutrients for growth and development. Using organic manures and inorganic fertilizers as a nutrient source has proved a sound soil fertility management strategy in many crop-producing countries. The application of these fertilizer sources enhances crop yields and reduces the soil acidity potential which will affect crop productivity performance (Ali et al., 2023). The recommended inorganic fertilizer application rate for sesame production was 60-60-60 kg/ha, which exhibited the highest seed yield (*Braganza, 2023*). However, using synthetic fertilizers regularly may harm soil quality and health and decrease sesame yields. As part of a comprehensive strategy to achieve sustainable agriculture practices using organic fertilizer as a substitute for synthetic fertilizer, educating farmers on the benefits of organic fertilizer is

essential to keep our agricultural soils and crops productive (Fitriani et al., 2023) and significantly reduce the adverse environmental effect of chemical fertilizers (Wang et al., 2018). Application of organic and inorganic fertilizers can improve sesame plant growth, and seed yield nutrient content, and it is recommended for sesame production (Shathi et al., 2023).

The application of animal manure as an optimal fertilizer for farming has been carried out across the globe for centuries. These organic manures contain desirable nutrients like nitrogen and phosphorus, which can be used as fertilizers to produce high-yield and good-quality crop products. The utilization of cattle manure has shown promising results in crop production by enhancing plant height, grain yield, biological yield (Chew et al., 2019) and it is an effective and economical management strategy for maintaining soil fertility and reducing environmental damage (Ren et al., 2022).

Similarly, vermicast as organic fertilizer was recognized as the best alternative fertilizer to lessen the application of inorganic fertilizer. It also proved itself as a "nature's wonder product" to restore soil health and nutritional value in food (Politud, 2016). This organic fertilizer significantly improves crop agronomic performance (i.e., number of leaves, plant height, and leaf area) and soil chemical and physical properties with diverse microbial and enzymatic reactions capable of retaining readily available N, P, and K forms (Barbadillo et al., 2021).

Another organic fertilizer source with a high amount of essential nutrients for sesame is bat manure, locally known as guano is an organic fertilizer that contains elements of N, P, and K, which are important for plant growth and development and are expected to increase the essential nutrient content of soil (Fitriani et al., 2022). According to Marwa et al. (2021), bat guano is the excreta of bats that is naturally used as a soil amendment in agriculture and occasionally as a pesticide in organic farming. Farmers utilized it for indoor and outdoor plant fertilizer and hydroponic crop production substrate. Guano also acts in the soils as a carbon (C) source and energy to drive microbial activities and a precursor to soil organic matter fractions. In addition, guano is reported to contain 2-6% total nitrogen, 1.5-10% available phosphoric acid, and 1.5-10% soluble potassium.

Despite the advantages of producing sesame seeds for agriculture, the interest in producing this crop is not propagated extensively in the Philippines. Most of the production is concentrated in small-scale production with limited knowledge of production practices, especially in nutrient management strategies to boost yield performance. The availability of organic materials as a source of fertilizer for sesame production is essential to produce sesame seeds with low production costs. This study evaluated the performance of sesame production under different fertilizer sources. This research output will help the agriculture sector develop the proper fertilizer recommendations for better plant growth and yield performance of sesame production.

METHODS

The field experiment was conducted at the Dr. Emilio B. Espinosa Sr. Memorial State College of Agriculture and Technology (DEBESMSCAT), Cabitan, Mandaon, Masbate, Philippines. The experimental area has a coordinate of 12.2812°" N and 123.3569° E, 57.2 m above sea level, with minimum and maximum temperatures of 24 ^{o}C-34 ^{o}C.

The experimental design was arranged in a Randomized Complete Block Design (RCBD) with three replications and a dimension of 4.5 x 3 m or 13.5 m^2 in every fifteen (15) plots. An alley of 50 cm was also provided between treatments and replications. The experimental samples were treatment A animal manure, treatment B guano, treatment C vermicast, treatment D inorganic fertilizer, and treatment E control.

The area was thoroughly prepared by plowing and harrowing using the four-wheel tractor. After land preparation, the specific area was laid out using a planting distance of 0.75cm between furrows.

Organic fertilizers (guano manure, animal manure, vermin-cast) was applied at 10 tons per hectare before planting as basal fertilizer for sesame. For inorganic fertilizer, (60-60-60) kg/ha. 50% of the fertilizer recommendation was applied at planting, while the remaining 50% was applied 30 days after planting. The inorganic fertilizer and no fertilizer application treatments served as a check plot of the study. Weeding and thinning were done manually 30 days after planting to remove weeds and excess sesame plants per plot. Likewise, water management was also done twice a day from planting until one week before harvesting using the sprinkler irrigation method.

Harvesting operations began when most leaves had turned yellowish or 85 days after

planting. The sesame plant was cut at the base, tied in bundles, dried under the sun, and later beaten or threshed. The effects of the different fertilizer management were determined regarding plant height at 30 and 60 days after planting, number of capsules per plant, and yield in kilogram produced per plot.

The data gathered was analyzed using Statistical Tool for Agricultural Research (STAR) software version 2.0.1 developed by the International Rice Research Institute (IRRI) following the analysis of variance in Randomized Complete Block Design (RCBD) to determine the effect of treatments. Comparison among means was made using Tukey's honest significant difference (HSD) test.

RESULTS AND DISCUSSION

Plant height at 30 DAP and 60 DAP

The plant height of sesame ranged from 13.94cm to 33.43cm. The results showed that the mean height of plants at 30 DAP of sesame was statistically significant. Comparing all treatment means showed that treatments applied with animal manure, vermicast, inorganic fertilizer, and check plot were not significantly different in height performance at 30 DAP. In contrast, treatment with guano application of fertilizer was significantly different and gave a better height performance compared to other fertilizer sources (organic and inorganic fertilizer) as treatments. Likewise, at 60 DAP, sesame applied with guano obtained the highest plant height among all treatments with a total height of 113.44 cm which was statistically significant with other fertilizer treatments, followed by a treatment applied with inorganic fertilizer with a mean height of 83.99 cm, cattle manure with a mean height of 72.72 cm, and vermicast with a mean height of 62.33 cm. Likewise, the shortest height was observed in the plants without fertilizer application, with only 61.93 cm in height, respectively. Table 1. shows the height responses of sesame under different fertilizer applications.

Figure 1. General view of the experimental crop (sesame) planted at 30 days after planting.

Figure 2. View of replication I of the study. It shows the growth responses of the experimental crop (sesame) planted in different plots at 30 days after planting. Treatment randomization includes Treatment C (Vermicast) front plot, followed by Treatment D (Inorganic fertilizer) as the second plot, Treatment A (Cattle manure) as the third plot, Treatment B (Bat manure/guano) as the fourth plot, and Treatment E (Control/no fertilizer application) as the fifth plot.

Figure 3. View of replication II of the study. It shows the growth response of the experimental crop (sesame) planted at different plots at 30 days after planting. Treatment randomization includes Treatment B (Bat manure/guano) front plot, followed by Treatment E (Control/no fertilizer application), Treatment D (Inorganic fertilizer), Treatment A (Cattle manure), and Treatment C (Vermicast).

Figure 4. View of replication III of the study. It shows the growth performance of the experimental crop (sesame) planted at different plots at 30 days after planting. Treatment randomization includes Treatment B (Bat manure/guano) as the front plot, followed by Treatment D (Inorganic fertilizer), Treatment E (Control/no fertilizer application), Treatment C (Vermicast), and Treatment A (Cattle manure).

Table 1. Plant Height at 30 and 60 days after planting (cm)

Treatment	Mean (30 dap)	Mean (60 dap)
A Cattle Manure	26.14^{b}	72.72^{b}
B Bat Manure (Guano)	32.86^{a}	113.44^{a}
C Vermicast	23.50^{b}	62.33^{b}
D Inorganic Fertilizer (60-60-60)	33.43^{ab}	83.99^{b}
E Control (No Application)	13.94^{c}	61.93^{b}

The mean followed by the same letter is not significantly different at the 5% level of Tukeys's Honest Significant Difference (HSD) Test.

Growth performance, specifically the height of the sesame crop, obtained a different response as applied with different fertilizer sources. Application of bat manure or guano fertilizer resulted in a significant height performance compared to the inorganic fertilizer materials with readily available nutrient sources, other organic fertilizers, and check plots with no fertilizer

application that rely only upon the soil's existing nutrients. A similar performance was reported by Tarigan et al. (2018), that application of guano fertilizer gave the best growth responses in height and stem diameter of cacao seedlings. Similarly, Dimande et al. (2023) also found that okra crops that received high rates of guano fertilizer (10 t ha $^{-1}$) had higher plant height, number of leaves, leaf area, total wet weight, and total dry weight than the control treatment.

The significant performance of sesame under guano application was attributed to the higher nitrogen and phosphorus content which is important for early vegetative growth of the crop. The slow release of nutrients as a characteristic of organic fertilizer allows the essential elements to become readily available at crop stages that require the necessary nutrients (Reid et al., 2022).

Number of capsules/pods produced per plant

The number of capsules/pods produced per sesame plant was statistically significant among fertilizer treatments (Table 2). Guano fertilizers obtained the average number of capsules/plants with a mean of 291.33 capsules per plant, significantly different in all fertilizer treatments tested. The shortest mean was obtained by treatment with cattle manure as fertilizer, with a mean of 115 capsules/pods per plant comparable to treatments applied with vermicast, inorganic fertilizer, and treatment without fertilizer application. Furthermore, the number of capsules/pods per plant produced by sesame responds differently to the kinds of fertilizers applied.

Table 2. Number of capsules/pods produced per plant

Treatment	Mean
A Cattle Manure	115.00^{b}
B Bat Manure (Guano)	291.33^{a}
C Vermicast	114.33^{b}
D Inorganic Fertilizer (60-60-60)	149.33^{ab}
E Control (No Application)	145.00^{b}

The mean followed by the same letter is not significantly different at the 5% level of Tukeys's Honest Significant Difference (HSD) Test.

The number of capsules/pods produced per plant, yield per plot in grams, and yield in kilograms/hectare of sesame were recorded as the highest in guano fertilizer treatment compared to other sources of fertilizer used. The result of the study contradicted the study of Amare et al. (2022) that the application of synthetic fertilizer increased the plant height, the number of capsules plant^{-1}, and the yield ha^{-1} of sesame crop compared to the organic fertilizer application. However, the result was supported by the study of Karimou et al. (2020) that fertilizer applications based on bat guano are essential to improve the availability of nutrients in the soil and increase the growth and yield of tomato crops when applied with 500 kg/ha of bat guano which gave a significant difference in yield over untreated tomato plants. They further explained that the increase in the number of fruits could be attributed to the ability of bat guano to promote vigorous growth and increase meristematic and physiological activities in the plants due to the supply of plant nutrients. Furthermore, Korn et al. (2023) also revealed that the application of bat manure significantly increased growth and productivity as the amounts of bat manure applied increased.

Yield in grams per plot and kilograms per hectare

The yield per plot in grams of sesame ranged from 696.00 g to 1,069.33 g per plot. Results of the study show that the yield of sesame in grams per plot and kilograms per hectare was statistically significant among the different fertilizer management applications. The result of the study indicated that the bat manure or guano fertilizer as an organic fertilizer applied to sesame had the highest yield in grams and kilograms per hectare among all other treatments. In contrast, treatments applied with cattle manure, vermicast, inorganic fertilizer, and treatments without fertilizer treatments were significantly comparable in terms of the yield produced. The yield differences of sesame crops applied with different organic fertilizers and inorganic fertilizers are attributed to the inherent nutrient availability of each fertilizer material and its interaction with the soil properties and sesame crop. Parmar (2020), stated that organic manure application in sesame crops increases the concentration of nutrients in soil solutions favors the supply of essential nutrients, and enhances root growth and development, making them more efficient for absorbing nutrients. In general, applying organic manures increased sesame yield by improving the physicochemical properties of soil and the amount of soil essential nutrients available for absorption (Sadegh et al., 2022).

Table 3. Yield per plot in grams/plot and kilograms/ha.

Treatment	Mean (Grams/Plot)	Mean (Kg/Ha)
A Cattle Manure	847.67[b]	627.90[b]
B Bat Manure (Guano)	1,069.33[a]	791.85[a]
C Vermicast	775.67[b]	574.50[b]
D Inorganic Fertilizer (60-60-60)	977.33[b]	723.94[b]
E Control (No Application)	696.00[b]	515.55[b]

The mean followed by the same letter is not significantly different at the 5% level of Tukeys's Honest Significant Difference (HSD) Test.

This study was novel in using organic fertilizers as a good source of essential plant nutrients for sesame growth and yield performance. These organic fertilizers serve as potential alternatives for synthetic fertilizers as a typical fertilizer used in conventional farming. Utilizing these organic fertilizers in crop production will increase crop performance, enhance the soil's physical and chemical properties, and maintain the fertility of the soil, thereby improving soil productivity.

The study showed several potential benefits in the farming community by providing additional knowledge in crop fertilizer management. Using these fertilizer sources, especially organic fertilizer, in crop production will reduce the cost of farm inputs without compromising the crop performance. In addition, utilizing other fertilizer sources like cattle manure, bat manure/guano, and vermicast promotes sustainable crop production and reduces farmers' reliance on commercial fertilizers. Lastly, the research findings also contributed to the sustainable goal of agricultural production that will produce safe and nutritious food for the growing population and reduce the environmental damage due to the overuse of commercial fertilizer.

CONCLUSION

Guano manure as a fertilizer source for sesame production at 10 tons per hectare or 1 k/m^2 influenced the growth and yield characteristics of the crop compared with the inorganic fertilizer source. The result further proved that naturally occurring fertilizer sources like guano could be used as a substitute for synthetic fertilizers in conventional farming practices by farmers. Applying guano will lessen the application of synthetic fertilizer, reduce farm costs, and increase the soil's organic matter content, thereby improving the soil's physical properties.

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