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Comparative Yield Performance of Hybrid Eggplant (*Solanum melongena*) Using Vermicast Produced by Different Earthworm Species

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ABSTRACT

The study aimed to determine the performance of the vermicast produced from the three surface-dwelling earthworms, Cross Bred Earthworm, African Night Crawler (*Eudrilus eugeniae*), and Native Earthworm (*Perionyx excavatus*), on the yield of hybrid eggplant. The study was conducted at the Central Experiment Station of the Department of Research and Development of the Isabela State University-Cabagan Campus. It is envisioned to encourage farmers in producing their own fertilizer through vermicomposting and using pure organic fertilizer instead of being dependent on inorganic fertilizer. This study evaluated the use of pure organic fertilizer on the production of hybrid eggplant, particularly the variety Morena. Treatments used are the result of the nutrient analysis of the five treatments from vermicomposting, particularly the Nitrogen, Phosphorus, and Potassium (NPK), namely: T_1 – 0.61-0.13-0.40, T_2 -0.48-0.18-0.36, T_3- 0.51-0.15-0.37, T_4 – 0.60-0.11-0.42, and T_5 – 0.59-0.17-0.43. The result of the study revealed that T_2 has the highest yield with an average weight of 5.53 t/ha, followed by T_5 with 5.49 t/ha. T_1 with 4.41 t/ha, T_3 with 4.27 t/ha, and T_4 has the lowest yield with a mean weight of 4.10 t/ha. Among the five treatments, T_2 has the highest return on investment (ROI) with 314%, followed by T_5 with 311% and T_1-230%, T_3-220%, and T_4-207%, respectively. This study showed that vermicast

was still productive when used in a hybrid variety of eggplant compared to the usual use of either balanced fertilization or pure inorganic fertilizer, which has more or less the same productivity.

Keywords: *hybrid eggplant, vermicast, vermicomposting, aubergine, nightshade*

Introduction

Eggplant (*Solanum melongena L.*), also known as aubergine, is a widely cultivated solanaceous crop grown for its edible fruits and is commonly consumed as vegetables. A tender perennial of the family *Solanaceae*, eggplant is typically grown as an annual in tropical and subtropical regions. It thrives in warm climates and has been cultivated in its native Southeast Asia since ancient times. Morphologically, eggplant plants are erect and bushy, often armed with spines, bearing large ovate leaves and solitary violet flowers approximately 5 cm across. The fruit is a glossy, egg-shaped berry, varying in color from purple to white, sometimes striped, and is the source of the common name (Britannica, 2019).

Eggplant is a major vegetable crop in Asia, recognized for its dietary and economic importance, particularly among smallholder farmers. Concerns about soil degradation and long-term environmental sustainability have arisen from the use of conventional fertilizers. Consequently, there is growing interest in organic soil amendments that sustain or enhance crop yield while maintaining soil health. Vermicast, an organic product produced through earthworm-mediated decomposition, has emerged as a promising, environmentally sustainable alternative (Katiyar et al., 2023; Patel et al., 2024).

Moreover, vermicast is known to be rich in essential nutrients, humic substances, and beneficial microorganisms that enhance soil fertility, improve nutrient cycling, and support plant growth. Previous reviews have highlighted that vermicompost-based fertilizers can enhance nutrient availability, stimulate root development, and improve plant resilience to biotic and abiotic stress (Katiyar et al., 2023; Patel et al., 2024). These qualities make vermicast particularly suitable for vegetable crops such as eggplant, which respond strongly to improvements in soil quality.

Globally, eggplant ranks as the fifth most economically important solanaceous crop after potato, tomato, pepper, and tobacco (Taher et al., 2017). Beyond its economic value, eggplant contributes to human nutrition due to its low caloric content and rich composition of vitamins, minerals, and bioactive compounds. Phenolic compounds, such as anthocyanins and chlorogenic acid, possess antioxidant and anti-inflammatory properties (Ware, 2019). Phytochemical analyses have revealed the presence of aspartic acid, flavonoids, steroid alkaloids, nasunin, solasodine, oxalic acid, and ascorbic acid, which contribute to its potential roles in reducing risks of cancer, cardiovascular diseases, asthma, and hypertension (Naeem & Ugur, 2019). Furthermore, chlorogenic acid has demonstrated antimicrobial, antiviral, cholesterol-lowering, and tumor cell growth-inhibitory effects (Blackwoods, 2022).

Compared to other solanaceous crops such as tomato (Solanum lycopersicum) and pepper (Capsicum annuum), eggplant shows greater drought tolerance, making it more resilient under suboptimal irrigation conditions (Perez & Eaton, 2015). This resilience is advantageous for production in regions facing water scarcity, although yield potential remains highly dependent on proper crop management practices. Among these

practices, nutrient management plays a critical role in maximizing hybrid eggplant production. Hybrid cultivars are widely adopted due to their superior yield potential, uniformity, stress tolerance, and disease resistance. However, sustaining these advantages requires appropriate soil fertility strategies. Organic fertilizers, particularly vermicompost (also known as vermicast), have gained increasing attention as sustainable alternatives to synthetic fertilizers. Vermicompost is the stabilized byproduct of organic waste decomposition through earthworms, enriched with plant-available nutrients (N, P, K, Ca, Mg), humic substances, microbial biomass, and phytohormone-like compounds. Its application enhances soil structure, fertility, and microbial activity, thereby improving crop growth and yield (Manzoor, 2024; Wang et al., 2017). Vermicompost improved tomato yield and quality, and the biochemical properties of the soils tested during tomato planting, Xin-Xin et al. (2017).

Furthermore, balanced fertilization strategies integrating organic and inorganic sources have shown promising results. For instance, Simon and Tarun (2020) reported yields of 5.7 t/ha during the dry season using a combination of 40% organic and 60% inorganic fertilizers. Despite this, consumer preference for organically grown vegetables continues to rise, whereas farmers remain hesitant to adopt pure organic farming due to perceptions of lower yields and greater labor intensity. This highlights the need to evaluate the viability of vermicompost as a sole fertilizer input in hybrid eggplant production.

This study examined the yield performance of hybrid eggplant under various fertilization strategies, with particular emphasis on vermicompost derived from cross-bred earthworms, African night crawlers, and native earthworms (Rodriguez & Simon, 2023). The objectives were to assess the growth and yield performance of hybrid eggplant using vermicast and to conduct an economic analysis of the application of pure organic fertilizer.

The findings were compared with hybrid eggplant performance under balanced fertilization (40% organic and 60% inorganic) and pure inorganic fertilizer. Long-term field experiments in the Philippines have shown that continuous application of organic compost increases soil organic carbon, microbial biomass, and soil stability compared to chemical fertilization alone (Li et al., 2015). Building on these insights, this research would provide baseline data on the use of pure organic fertilizer in hybrid eggplant cultivation and offer a comparative economic analysis of organic and integrated fertilization systems.

Methods

Location of the Study

The study site was located within the Central Experimental Station of the Department of Research and Development of the Isabela State University- Cabagan Campus, Garita, Cabagan, Isabela, Philippines.

Production of Vermicast

The crossbred earthworms (CBE) were obtained from the offspring of the previous study on the vermicomposting performance of combined African Night Crawler (ANC) and Native Earthworm (NE) (Rodriguez & Simon, 2023). They were maintained at the Central Experimental Station (CES) of the Department of Research and Development of ISU-Cabagan. These are a mixture of 50% native earthworms and 50% African Night Crawlers. There was no evidence that these two kinds of earthworms underwent cross-breeding, but based on the vermicast produced and their offspring, they were

represented differently. This earthworm had not yet been properly named or identified by experts, but during this period, it was temporarily called a crossbred earthworm.

Native earthworms (NE) were collected from a vegetable garden in San Rafael Alto, Santo Tomas, Isabela, and raised at the CES. These earthworms were fed pre-decomposed cuttings of beans, sweet potato, rice hay, weeds, and cow manure, and were constantly watered to maintain moisture. On the other hand, the African Night Crawlers (ANC) were bought from the Payoga-Kapatagan Multipurpose Cooperative in Gamu, Isabela. The vermicast produced in the study by Rodriguez and Simon (2023) was used as fertilizer in this study to assess the yield performance of the hybrid eggplant using pure organic fertilizer.

The experiment was set up at the R&D experimental station. It was conducted during the dry cropping season. The vermicast used was taken from the production of a previous study, as treatment combinations with the same amount of recommended organic fertilizer, namely one 10-bag/ha at 50 kg/bag.

Selection of Crop Variety

A hybrid eggplant variety, particularly the Morena, was selected for the study since it is readily available from the Municipal Agriculture Nursery of the Local Government Unit (LGU) of the municipality of Cabagan. Due to their popularity with the LGU of Cabagan, these seedlings were the preferred variety and were used in the study. The characteristics of the Morena variety of eggplant were emphasized for good fruit quality, glossy skin, long shelf-life, and good transportability. Most people like this variety much more than the Fortuner variety, which is very large.

In general, the average daily temperature in Cabagan during the dry cropping season is 28 °C, which is generally suitable for eggplant growth.

Land Preparation

The area was thoroughly prepared using a hand tractor. It was plowed once and harrowed twice with a one-week interval to ensure the destruction of weeds and to provide favorable soil conditions for the crop. The land area was set up manually using garden tools such hoe and a trowel. Plastic mulch was not used to control weeds since it was dry season, and the occurrence of weeds could be easily controlled. The study area was about 120 m^2, in which 30 m^2 was allocated to each block.

Transplanting

The seedlings were transplanted strictly following the recommended planting distance of 1m x 1m. The research study area experienced three (3) typhoons during the implementation, and no replanting was done since very few died in the occurrence of typhoons. Fortunately, not all randomly selected samples are affected.

Pest and Disease Control

The research study was conducted using purely organic methods, with no pesticides applied during implementation. Some plants were affected by shoot borer infestations, and these were promptly managed by removing infected shoots and branches. As this is a baseline study, organic pesticides such as neem leaf and hot pepper extracts were not used; however, pest and disease incidence remained manageable.

Fertilizer Application

The vermicast produced from the previous study was used as organic fertilizer in the study. The vermicast from each treatment was also used in the different treatments. The treatment combinations were composed of the following: T-1 (100% CBE), T-2 (100% ANC), T-3 (50% CBE + 50% ANC), T-4 (50% CBE + 50% NE), and T-5 (70% ANC 30% NE) (Rodriguez & Simon, 2023).

The recommended fertilizer rate was used in this study, which is 10 bags per hectare. The exact amount of organic fertilizer was applied, as recommended, based on the soil analysis results for the experimental area. The nutrient analysis results were relatively low in NPK, as the substrates fed to the earthworms were composted in a 1:1:1 ratio: 100% rice hay from black rice, 100% Narra leaves, and 100% carabao manure. These agricultural wastes were pre-decomposed materials and were fed to earthworms as substrates, as they were directly available at the central experimental station during this period. Table 1 shows the results of the fertilizer analysis produced from the previous study.

Table 1. Macronutrient Contents of the Vermicast

TREATMENTS	Total Nitrogen, %N	Total Phosphorus, %P205	Total Potassium, %K20	Total Nutrients	Average Nutrient Content
T1	0.61	0.13	0.40	1.14	0.38
T2	0.48	0.18	0.36	1.02	0.34
T3	0.51	0.15	0.37	1.03	0.34
T4	0.60	0.11	0.42	1.13	0.38
T5	0.59	0.17	0.43	1.19	0.40

Note: The substrates used in the vermicomposting study were in a 1:1:1 ratio, composed of 100% animal manure and 100% rice hay (black rice), and 100% Narra leaves; hence, the nutrient content was relatively low.

To validate the performance of treatment combinations of the three earthworms on the production of the hybrid eggplant, the same amount of organic fertilizer was used on each treatment (Table 1). The fertilizer was applied in four (4) doses. Basal was applied during transplanting, with organic fertilizer placed in the hole and covered with thin topsoil at 15, 30, and 45 days, respectively.

Experimental Layout

The experiment was laid out following the Randomized Complete Block Design (RCBD) with five treatments and three (3) replicates. Each experimental plot was 2.0 m x 3.0 m, with a 1.0 m distance between plots and blocks.

All treatments within each block were selected by drawing lots. Five sample plants were selected for each treatment for data collection. Figure 1 below shows the experimental layout of the study, while Figure 2 shows the experimental setup for the research study.

Block	Plot 1	Plot 2	Plot 3	Plot 4	Plot 5
1	T3	T1	T4	T5	T2

Block	Plot 1	Plot 2	Plot 3	Plot 4	Plot 5
2	T2	T5	T1	T3	T4
3	T4	T3	T2	T1	T5

Figure 1. *Experimental Layout*

Figure 2. *Experimental Setup*

Data Collection

Data on fruit weight were collected after each harvest. Fruits from each sample plot were collected and weighed separately. Marketable and unmarketable fruits were sorted and recorded independently. Marketable fruits were sold within the campus and posted online, with orders delivered by R&D staff. Sales proceeds were deposited at the Cashier's Office. The researcher managed data recording, including weighing and sorting, to ensure data accuracy.

On the other side, the unmarketable fruits were accounted for and recorded, given to the laborers, and some were used as food, while the rest were stored at the vermicomposting facility for pre-decomposition.

Data Analysis

The data on marketable and unmarketable fruits were recorded in an Excel sheet. Sales were also recorded at the current price during this period. All production costs were properly recorded for the analysis of return on investment (ROI). The data was analyzed using Analysis of Variance (ANOVA) with Statistical Tool for Agricultural Research (STAR).

Results and Discussion

Yield of Hybrid Eggplant

As shown in Table 2, T_2 produced the highest average yield (5.53 t/ha), followed closely by T_5 (5.49 t/ha), then T_1 (4.41 t/ha), T_3 (4.27 t/ha), while T_4 had the lowest yield at 4.10 t/ha. The analysis of the data revealed no significant differences among the treatment means, but there were large differences in yield between T_2 and T_5, and between T_1, T_3, and T_4. Based on the analysis of variance, the treatments tested did not have a significant effect on the average response variable weight. The high p=0.1313 (>0.05) indicates that the observed weight variations may be due to random chance

rather than treatment effects. There was also no significant difference among the blocks with p=0.9460>0.05 (Table 3).

Table 2. Average Yield of Hybrid Eggplant

Treatments	R1	R2	R3	Total	Average (kg)	Yield/ha (t/ha)	Yield/ha
T1	515.7	273.8	533.0	1,322.5	440.8	4.41	132,250.00
T2	509.0	832.8	318.2	1,660.0	553.3	5.53	166,000.00
T3	243.8	708.0	330.2	1,282.0	427.3	4.27	128,200.00
T4	428.7	542.5	260.3	1,231.5	410.5	4.10	123,150.00
T5	627.5	497.7	522.0	1,647.2	549.1	5.49	164,716.67

**Not Significant*

Table 3. ANOVA of the Average Weight of the Marketable Fruits of Hybrid Eggplant

Source	DF	Sum of Squares	Mean Squares	F Value	Pr (> F)
REP	2	173465.3613	86732.6807	2.65	0.1313
TREATMENT	4	22714.2293	5678.5573	0.17	0.9460
ERROR	8	262291.5587	32786.4448		
Total	**14**	**458471.1493**			

The computed yield using pure organic fertilizer (5.53 t/ha) was slightly lower than that of the balanced fertilization strategy combining 40% organic and 60% inorganic (5.70 t/ha) (Simon & Tarun, 2020). The result also shows that the yield of 5.53 t/ha was higher than the 4.05 t/ha reported by Simon and Tarun (2020) during the dry cropping season. The use of vermicast in this study also proves that it enhances soil structure, fertility, and microbial activity, and improves crop growth and yield (Manzoor, 2024; Wang et al., 2017). Despite the research study being affected by three typhoons during its conduct, the rain brought more moisture, resulting in more fruit production.

Furthermore, this also shows that the application of pure organic fertilizer remains economical compared to a balanced fertilization strategy (Concepcion et al., 1999; Tarun & Simon, 2020). Moreover, both used and pure organic fertilizers have been shown to achieve high survival rates and increased yields, as they enhance soil moisture and aeration, thereby increasing plant survival (Xin-xin et al., 2017). Based on the researcher's observations, very few plants died during the study, despite extreme drought. The typhoon brought additional moisture during the fruiting season.

Moreover, the vermicompost produced from African Night Crawler (ANC) has low nutrient content with a mean of 1.02 (N-0.48, P-0.18, K-0.36, 100% ANC); however, it has the highest Phosphorus content compared to other treatments (Table 1). Moreover, the research study experienced at least three (3) typhoons, and the vermicast from the ANC was the finest among the vermicasts produced from Cross Bred Earthworm (CBE) and Native Earthworm (NE). The vermicast from the ANC have been dissolved quickly and easily absorbed by the eggplants, whereas other applied vermicast, which is relatively coarse in texture, took longer to dissolve and be absorbed by the plants.

The results indicate that small-scale farmers can benefit economically from using pure organic fertilizer rather than relying solely on inorganic fertilizers, which may

negatively impact human health and soil quality. Additionally, the study demonstrates that small-scale farmers can produce their own organic fertilizer for use in their gardens. Vermicast, an organic product produced through earthworm-mediated decomposition, has emerged as a promising, environmentally sustainable alternative and/or organic soil amendments that sustain or enhance crop yield while maintaining soil health (Katiyar et al., 2023; Patel et al., 2024).

Unmarketable Fruits

Table 4 shows that T_3 has the highest unmarketable value with an average weight of 1.65 t/ha, followed by T_5 with an average weight of 1.28 t/ha, T_2 with an average weight of 1.27 t/ha, T_1 with an average weight of 1.22 t/ha, and T_4 has the lowest nonmarketable value with a mean of 0.90 t/ha.

The analysis of the data revealed no significant difference among the treatment means for nonmarketable values. The ANOVA results revealed no significant treatment effect on the average weight of nonmarketable fruits ($p = 0.7013$), indicating that the treatments performed similarly in terms of average weight. Likewise, the replication effect was not significant ($p = 0.7077$), suggesting uniform environmental conditions across blocks.

Table 4. Weight of Nonmarketable Fruits of Hybrid Eggplant (kg)

Treatments	R1	R2	R3	Total	Average (t/ha)
T1	1,153.3	833.3	1,678.3	3,665.0	1.22
T2	1,168.3	,916.7	740.0	3,825.0	1.27
T3	708.3	2,291.7	1,945.0	4,945.0	1.65
T4	570.0	1,010.0	1,120.0	2,700.0	0.90
T5	1,781.7	631.7	1,440.0	3,853.3	1.28

**Not significant*

Table 5. ANOVA of the Average Weight of Nonmarketable Fruits of Hybrid Eggplant

Source	DF	Sum of Squares	Mean Squares	F Value	Pr (> F)
Rep	2	2755.1293	1377.5647	0.36	0.7077
Treatment	4	8476.7773	2119.1943	0.56	0.7013
Error	8	30517.2907	3814.6613		
Total	**14**	**41749.1973**			

Based on the recorded unmarketable fruits, there was a moderately high rate of unmarketable fruits due to the attack of pests and diseases. Although most of the insects were shoot borers and fruit worms, very few were wasted, as the researchers and workers still chose the good ones for home consumption, and the rest were segregated for vermicomposting. The unmarketable fruits were not included in the computed yield, even though they were consumed. This also means that organic pesticides, such as diluted neem leaves and diluted hot pepper, are needed to increase production. Moreover, natural pesticides such as marigolds can be planted between rows or along the edges of the vegetable beds to provide natural pest control.

Cost and Return Analysis

Table 6 shows the simple computation of the return on investment, with T_2 having the highest ROI of 314%, followed by T_5 (311%), T_1 (230%), T_4 (220%), and T_3 (207%).

Table 6. Cost and Return Analysis

Particulars	**T1**	**T2**	**T3**	**T4**	**T5**
I. Inputs					
A. Labor Cost					
Plowing (3000/Ha/Tractor)	3000.00	3000.00	3000.00	3000.00	3000.00
1st Harrowing (2500/Ha/Tractor)	2500.00	2500.00	2500.00	2500.00	2500.00
2nd Harrowing (2500/Ha/Tractor)	2500.00	2500.00	2500.00	2500.00	2500.00
Pulverizing of soil (Hand Tractor)	800.00	800.00	800.00	800.00	800.00
Planting (10 MD/400)	2000.00	2000.00	2000.00	2000.00	2000.00
Fertilizer Basal (5 MD/400)	2000.00	2000.00	2000.00	2000.00	2000.00
Hilling Up (10 MAD/400)	4000.00	4000.00	4000.00	4000.00	4000.00
Weeding (30 MD/400)	12000.00	12000.00	12000.00	12000.00	12000.00
Irrigation	1200.00	1200.00	1200.00	1200.00	1200.00
Harvesting (5 MD/400)	2000.00	2000.00	2000.00	2000.00	2000.00
Sub-total	**32000.00**	**32000.00**	**32000.00**	**32000.00**	**32000.00**
B. Supplies and Materials					
Diesel (Hand Tractor)	600.00	600.00	600.00	600.00	600.00
Vermicompost at 250/50 kgs	7500.00	7500.00	7500.00	7500.00	7500.00
SUB-TOTAL	8100.00	8100.00	8100.00	8100.00	8100.00
Total	**40100.00**	**40100.00**	**40100.00**	**40100.00**	**40100.00**
II. Output					
Yield (kg/ha)	4,408.33	5,533.33	4,273.33	4,105.00	5,490.56
Gross Income (P30/kg)	132,249.90	165,999.90	128,199.90	123,150.00	164,716.80
III. Income Analysis					
Net Income	92,149.90	125,899.90	88,099.90	83,050.00	124,616.80
ROI	230%	314%	220%	207%	311%

The difference in the yield of eggplant between Treatment 1 and Treatment 2 was relatively low, with an average weight of 5.53 t/ha and 5.49 t/ha, but it was relatively high compared to T_2 with a mean weight of 4.41 t/ha, T_3 with 4.27 t/ha, and T_4 with

4.10 t/ha. Compared to the previous study by Tarun and Simon (2020). The highest yield during the dry season was 5.70 t/ha with 40% inorganic and 60% organic. The use of pure organic fertilizer was shown to yield returns on investment of 314% and 328% (Tarun & Simon, 2020).

Although there was no significant difference among the treatment means, all treatments yielded high returns on investment (Table 2 and Table 6). The application of pure vermicompost fertilizer yielded high yields of hybrid eggplant, particularly the Morena variety, during the dry cropping season. Farmers may consider investing in vermicompost fertilizer as an alternative to inorganic fertilizers, which entail higher costs and possible health risks.

Conclusion and Future Works

The study found that using vermicast or pure organic fertilizer yields good economic returns for growing hybrid eggplant varieties, such as Morena. Although there were no significant differences among the treatment means and blocks, the observed range was considerable: the yield with balanced fertilization (40% organic + 60% inorganic) was 5.70 t/ha, compared with 5.53 t/ha for the pure organic treatment. This also showed that local farmers can use organic fertilizer to grow hybrid eggplant, reducing their reliance on inorganic fertilizer, which can be detrimental to the soil.

Among the different NPK treatments derived from vermicomposting, Treatment 2 (Vermicast from African Night Crawler) has the highest yield, with a mean weight of 5.53 t/ha. Moreover, the vermicast applied in this research also has a very low NPK content due to the feeding materials used in vermicomposting.

On the other hand, Treatment 2 achieved the highest return on investment (ROI) at 314%, as the earthworms were collected from nearby backyards at no purchase cost, with labor being the only expense. The vermicompost fertilizer produced from African Night Crawlers was the best for producing vermicast and yielded the highest yields when planted with a high-yielding eggplant variety, especially Morena.

Thus, using pure vermicompost fertilizer to produce a hybrid eggplant variety is recommended as it offers a high return on investment and provides health benefits. In the absence of vermicast from African Night Crawlers, Native Earthworms are also recommended, as they offer a good yield and a high return on investment.

Since the study uses only one eggplant variety, for an in-depth study, we recommend using different hybrid eggplant varieties, such as Fortuner. The study was also conducted during the dry cropping season, and it is recommended to conduct the study during the wet cropping season. Planting Marigolds along the borders of vegetable plantations and the use of integrated pest management, including spraying diluted neem leaf and hot pepper extracts, are also suggested to reduce pest and disease incidence and increase production.

In the absence of inorganic fertilizer, especially in remote areas, farmers can still use pure organic fertilizer from vermicomposting using Native earthworms and African Night Crawlers. In vermicomposting, using goat, cow, and horse manures, as well as banana, legume, and vegetable waste is likewise recommended to increase the NPK content of the vermicast.

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Conflict of Interest

The authors declare that they have no conflict of interest in the publication of this research paper. No financial or personal relationships with other people or organizations have influenced the conduct of this research or the preparation of this manuscript.

Artificial Intelligence (AI) Declaration Statement

During manuscript preparation, the researchers used ChatGPT, particularly for polishing and editing the introduction section. They also utilized it to make their research article more presentable and grammatically correct, although most of the work was carried out by the researchers themselves with the aid of online references.