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Effect of organic manure and seasons on pungency of two varieties of pepper (*Capsicum spp*. L.) In Rivers State, Southern Nigeria

Azubuike A A*, Jaja ET, Ajuru M G, Amadi N
Department of Plant Science and Biotechnology, Rivers State University, Nkpolu-Oroworukwo, P.M.B. 5080 Port Harcourt, Rivers State, Nigeria
Corresponding Author: Azubuike A A
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Abstract
Pepper is a crucial fruit and vegetable that is grown for commercial purposes due to it pungency. This study therefore examined the impact of goat, and pig dung on the pungency of habanero, and chili, pepper varieties while taking into account the effects of seasons (wet and dry seasons). The study was carried out in the Department of Plant Science and Biotechnology, Rivers State University, Port Harcourt, Nigeria. Pepper seeds were nursed, and later transplanted to different perforated 10L polythene bags containing soil that was amended with different rates of goat, and pig dungs. The fruit pungency was measured at ripened stage by using spectrophotometric method. Results showed that: habanero had the highest pungency (13,519.89±1.32), than chili (893.93±0.24), for habanero pepper, the highest pungency (28,325.60±1.31) was recorded in the soil amended with 300g of goat dung during the dry season, while the least (0.00) was recorded in the control during the wet season; for chili pepper, the highest pungency (2,369.75±1.22) was recorded in the soil amended with 300g of goat dung during the dry season, while the least (0.00) was recorded in the control during the wet season; The application of goat, and pig dungs increased the pungency of the various pepper varieties, with the wet and dry seasons having a substantial impact. The use of goat dung is highly recommended in situations where raising the pungency level is the aim of pepper cultivation.

Keywords: Cow dung, goat dung, organic manure, pig dung, pungency

Introduction
In the tropics, pepper is a crucial fruit and vegetable that is grown for commercial purposes, and in Nigeria, it is one of the most widely produced crops in the genus Capsicum after tomatoes (Mustapha *et al*., 2021) [17], while potatoes, tobacco, and petunias are other significant members of this genus (Abu *et al*., 2020) [2]. As a member of the Solanaceae family, pepper is thought to have originated in tropical America before spreading to Europe and ultimately the entire world (Mustapha *et al*., 2021) [17]. There are five domesticated species and twenty-two wild species in the genus Capsicum, and according to George and Enyi-Onwugbuta (2023) [9], the five domesticated species are: *Capsicum annuum*, *Capsicum frutescens*, *Capsicum chinense*, *Capsicum baccatum*, and *Capsicum pubescens*. However, *C. annuum* is the most widely grown variety worldwide (Umeri *et al*., 2024) [26]. Pepper is also called other names like sweet pepper, bell pepper, cherry, paprika pepper, and pimento pepper (Umeri *et al*., 2024) [26].
The most popular variety of peppers in field gardens are sweet green bell-shaped peppers that, when allowed to ripen, turn red, yellow and orange and gain varying degrees of sweetness depending on the variety (Mustapha *et al*., 2021) [17]. Sweet peppers are less strong than hot (chili) peppers; they have smooth, hairless leaves, an unpredictable branching stem, an unsocial white flower that appears at each node, and fruits with hollow berries that vary in size and shape based on the nutrient status and ecology of their production (Akinnifesi *et al*., 2023) [3]. The extremely hot pepper varieties, known as chilies, have a high content of the alkaloid capsaicin, which gives them their pungency or spicy taste (Umeri *et al*., 2024) [26].
To boost pepper production, the use of inorganic fertilizers have been employed by farmers; however, this comes with a lot of agricultural and environmental challenges (Mustapha *et al*., 2021; Umeri *et al*., 2024) [17, 26]. In order to address a number of these issues, the use of organic fertilizers (especially livestock manures) is becoming more widely acknowledged as a sustainable substitute for synthetic fertilizers (Almeida *et al*., 2019; Odeje and Omogoroye, 2025) [4, 20]. Organic fertilizers are fertilizers that come from both urban and rural waste sources, including domestic waste, livestock manure from animal husbandry, plant residues from agriculture (like straw, green manure, and cake fertilizer), and similar sources (Wang and Cui, 2024; Li *et al*., 2025) [14, 29]. These fertilizers give plants a wide range of vital inorganic and organic nutrients due to their high organic matter content (Graves *et al*., 2019; Wang and Cui, 2024; Liao *et al*., 2025) [10, 14, 29], and have a lot of potential for improving plant development in the soil environment (Liu *et al*., 2026) [15].
Animal manure (AM) which is a form of organic manure have been reported to improves soil organic matter, microbial activity, and nutrient dynamics, meeting environmental quality standards and lowering dependency on mineral fertilizers in addition to providing phosphorus, calcium, magnesium, and potassium (Almeida *et al*., 2019; Abid *et al*., 2020) [1, 4]. Notably, AM from ruminants like cows and goats breaks down more slowly, releasing nutrients gradually due to their increased fiber content (Zhu, 2019) [34]. A valuable organic fertilizer that can improve nutrient availability and promote plant growth is goat dung which is a byproduct of goat farming (Abdulkareem *et al*., 2024). Also, pig manure, on the other hand, provides a middle ground in terms of nutrient content and

decomposition rate but is less frequently used (Kacprzak *et al*., 2022) [11].

Additionally, despite the variations in the properties of organic manure, comparative research evaluating the effects of different livestock manures on the pungency of various pepper varieties is still lacking. This study therefore examined the impact of goat, and pig dung on the pungency of habanero and chili pepper varieties while taking into account the effects of seasons (wet and dry seasons).

Materials and Methods

Experimental site the study was carried out in the Department of Plant Science and Biotechnology, Rivers State University, Port Harcourt, Nigeria (4.804 ^{o}N, 6.980 ^{o}E). The screen house of the department was used for the nursery, while the botanical garden was used for the field experiment. The experimental site has an annual temperature range of 25-27 ^{o}C, annual rainfall of 2,400mm, relative humidity of 78-89% and solar radiation averaging 4 hours daily. The environment is humid, having distinct rainy and dry season. Generally, rains begin in the month of March and may extend into early December, with a few showers occurring in this closing month. However, the actual plantings generally begin in April for most places. Crops grown are predominately tubers and cereals, with legumes coming into the cropping systems in the second half of the cropping season.

Seed Sources, Collection, and Preparation of Organic Manures

Seeds of two (2) varieties of pepper (Chili and Habanero) were sourced from Rivers State Agricultural Development Project (ADP), Port Harcourt and used in this study. The organic manures (goat and pig dung) that were used in this study were obtained from Agricultural Farm in the Rivers state University, Port Harcourt. The manures were air dried under shade, crushed and sub sample taken for laboratory analysis.

Experimental Design and Treatments

The experiment was laid out as factorial experiment in a completely randomized design (CRD) replicated three times.

Factor levels

Factor 1: Two (2) varieties of pepper (habanero and chili).
Factor 2: Four rates of goat dung (0g, 100g, 200g and 300g).
Factor 3: Four rates of pig dung (0g, 100g, 200g and 300g).

Nursery Establishment

The experiment was carried in the wet season (July to September, 2025) [24] and in the dry season (December, 2025 [24], to February, 2026). The first nursery for the wet season experiment was established in July, 2025 [24], while the second nursery for the dry season experiment was established in December, 2025 [24]. Prior to starting the experiment, the seeds were sorted: broken seeds were discarded and good quality seeds were chosen for further use in the establishment of the nursery. The seeds' surface was sterilized with a 0.2% Hg_2Cl solution for 3 minutes, rinsed in distilled water thoroughly, and left to dry at room temperature (25 ▪C). Polythene bags (10L capacity) were perforated at the bottom to allow for easy drainage and facilitate aeration, and 100 kilograms of the 4 mm sieved soil was measured into each of the polythene bags. The appropriate treatment was applied, then, four seeds were sown directly into 2 cm depth soil in each of the bags. The experiment was carried out in the screen house of the Department of Plant Science and Biotechnology, Rivers State University, before moving them to the botanical garden of the same department.

Field Establishment and Agronomic Practices

At 14 Days After Sowing (DAS), all the bags were carefully moved to the botanical garden of the department of Plant Science and Biotechnology, Rivers State University. Thinning was done to ensure that only one seedling are established in each bag and handpicking of weeds was done as often as required to ensure that no weed grows in each of the bags.

Determination of Pungency

The unit of pungency is Scovill Heat Unit (SHU)

Spectrophotometric Method was used for determining Pungency of Pepper Materials: Dried pepper sample, Ethanol or acetone (solvent), Spectrophotometer Filter paper, Volumetric flask, Pipette, Mortar and pestle or grinder

Step-by-Step Procedure

1. **Sample Preparation:** The Dry pepper fruit pungency was thoroughly grinding into a fine powder.
2. **Weigh the Sample:** Accurately weigh about 1 g of the powdered sample.
3. **Extraction of Capsaicin:** Transfer the sample into a flask, add 10–25 mL of ethanol or acetone and shake or stir for about 15–30 minutes to extract capsaicinoids.
4. **Filtration:** Filter the mixture using filter paper, collect the clear extract (this contains capsaicin).
5. **Dilution:** Dilute the extract to a known volume using solvent (if necessary).
6. **Set Up Spectrophotometer:** Turn on the spectrophotometer set, wavelength to about 460 nm (common for capsaicin analysis). Use solvent (ethanol/acetone) as blank to zero the instrument.
7. **Measure Absorbance:** Pour the sample extract into a cuvette, place it in the spectrophotometer, Record the absorbance value (A). (Augustine Aniefiok Pilate ,2026) [6]

Data Analysis

Data collected were subjected to analysis of variance (ANOVA) using Minitab statistical software version 21. Treatment means were separated using least significant difference (LSD), and the result s were presented as mean ± standard dev

Results

Pungency of Habanero Pepper at Different Seasons

The result of the pungency of habanero pepper during the wet and dry season is shown in Table 1: The highest pungency (28,325.60±1.31) was recorded at 300g of goat dung during the dry season, and the least (0.00) was recorded at the control during the wet season; in 100g, and during the dry season, the highest pungency (20,165.96±3.13 was recorded at 100g , and the least (16,900.37±14.50) was recorded in 100g; in soil amended

with goat dung, during the wet season, the highest pungency (26,469.55±71.54) was recorded at 300g, and the least (18,962.72±1.38) was recorded at 100g, and during the dry season, (19,895.02±0.56) was recorded in 100g; in soil amended with pig dung during the wet season, the highest pungency (23,581.46±0.99) was recorded at 300g, and the least (15,309.32±1.29) was recorded at 100g, and during the dry season, the highest pungency (24,260.75±1.60) was recorded at 100g and the least (17,141.06±1.70) was recorded in 100g; in the control, the highest pungency (13,674.17±0.48) was recorded during the dry season while the least (0.00) was recorded during the wet season; and significant difference was recorded in the pungency during the wet season (P = 0.000) and dry season (P = 0.000).

Table 1: Pungency of Habanero Pepper during the Wet and Dry Season

	Habanero	
Treatments	**Wet Season**	**Dry Season**
100g CD	14,729.29±1.61 ^{i}	16,900.37±14.50 ^{i}
200g CD	16,814.53±1.11 ^{g}	18,758.15±24.41 ^{g}
300g CD	19,222.71±2.64 ^{d}	20,165.96±3.13 ^{d}
100g GD	18,962.72±1.38 ^{e}	19,895.02±0.56 ^{e}
200g GD	22,941.67±1.20 ^{c}	24,576.51±7.94 ^{b}
300g GD	26,469.55±71.54 ^{a}	28,325.60±1.31 ^{a}
100g PD	15,309.32±1.29 ^{h}	17,141.06±1.70 ^{h}
200g PD	18,264.86±0.24 ^{f}	19,673.00±3.61 ^{f}
300g PD	23,581.46±0.99 ^{b}	24,260.75±1.60 ^{c}
Control	0.00	13,674.17±0.48 ^{j}
LSD	9.46	.21.46

Key: Means with different superscripts within the same row are significantly different ($P \leq 0.05$) and **indicates significant difference

Pungency of Chili Pepper at different Season

Table 2: shows the result of pungency of chili pepper during the dry and wet season. The highest pungency (2,369.75±1.22) was recorded at 300g of goat dung during the dry season, and the least (0.00) was recorded in the control during the wet season (1,239.77±1.47) was recorded in 100g; in soil amended with goat dung during the wet season, the highest pungency (2,139.69±1.76) was recorded at 300g, and the least (1,209.82±1.47) was recorded at 100g, and during the dry season, the highest pungency (2,369.75±1.22) was recorded at 300g and least (1,370.77±0.50) was recorded at 100g; in soil amended with pig dung during the wet season, the highest pungency (1,840.07±0.38) was recorded at 300g, and the least (1,199.92±2.56) was recorded at 100g, and during the dry season, the highest pungency (2,180.24±1.81) was recorded at 300g and the least (1,349.85±1.02) was recorded at 100g; in the control, the highest pungency (924.92±0.12) was recorded during the dry season while the least (0.00) was recorded during the wet season; and significant difference (P = 0.000) was recorded in the pungency during the wet season and dry season respectively.

Table 2: Pungency of Chili Pepper during the Wet and Dry Season

	Chili	
Treatments	**Wet Season**	**Dry Season**
100g CD	958.87±8.33 ^{i}	1,239.77±1.47 ^{i}
200g CD	1,131.07±0.77 ^{h}	1,419.76±1.88 ^{f}
300g CD	1,286.27±1.59 ^{e}	1,570.14±0.51 ^{e}
100g GD	1,209.82±1.47 ^{f}	1,370.77±0.50 ^{g}
200g GD	1,782.385±1.67 ^{c}	1,962.43±1.22 ^{c}
300g GD	2,139.69±1.76 ^{a}	2,369.75±1.22 ^{a}
100g PD	1,199.92±2.56 ^{g}	1,349.85±1.02 ^{h}
200g PD	1,470.99±2.02 ^{d}	1,681.59±1.17 ^{d}
300g PD	1,840.07±0.38 ^{b}	2,180.24±1.81 ^{b}
Control	0.00	924.92±0.12 ^{j}
LSD	9.46	2.728

Key: Means with different superscripts within the same row are significantly different ($P \leq 0.05$) and **indicates significant difference

Discussion

The use of organic fertilizers (especially animal manures) is becoming more widely acknowledged as a sustainable substitute for synthetic fertilizers as a means to address a number of agricultural issues associated with the use of synthetic fertilizers (Odeje and Omogoroye, 2025) [20]. Animal manure (AM) in addition to providing phosphorus, calcium, magnesium, and potassium, improves soil organic matter, microbial activity, and nutrient dynamics, meeting environmental quality criteria and lowering dependency on mineral fertilizers (Almeida *et al*., 2019) [4]. In this study, animal manures (specifically goat dung, and pig dung) were used at different rates as soil amendments and their effects on pungency of different varieties of pepper were investigated during the wet and dry seasons.

The result of the pungency of the different varieties of pepper showed remarkable effects of the application of different organic manure types and rates (Tables 1 to 4). For dry season, the findings showed that applying goat, and pig dung enhanced the pungency of habanero, and chili peppers. Pungency rose with increasing manure application rate (100 g < 200 g < 300 g) in all the two pepper cultivars, indicating that organic manure had a favorable effect on capsaicinoid accumulation. Additionally, goat dung consistently yielded the greatest pungency scores, followed by pig dung.

In all two cultivars and under all two manure sources, pungency gradually increased with increasing application rates from the 100g to the 200g to the 300g This demonstrated a definite dose-dependent stimulation of capsaicinoid biosynthesis by the supply of organic nutrient. This finding is related to the fact that Vanillylamine, which is derived from phenylalanine through the phenylpropanoid pathway, condenses to form capsaicinoids, which are nitrogenous alkaloids with a branched-chain fatty acyl moiety derived from valine (Naves *et al*., 2019 [19]; Arce-Rodríguez and Ochoa-Alejo, 2019) [5]. Also, the amino acid pool of pepper plant is directly used in their synthesis, and any treatment that increases this pool in the placenta, which is the primary site of capsaicinoid accumulation, may be anticipated to increase capsaicinoid output. This assertion was directly supported by Zhang *et al*. (2020) [33], who demonstrated that nitrogen absorbed through the glutamine synthetase–glutamate synthase (GS–GOGAT) pathway is directed into capsaicin and dihydrocapsaicin in placental tissue, with GS and GOGAT activities positively correlated with capsaicinoid synthase activity and with AT3 and FatA transcript abundance. In contrast to findings in the controls in this study, Zhang *et al*. (2024) [32] found that nitrogen application increased placental mass and up-regulated PAL, AT3, 4CL, C4H, COMT, PAMT, and HCT, increasing capsaicinoid content by more than 100%. The same precursor-supply mechanism is consistent with the increase in pungency with increasing amounts of manure reported in this study.

Contrary to findings in this study, recent research showed a quadratic relationship between pungency and nitrogen supply, with capsaicinoid content peaking at an intermediate rate and then declining (Zhang *et al*., 2024; Viana *et al*., 2026) [27, 32]. This decrease at high nitrogen rates is explained by a growth-defense trade-off that posited that excessive nitrogen encourages the accumulation of lignin, flavonoids, and tannins, which compete with capsaicinoids for the same phenylpropanoid precursors, and it favors vegetative growth over secondary metabolism (Zhang *et al*., 2024) [32]. While Zamljen *et al*. (2022) used a labeling of 15N to show that nitrogen status, water availability, and capsaicinoid content are closely correlated in capsicum, Zamljen, *et al*. (2022) [7]

In this study, goat dung produced the highest pungency values across the cultivars and application rates, then pig dung at an intermediate level, all of which were higher than the control. Therefore, it is accurate to say that the effectiveness of the organic amendments is goat dung > pig dung > control. For instance, 300 g of goat dung increased the pungency of chili pepper to about 2,140 SHU, compared to about 1,840 SHU for pig dung and about 1,285 SHU. This ordering was consistent across cultivars and rates, suggesting that it is not a product of a specific genotype or dosage.

By implications, goat dung applied at 300 g per plant was found to be the most effective treatment for increasing pungency for growers of pungent pepper varieties. In small holder systems, where mineral fertilizer is costly and frequently hard to obtain, livestock manure is readily available on-farm for very little money. A management strategy that increases capsaicinoid content without using synthetic inputs is a low-cost way to increase product value because pungency is a major factor in determining the market value of chili and habanero intended for oleoresin extraction, pepper sauce production, and pharmaceutical capsaicin recovery (Maharjan *et al*., 2024) [16]. Additionally, by returning livestock waste to the soil, the practice contributes to the cycling of nutrients and the preservation of soil organic matter. It also complies with organic and low-external-input production standards.

Conclusion

This study examined the effects of applying animal manures (specifically, goat and pig dung) at varying rates as soil amendments on the pungency of various pepper cultivars during the wet and dry seasons. Findings showed that pepper pungency was significantly enhanced by organic manure and the extent of this enhancement varied depending on the type of manure and application rate. When manure application was raised from 100g to 300g, all pepper cultivars consistently displayed an increase in pungency, suggesting a dose-dependent response. Out of the two manure sources, goat dung consistently produced the highest pungency ratings, than pig dung, Based on the findings the application of goat, and pig dungs increased the pungency of the various pepper varieties, with the wet and dry seasons having a substantial impact.

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