



Effect of Bioactive Compound (Poultry Manure) on the Yield and Capsaicinoid Content of Sweet Pepper (*Capsicum annuum* L.) Cultivars

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Authors' contributions

This work was carried out in collaboration among all authors. Author RS conceptualized and supervised the study, performed methodology, reviewed and edited the manuscript. Author BB conceptualized the study, performed the field trial did data curation. Author SEA performed the methodology, did data visualization, validation, wrote, reviewed and edited the manuscript. Authors LA and IHM supervised the study, helped in project administration, searched for resources and did funding acquisition. Author BTT did data visualization and data analysis. All authors read and approved the final manuscript.

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ABSTRACT

To assess the impact of poultry manure fertilization on the yield and capsaicinoid content of sweet pepper cultivars, field experiments were carried out during the 2018 rainy seasons at two locations within the Sudan savanna agro-ecological region: the Teaching and Research Farm Bayero University Kano (11° 58 N, 8° 25 E, and altitude 458 m) and Kadawa Irrigation Scheme Bunkure (11° 42 N, 8° 33 E, and altitude 476 m). The experiment was a 4 x 3 factorial laid out in a randomized

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complete block design with four replicates comprising four levels of poultry manure (PM) (0, 1.0, 2.0, and 3.0 tha^{-1}) and three cultivars of sweet pepper (Tattasai Dan Damasak, Yolo wonder and Nsukka yellow). The result reveals that the growth, yield and capscinoid content of sweet pepper cultivars were greatly influenced by the application of PM. The application of 3.0 tha^{-1} of PM significantly gave taller plants, more branches, larger leaves, and a higher number of fruits. Similarly, the Dan Damasak cultivar significantly produced higher growth characters above, except for the number of fruits plant⁻¹. The Dan Damasak and Yolo wonder cultivars at BUK and Yolo wonder at BKR significantly gave a higher number of fruit plants. Fresh fruit yield, total fruit yield, and capsaicinoid content were significantly higher with 3.0 tha^{-1} of PM at both locations. The Dan Damasak cultivar resulted in higher yield related characters at both locations. The capsaicinoid content was, however, significantly higher with Nsukka yellow (17.43 and 18.83 mg kg^{-1}) at BUK and BKR locations, respectively. Thus, the application of 3.0 tha^{-1} PM combined with the Dan Damasak cultivar for improved growth and yield, while the Nsukka Yellow cultivar and the application of 3.0 tha^{-1} PM for higher capsaicinoid could be suggested to the farmers in the study area to improve the productivity of the crop.

Keywords: Bioactive compounds; poultry manure; sweet pepper; cultivars; fruit yield; capsaicin.

1. INTRODUCTION

Sweet pepper (*Capsicum annuum* L.) belongs to the Solanaceae family and genus Capsicum, which is grown throughout the year around the world, although it's native to the northern region of South America and southwestern North America [1,2]. The plant yields berries that are red, green, and yellow in color, and they frequently have a pungent flavor. Within the species, there are about 200 variations, and it also has several popular names and varieties, such as bell pepper, cayenne, jalapeño, chili pepper, and paprika [3].

Out of the roughly 25-200 wild species of capsicum, only five were classified as domesticated species. *C. annuum* L., *C. baccatum* L., *C. chinensis* L., *C. pubescens* L., and *C. frutescens* L. are the five domesticated species [4,5]. According to Barboza et al. [6], pepper is the second most significant crop among Solanaceous fruits, whereas Tiamiyu et al. [7] placed it third globally in terms of vegetable importance, behind tomato and onion.

Due to its vulnerability to frost, pepper is typically planted as an annual crop, although in tropical conditions, it is actually a herbaceous perennial that can live and produce for several years [8,9,10]. Due to its high nutrient content which could be missing in other dietary items, it enhances the flavor and palatability of food, aiding in digestion and absorption [11,1]. To boost crop yields and food security, the current system of producing capsicum spp. mainly relies on chemical fertilizers. Nevertheless, this has resulted in soil degradation, decreased

agricultural output, loss of soil fertility, and deterioration of the environment [12]. Substantial use of chemical fertilizers containing only one or two nutrient components affected the availability of micronutrients (Zn, Mn, Fe, B, and Cu) and secondary nutrients (S and Ca), endangering food security and raising severe concerns for the sustainable production system [13].

Farmers can easily obtain organic manure at a lower cost as compared to inorganic fertilizer.

Additionally, it delivers macro and micronutrients to the soil, boosts the microbial population, which improves soil health, and replenishes soil organic matter in the form of humus [14,15]. Additionally, these manures can enhance the qualities of the soil in terms of aeration, moisture retention, and nutrient conservation. In addition to enhancing the physical and chemical characteristics of soil, poultry manure can boost crop output and growth. According to Bade et al. [16], it also has higher levels of NPK than other kinds of manures. This manure can increase the soil's organic matter content, microbial activity, anion and cation exchange capacity, and carbon content [17]. This work was designed to assess the effects of chicken manure levels on sweet pepper types' yield and capsaicinoid content in an effort to improve the development of capsicum varieties with high capsaicin content.

2. MATERIALS AND METHODS

2.1 Experimental Site

Two field trials were carried out at the Faculty of Agriculture Research and Teaching Farm,

Bayero University Kano, and Kadawa Irrigation Scheme, Bunkure local government area, Kano State (Fig. 1). The BUK research farm was located in the northern part of Kano at a latitude of 11°58' N and a longitude of 8° 25' E, and Bunkure Farm was located in the southern part of Kano at a latitude of 11°42'N and a longitude of 8° 33'E. All of the research sites were situated in the Sudan Savanna agro-ecological zone of Nigeria, which is characterized by a monomodal rainfall pattern with a mean annual rainfall of 739.80 mm and a daily range of temperature between 17.89°C to 31.83°C.

2.2 Treatments and Experimental Design

The treatments consisted of three varieties of sweet pepper (Tattasai Dan Damasak, Nsukka Yellow, and Yolo Wonder) and four levels of poultry manure (0.0, 1.0, 2.0, and 3.0 t ha⁻¹) which were factorially combined and laid out in a Randomized Complete Block design with four replications.

2.3 Varietal Seed Source and Their Characteristics

1. Nsukka Yellow pepper is an aromatic pepper grown mostly in specific rural areas located in southeastern Nigeria. Ripe fruits are predominantly yellow and are exported to Nigerian cities, where they command a premium price. The seeds were sourced

from Techni Seeds Ltd., Hadejia Road, Kano State. This cultivar has a yield potential of up to 9 t ha⁻¹.

2. Yolo wonder pepper is one of the most frequently seen sweet peppers; it is predominantly green in color. It is a very productive variety with good leaf cover to reduce sun scald. The seeds were sourced from Abubakar Rimi Market (Yan Kura), Kano. This variety has a yield potential of up to 11 t ha⁻¹.
3. Tattasai Dan Damasak is among the most popular local cultivars. It is very productive, and the fruits ripen to red quickly. The seeds were sourced from the local farmers at Kura Market, Kano State. This cultivar has a yield potential of up to 11 t ha⁻¹.

2.4 Field Preparation and Crop Husbandry

Adequate land preparation for good sweet pepper production in the form of plowing and harrowing in order to bring the soil to a fine tilth was carried out, while a portion was reserved for the nursery establishment. Three nursery seed beds were prepared for the three varieties of pepper for the purpose of producing good pepper seedlings to be used for the experiment. The seeds were drilled in rows of 10 cm apart in nursery beds separately. The seed beds were

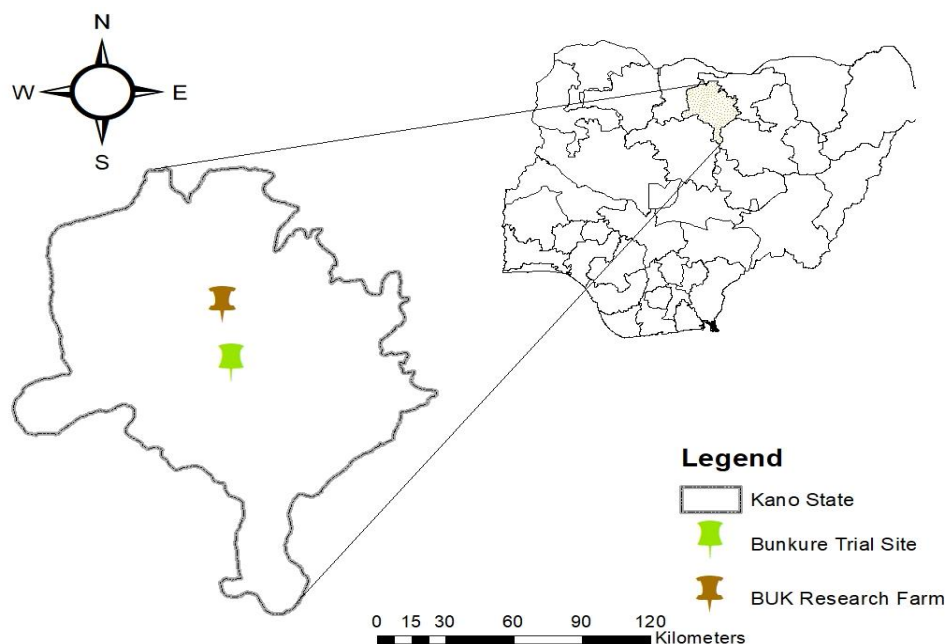


Fig. 1. Map showing the study sites

covered with rice straw to avoid the displacement of the seeds and keep the soil moist. Watering was carried out every day in the morning and in the afternoon. The nursery lasted for 39 days. The land for the experiment was further ridged following the initial ploughing and harrowing and then plots were laid out as per the specifications quoted in the experimental design. Pegs were used to mark out the field according to the experimental design. All these were carried out a week before the transplanting of seedlings into the field. The gross plot was 3 x 4 m (12 m²) while the net plot size was 1.5 m x 3 m (4.5 m²) with a discard of 0.5 m between the plots and 1.0 m between replications.

Poultry manure was incorporated into the field as per the treatment at a depth of 5 cm and 8 cm away from the spots where the seedlings would be transplanted a week before transplanting. However, the sample poultry manure used for the experiment was collected and analyzed for mineral content before the commencement of the experiment. Similarly, soil samples from the experimental sites were collected at a depth of 0–15 cm and 15–30 cm and analyzed for the physico-chemical properties of the soils. All other agronomic practices of weed control, pest control, and disease control were duly carried out as and when due. Harvesting was done manually at the physiological maturity stage of the crop through hand picking.

2.5 Data Collection and Data Analysis

Data were collected on plant height, number of branches plant⁻¹, leaf area index, number of fruits plant⁻¹, fresh fruit weight and total fruit yield. Also, the capsaicin content of the varieties was also analysed using the Liquid-Chromatography-electro-spray/time of flight mass Spectrometry according to standard method as described by Graces *et al.* (2006). Data collected was subjected to Analysis of variance (ANOVA) using Genstat (17th edition). Significant means were separated using Student's New Man's Kuel at 5% probability level.

3. RESULTS

Plant height, Number of branches plant⁻¹, Leaf area index and Number of fruits plant⁻¹ of Sweet Pepper was Influenced by cultivar and Poultry manure rates at BUK and Bunkure (Table 1). Dan damasak cultivar significantly ($p < 0.05$) produced the tallest plants, number of branches plant⁻¹, and leaf area index at both locations while number of fruits plant⁻¹ was higher with Dan

Damasak and Yolo wonder in BUK and Yolo wonder in Bunkure. Similarly, the application of 3 t ha⁻¹ of poultry manure significantly resulted in higher characters compared to other rates under investigation. The interaction between cultivar and PM on plant height was highly significant at BUK where application of 3 tha⁻¹ of PM in Dan Damasak cultivar significantly produced the tallest plant compared with the rest of the interaction effects (Table 2). Interaction of cultivar and PM on number of branches plant⁻¹ was significant ($p < 0.05$) at BUK and highly significant ($p < 0.01$) at BKR, where the application of 3 tha⁻¹ of PM in Dan Damasak at BUK and 2 & 3 tha⁻¹ of PM at BKR resulted in producing a greater number of branches plant⁻¹ than the rest of the interaction effects (Table 3). The highly significant ($p < 0.01$) interaction obtained between cultivar and PM in both locations (Table 4) reveals that the application of 3 tha⁻¹ in Dan Damasak and Yolo wonder significantly produced larger leaves compared with the rest of the interaction effects at BUK and BKR, respectively.

Fresh fruit weight and total fruit yield of sweet pepper as influenced by cultivar and poultry manure at BUK and Bunkure are presented in Table 5. Results show that the fresh fruit weight per plant and total fruit output of the Dan Damasak cultivar were found to be higher than those of other cultivars; Yolo Wonder trailed closely behind, while Nsukka Yellow gave the lowest values at the BUK and BKR locations, respectively. The application of 3 tha⁻¹ PM significantly produced the highest fresh fruit weight plant⁻¹ and fresh fruit yield compared with the rest of the PM rates. However, 0 tha⁻¹ resulted in the lowest yield characters at both locations, respectively. There was no interaction observed between cultivar and PM on the measured characters across the locations.

The capsaicin content of sweet pepper as influenced by cultivar and PM is shown in Table 6. The Nsukka yellow significantly produced a higher capsaicin content, which was closely followed by Dan Damasak, while Yolo Wonder produced the lowest content at BUK and BKR, respectively. Application of PM at 3.0 t ha⁻¹ significantly resulted in higher capsaicin content compared with other rates at both locations, respectively. The interaction between cultivar and PM (Table 7) was highly significant ($p < 0.01$), where the application of 3 tha⁻¹ of PM in Nsukka yellow yielded the highest capsaicin content compared with the rest of the interaction effects.

Table 1. Plant height, Number of branches plant⁻¹, Leaf area index and Number of fruits plant⁻¹ of Sweet Pepper as Influenced by cultivar and Poultry manure rates at BUK and Bunkure during 2018 rainy season

Treatment	Plant height (cm)		Number of branches plant ⁻¹		Leaf area index		Number of fruits plant ⁻¹	
	BUK	Bunkure	BUK	Bunkure	BUK	Bunkure	BUK	Bunkure
Cultivar (C)								
Dan Damasak	28.95a	28.87a	4.19a	4.13a	0.94a	0.92a	12.12a	13.15b
Nsukka yellow	24.37c	23.95c	3.09c	3.09c	0.79c	0.81c	10.84b	11.73c
Yolo wonder	25.22b	25.23b	3.51b	3.51b	0.89b	0.88b	12.34a	14.14a
SE±	0.076	0.463	0.063	0.052	0.003	0.0048	0.308	0.347
Poultry Manure (PM) (t ha⁻¹)								
0	21.93d	22.49d	2.72d	2.72d	0.58d	0.58d	5.67d	6.58d
1	24.68c	24.37c	3.19c	3.15c	0.79c	0.78c	10.35c	11.58c
2	28.10b	27.96b	4.09b	4.12b	0.99b	0.98b	14.67b	15.58b
3	29.99a	29.26a	4.38a	4.32a	1.12a	1.13a	16.38a	18.27a
SE±	0.087	0.534	0.073	0.060	0.0035	0.0055	0.355	0.401
Interaction								
C x PM	<0.001	0.663	0.021	<0.001	<0.001	<0.001	0.949	0.965

Means followed by the same letters in a column are not significantly different at $p < 0.05$ using Student Newman Keuls (SNK)

Table 2. Interaction between cultivar and poultry manure on plant height at BUK during 2018 rainy season

Cultivar	Poultry manure (t ha ⁻¹)			
	0	1	2	3
Dan Damasak	23.97f	27.95d	30.78b	33.10a
Nsukka yellow	20.24j	22.62h	26.58e	28.04d
Yolo wonder	21.59i	23.47g	26.96e	28.86c
SE±	0.152			

Table 3. Interaction between cultivar and poultry manure on number of branches plant⁻¹ at BUK and Bunkure during 2018 rainy season

Cultivar	Poultry manure (t ha ⁻¹)			
	0	1	2	3
BUK				
Dan Damasak	2.90f	3.58c	4.88b	5.40a
Nsukka yellow	2.30g	2.90f	3.40e	3.75d
Yolo wonder	2.95f	3.10f	4.00c	4.00c
SE±	0.127			
Bunkure				
Dan Damasak	2.90e	3.50cd	4.95a	5.20a
Nsukka yellow	2.30f	2.90e	3.40d	3.75c
Yolo wonder	2.95e	3.10de	4.00b	4.00b
SE±	0.105			

Means followed by different letter(s) in a column and row differ significantly at $P \leq 0.05$ using Student Newman Keuls (SNK)

Table 4. Interaction between Cultivar and Poultry Manure on Leaf area index at BUK and Bunkure during 2018 rainy season

Cultivar	Poultry Manure (t ha ⁻¹)			
	0	1	2	3
BUK				
Dan Damasak	0.63g	0.84e	1.10c	1.21a
Nsukka yellow	0.53h	0.72f	0.92d	1.02b
Yolo wonder	0.58h	0.84e	0.98c	1.13a
SE±	0.006			
Bunkure				
Dan Damasak	0.61g	0.83e	1.07b	1.18a
Nsukka yellow	0.56h	0.71f	0.91d	1.06b
Yolo wonder	0.57h	0.82e	0.97c	1.16a
SE±	0.0095			

Means followed by different letter(s) in a column and row differ significantly at $p \leq 0.05$ using Student Newman Keuls (SNK)

Table 5. Fresh fruit weight and Total fruits yield of Sweet Pepper as Influenced by cultivar and Poultry manure rates at BUK and Bunkure during 2018 Rainy Season

Treatment	Fresh fruit weight plant ⁻¹ (g)		Total fruit yield ha ⁻¹ (kg ha ⁻¹)	
	BUK	Bunkure	BUK	Bunkure
Cultivar (C)				
Dan Damasak	369.80a	377.10a	9861.00a	10063.00a
Nsukka yellow	270.00c	278.60c	7199.00c	7430.00c
Yolo wonder	341.70b	371.70b	9113.00b	9912.00b
SE±	8.850	13.310	236.100	353.000

Treatment	Fresh fruit weight plant ⁻¹ (g)		Total fruit yield ha ⁻¹ (kg ha ⁻¹)	
	BUK	Bunkure	BUK	Bunkure
Poultry Manure (PM) (t ha⁻¹)				
0	81.70d	86.80d	2178.00d	2313.00d
1	239.10c	252.90c	6375.00c	6743.00c
2	457.10b	461.70b	12191.00b	12324.00b
3	530.80a	568.50a	14154.00a	15160.00a
SE±	10.220	15.370	272.600	407.600
Interaction				
C x PM	0.397	0.648	0.392	0.684

Means followed by the same letters in a column are not significantly different at $P < 0.05$ using Student Newman Keuls (SNK)

Table 6. Capsaicin content of sweet pepper as Influenced by Cultivar and Poultry Manure at BUK and Bunkure in 2018 rainy season

Treatment	Capsaicin content (mg kg ⁻¹)	
	BUK	Bunkure
Cultivar (C)		
Dan Damasak	15.87b	16.89b
Nsukka yellow	17.43a	18.83a
Yolo wonder	11.78c	12.69c
SE±	0.122	0.170
Poultry Manure (PM) (t ha⁻¹)		
0	10.59d	11.33d
1	13.66c	14.81c
2	16.57b	18.58b
3	19.29a	19.83a
SE±	0.141	0.196
Interaction		
C x PM	<0.001	0.194

Means followed by the same letters in a column are not significantly different at $p < 0.05$ using Student Newman Keuls (SNK)

Table 7. Cultivar and Poultry manure interaction on Capsaicin Content (mg kg⁻¹) of Sweet Pepper at BUK during 2018 rainy season

Cultivar	Poultry manure (t ha ⁻¹)			
	0	1	2	3
Dan Damasak	11.32j	14.64g	17.25d	20.28b
Nsukka yellow	12.25i	16.15e	19.09c	22.23a
Yolo wonder	8.20l	10.20k	13.36h	15.36f
SE±	0.244			

Means followed by different letter(s) in a column and row differ significantly at $p \leq 0.05$ using Student Newman Keuls (SNK)

4. DISCUSSION

The significant differences observed in some growth characters, yield and yield component as well as the capsaicin content among the tested sweet pepper varieties could be attributed to the variations in the genetic constitution of the cultivars. A crop variety has the ability to outyield other varieties in terms of growth and yield attributes owing to its genetic potentials. Similar finding was reported by Kavhiza et al. [18] on

increase in crop yield by the adoption of improve cultivars. The ability of Dan Damasak cultivar at both experimental locations to outperformed other cultivars might be attributed to its genotypic makeup. Similarly, Shahein et al. [19] reported that the growth differences between two pepper hybrids might be correlated with gene action of the tested hybrid, as well as the adaptability to agro-ecological conditions of the variety to the study areas. The little variations in the capsaicin content observed between two locations of the

experiment could be due to some differences in the environmental factors of the locations. This also corroborates the finding of Das et al. [20] who reported that the environmental factors especially the climate, light intensity, soil type, moisture level, fertilization and temperature during plant growth, is considered to have an impact on capsaicinoids level, as does the age of the fruits. Oh and Koh [21] reported similar findings on the quality of hot pepper owing to variation in temperature regimes.

The results obtained from these experiments clearly shown that the poultry manure used in the trails substantially increased the yield and chemical composition of sweet pepper fruits across the two locations. These effects of poultry manure could be attributed to the fact that it contains essential elements needed by the crop plant. Farhad et al. [22] observed that poultry manure contains essential nutrient elements associated with high photosynthetic activities, and they stimulate the roots and vegetative growths of vegetable maize. The improved tuber output and nutritional uptake of potatoes were noted by Oustani et al. [23]. Releasing nutrient elements into the soils was also noted by Adekiya et al. (2018) and Sajid et al. [24], who found that this improved other soil chemical and physical qualities that support crop growth and development in *Amaranthus hybridus* and *Curcuma longa*, respectively [25].

5. CONCLUSION

The outcomes of these studies show that the application of PM significantly affected the capscinoid content, number of branches per plant, leaf area index, number of plants per plant, and plant height of sweet pepper cultivars. Taller plants, more branches, larger leaves, and more fruits per plant⁻¹ were the notable results of applying 3.0 tha⁻¹ of PM. Similarly, the Dan Damasak cultivar significantly produced higher growth characters mentioned above except for the number of fruits plant⁻¹. The Dan Damasak and Yollow Wonder cultivars at BUK and Yolo wonder at BKR significantly gave a higher number of fruits plant⁻¹. Fresh fruit yield, total fruit yield, and capsaicinoid content were significantly higher with the application of 3.0 tha⁻¹ of PM at both locations. The Dan Damasak cultivar resulted in higher yield-related traits at both locations. However, the Nsukka Yello cultivar has a noticeably higher capsaicinoid concentration at both locations when compared to other cultivars. Therefore, farmers in the study region may be

advised to apply 3.0 tha⁻¹ PM combined with Dan Damasak cultivar. Similarly, the Nsukka yellow cultivar and the application of 3.0 tha⁻¹ PM can also be suggested for greater capsaicinoid concentration.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. García-Gaytán V, Gómez-Merino FC, Trejo-Téllez LI. The Chilhuacle Chili (*Capsicum annuum* L.) in Mexico: Description of the Variety, Its Cultivation, and Uses. International Journal of Agronomy. 2017;e5641680 Available:https://doi.org/10.1155/2017/5641680
2. Aguilar-Meléndez A, Azurdia C, Cerén-López J, Menjivar J, and Contreras A. *Capsicum annuum* (amended version of 2019 assessment). The IUCN Red List of Threatened Species; 2020. Available:https://dx.doi.org/10.2305/IUCN.UK.2020-2.RLTS.T100895534A172969027.ene
3. Zhigila DA, AbdulRahaman AA, Kolawole OS, and Oladele FA. Fruit Morphology as taxonomic features in five varieties of *Capsicum annuum* L. Solanaceae. Journal of Botany. 2014;e540868. Available:https://doi.org/10.1155/2014/540868
4. Roy A. Bhut jolokia (*Capsicum chinense* Jacq): A review. International Journal of Pharmaceutical Sciences and Research. 2016;7(3):882-889.
5. Swamy KRM. Origin, distribution, taxonomy, botanical description, genetic diversity and breeding of capsicum (*Capsicum annuum* L.). International Journal of Development Research. 2023; 13(03):61956-61977.
6. Barboza GE, Carrizo GC, Leiva GS, Scaldaferrero M, Reyes X. Four new species of *Capsicum* (*Solanaceae*) from the tropical Andes and an update on the phylogeny of the genus. PLoS One. 2019; 14(1):e0209792. Available:https://doi.org/10.1371/journal.pone.0209792.
7. Tihamiyu QM, Adebayo SE and Ibrahim N. Recent advances on postharvest

- technologies of bell pepper: A review. *Heliyon*. 2023;9(4):e15302. Available:<https://doi.org/10.1016/j.heliyon.2023.e15302>
8. Gruda N, and Tanny J. Protected crops. *Horticulture: Plants for People and Places, Production Horticulture*. 2014;1:327-405. Available:https://doi.org/10.1007/978-94-017-8578-5_10
 9. Anitha M, and Hore JK. Production technology of some major and minor spice crops. *Indian Spices: The Legacy, Production and Processing of India's Treasured Export*. 2018;95-175.
 10. Bhattacharya A. Effect of low-temperature stress on germination, growth, and phenology of plants: A review. In: *Physiological Processes in Plants Under Low Temperature Stress*. Springer, Singapore; 2022. Available:https://doi.org/10.1007/978-981-16-9037-2_1
 11. Olatunji TL, and Afolayan AJ. The suitability of chili pepper (*Capsicum annuum* L.) for alleviating human micronutrient dietary deficiencies: A review. *Food Science and Nutrition*. 2018;6(8): 2239–2251. Available:<https://doi.org/10.1002/fsn3.790>
 12. Martey E, Kuwornu JK, Adjebeng-Danquah J. Estimating the effect of mineral fertilizer use on Land productivity and income: Evidence from Ghana. *Land Use Policy*. 2019;85:463-475. Available:<https://doi.org/10.1016/j.landusepol.2019.04.027>
 13. Penuelas J, Coello F, and Sardans J. A better use of fertilizers is needed for global food security and environmental sustainability. *Agriculture and Food Security*. 2023;12:5. Available:<https://doi.org/10.1186/s40066-023-00409-5>
 14. EL-Shimi NMM, El-Badawy EHM, and Tolba HI. Response of sweet pepper plants to some organic and bio-fertilizers and its effect on fruit yield and quality. *Middle East Journal of Agricultural Research*. 2015; 4(3):435-445.
 15. Alhrouf HH. Response of Growth and yield components of sweet pepper to two different kinds of fertilizers under green house conditions in Jordan. *Journal of Agricultural Science*. 2017;9(10):265-276.
 16. Bade KK, Vidya B, and Singh VB. Effect of Organic Manures and Biofertilizers on Growth, Yield and Quality of Chilli (*Capsicum annuum*) cv. Pusa Jwala. *International Journal of Current Microbiology and Applied Science*. 2017;6(5):2545-2552. DOI:<https://doi.org/10.20546/ijcmas.2017.605.286>
 17. Masocha BL, Dikinya O. The role of poultry litter and its biochar on soil fertility and *Jatropha curcas* L. Growth on Sandy-Loam Soil. *Applied Sciences*. 2022;12(23): 12294. Available:<https://doi.org/10.3390/app122312294>
 18. Kavhiza NJ, Zargar M, Prikhodko SI, Pakina EN, Murtazova KMS, and Nakhaev MR. Improving crop productivity and ensuring food security through the adoption of genetically modified crops in Sub-Saharan Africa. *Agronomy*. 2022; 12(2):439. Available:<https://doi.org/10.3390/agronomy12020439>
 19. Shahein MM, Hassan HA, and Abou-El-Hassan S. Response of sweet pepper plants to fertilize by different organic fertilizers under protected agriculture. *Journal of Plant Production, Mansoura University*. 2015;6(5):809 – 822.
 20. Das K, Teja C, Duary B, Agrawal PK, and Bhattacharya SS. Impact of nutrient management, soil type and location on the accumulation of capsaicin in *Capsicum chinense* (Jacq.): One of the hottest chili in the world. *Scientia Horticulturae*. 2016; 213:354-366. Available:<https://doi.org/10.1016/j.scienta.2016.10.041>
 21. Oh S, Koh SC. Fruit development and quality of hot pepper (*Capsicum annuum* L.) under Various Temperature Regimes. *Horticultural Science and Technology*. 2019;37(3):313-32. Available:<https://doi.org/10.7235/HORT.20190032>
 22. Farhad W, Cheema MA, Hammad HM, Saleem MF, Fahad S, Abbas F, Khosa I, and Bakhat HF. Influence of composted poultry manure and irrigation regimes on some morpho-physiology parameters of maize under semiarid environments. *Environmental Science and Pollution Research*. 2018;25:19918-19931. Available:<https://doi.org/10.1007/s11356-018-2125-9>
 23. Oustani M, Halilat MT, and Chenchouni H. Effect of poultry manure on the yield and nutriments uptake of potato under saline

- conditions of arid regions. Emirates Journal of Food and Agriculture. 2015;27(1):106-120.
DOI:10.9755/ejfa.v27i1.17971
24. Sajid M, Shah ST, Basit A, Ahmed A, Ullah I, Jawad Shah S, Khan F, and Mohamed HI. Enhancement of yield, essential oils, and active ingredients of turmeric (*Curcuma longa* L.) by application of organic manures (farmyard and poultry manure). Gesunde Pflanzen. 2023;75(3): 525-538.
25. Gen Stat. Release 16.3DE. VSN International, 5 The Waterhouse, Waterhouse Street, Hemel Hempstead, Hertfordshire HP1 1ES, UK; 2015.

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