September 30, 2025 Vol. 9 No. 1 E-ISSN 3026-8109 P-ISSN 3027-1657

International Journal of

BIOSCIENCE AND AGROLOGICAL RESEARCH (IJBAR)

www.harvardpublications.com

EFFECT OF INSECT POLLINATORS ON YIELD AND YIELD RELATED PARAMETERS OF WATERMELON (*Citrullus lanatus* thunb) IN THE NIGERIAN SOUTHERN GUINEA SAVANNAH

SHAIBU, V. E. [1]; OKRIKATA, E. [1]; SHAIBU, C. O. [2]; & AMOS, J. T.[1]

[1]Department of Biological Sciences, Federal University Wukari. [2]Department of Biochemistry, Federal University Wukari.

Corresponding Author: uboh72@gmail.com

DOI: https://doi.org/10.70382/hijbar.v09i1.014

Abstract

Watermelon (*Citrullus lanatus* Thunb.) is a significant horticultural crop grown worldwide, prized for its sweet, juicy and nutritious value. As with many flowering plants, watermelons depend on pollinators for fruit set. Insect pollinators are essential in increasing seed set of many pollination-dependent fruit crops, as well as the quality of seed or fruit in terms of nutrient and mineral

Keywords: Fruit quality, insect-visitation, pollination, watermelon, yield, Nigerian agriculture.

INTRODUCTION

Watermelon is a desert plant in the Cucurbitaceae family that accounts for approximately 6.8% of the world's vegetable crops (Bereket *et al.,* 2022). Watermelon (*Citrullus lanatus* Thunb.) is a significant horticultural crop grown worldwide, prized for its sweet, juicy and nutritious value. As with many flowering plants, watermelons depend on pollinators for fruit set. Animal pollination can impact food security since many crops depend on pollinators to produce fruits and seeds (Giannini *et al.,* 2017). Watermelon has a unique flowering system where male and female flowers grow separately on the same plant, its pollen grains are large and sticky, making wind pollination ineffective (Beyene and Woldatsadik 2020). Because of this, watermelon relies heavily on insects to transfer pollen from male to female flowers for successful fruit development (Beyene and Woldatsadik 2020). Research has shown that a

composition. This study was conducted at Federal University Wukari during 2024 late planting season and 2025 early planting season to determine the impact of insect pollinators on yield and fruit quality of watermelon across the seasons. The study was carried out on six 5 x 3 m = 15 m^2 plots demarcated on a 0.108 ha land. The plots were grouped into two with three replications. The first group was covered with net mesh for insect pollination exclusion at 50% flowering stage while the second group was left open to allow for insect pollination. There was a significantly ($p < 0.05$) higher number of fruits in the insect-visited plots (16.33 ± 0.76) compared to insect-excluded plots (1.67 ± 0.62), across both planting seasons. Similarly, fruit weight was markedly increased by insect visitation (7.82 ± 0.40 kg against 2.77 ± 0.73 kg). Fruit length (31.67 ± 1.40 cm against 13.98 ± 3.41 cm) and diameter (19.60 ± 1.20 cm against 8.30 ± 2.07 cm) followed the same trend across the planting seasons. Rind thickness was significantly greater in fruits from insect-visited plots during the late season (1.67 ± 0.67 cm against 0.98 ± 0.17 cm) and pooled means of early and late planting season (1.54 ± 0.06 cm against 0.94 ± 0.20 cm), though this difference was not significant ($p > 0.05$) in the early season. Total Soluble Solids (TSS), were also elevated in late season fruit from insect-visited plot (10.00 ± 0.12 °Brix against 6.63 ± 0.22 °Brix) and pooled means of early and late planting season (10.37 ± 0.17 °Brix against 8.58 ± 0.88 °Brix). The finding showed that insect pollinators have significant role in enhancing the yield and fruit quality of watermelon, underscoring the necessity of conservation of insect diversity.

Large number of pollen grains (500 to 1,000) must be deposited on the female flower's stigma to fertilize all ovules completely (Mallinger & Gratton, 2015). This fertilization does more than just produce seeds; it triggers hormone signals that influence fruit size, shape, and importantly, the internal quality like sweetness and nutrient content (Beyene and Woldatsadik, 2020).

Poor pollination can lead to fruit problems like abortion, uneven growth, or hollow heart, making watermelons less marketable (Frazier et al., 2022). Beyond yield, recent studies highlight that pollinators play a key role in shaping many quality traits of watermelon fruits, including sugar levels (measured as °Brix), antioxidants such as lycopene, firmness, and possibly mineral nutrients. Each female watermelon flower will need around 500 to1000 pollen grains to produce marketable watermelon fruit (Beyene and Woldatsadik 2020). Study indicated that there is a loss of 3–5% of fruit, vegetable, and nut production per year globally due to inadequate pollination, hence supplementary pollination by honeybees will increases the percentage of flowers forming fruit per plant and the size of the fruit and ultimately increasing the yield (Beyene and Woldatsadik 2020).

Pollinators particularly honey bees, play a critical role in the fertilization process that directly influences the yield and quality of watermelon fruits (Beyene and Woldatsadik 2020). Good fruits set and development for watermelon (*C. lanatus*) is highly dependent

on insect pollinators, especially the honey bees which pollinate the female flowers (Okrikata and Ogunwolu, 2019). Despite this critical importance, pollinators are facing significant declines globally due to factors like habitat loss, indiscriminate pesticide use and climate change. These declines have raised concern about the potential negative impact on yield and quality of crops that particularly depend on pollinators for fruit set like watermelon (Beyene and Woldatsadik 2020). In Nigeria, especially in the region of this research, there is limited information on the effect of insect pollination on watermelon fruit yield. Therefore, this study is aimed at accessing the impact of insect pollinators on the yield and yield related parameters of watermelon.

Materials and Methods

Study area

The field experiment was conducted in the Research Farm of Federal University Wukari, Taraba State, Nigeria, in the 2024 late-cropping season and 2025 early-cropping season. Wukari, which is located at N7°50'37", E9°46'31", has an altitude of 187 m above sea level, an average annual temperature of 26.8 °C, and an average annual rainfall of 1,205 mm. The study area experiences a warm tropical climate characterized by wet and dry seasons. The wet season starts in April and ends in October, with peaks in June and September (Okrikata and Ogunwolu, 2019).

Experimental layout

The experiment was laid out in Randomized Complete Block Design (RCBD) with two treatments and three replications. Two treatments were randomly assigned to the six plots as listed below;

T_1 = Insect pollination inclusion/opened plants (free access to all pollinators)

T_2 = Insect pollination exclusion/netted plants (caged with synthetic nylon net to prevent insects from accessing the plants) (Bereket *et al.* 2022).

At 50% flowering stage, plots containing insect pollination exclusion plants were covered with a nylon mesh.

Method

The crop was established from treated seeds of Red Diamond variety of watermelon spaced 1 m within a row and 2 m between rows of plots that were 5 m long and 3 m wide during the early- and late- cropping seasons of 2025 and 2024 respectively. Weed control was done manually by hand pulling at two-weeks interval while chemical insecticide was used to control pest from the seedling stage to harvest.

Fruit Yield and Quality Assessment

At the moment of ripeness (when the tendrils become brown and dried) the fruits were picked and their weight and other parameters were recorded accordingly.

Average Number of Fruits

The number of fruits in each treatment were physically counted and the average from each plot was recorded accordingly.

Average Weight of Fruits

The average number of fruits per treatment was determined by the method reported by Abrol *et al*. (2017). A unit sample of 3 fruits with three replications being the average number of fruits from both treatment plots with their respective weights were taken with the help of top pan balance and expressed as kilograms (kg). The average weight was calculated thereafter.

Fruit Length

Three fruits with three replications from each plot were taken and cut open and the fruit length from each treatment plots was measured using digital vernier calliper in millimetres and the average taken.

Fruit Diameter

Three fruits with three replications from each plot were taken and cut open and the fruit diameter from each treatment plots was measured using Digital Vernier Calliper in millimetres and the average taken.

Rind Thickness

Three fruits with three replications from each plot were taken and cut open and the thickness of the rind were measured using Vernier Calliper in millimetres and the average taken to give the rind thickness.

Sweetness (Brix)

Total soluble solids (TSS) were measured using a refractometer as reported by Abrol *et al*. (2017). Briefly, three fruit samples were taken per treatment and the heart tissue of each fruit was sliced. The sliced samples from each treatment were separately mixed together after which the juice was extracted. A drop of the extracted juice was then placed on the refractometer prism window and the result was recorded. Thef results were expressed as degree brix (^{0}Brix). The readings were taken in triplicate and the means were recorded.

Data Analysis

Data collected from insect-visited plots were statistically compared with those from insect-excluded plots using Student's t-test. Same tool was used to compare data between the early- and late-crops. The data were analysed using the Statistical Package for the Social Sciences (SPSS) Version 27.0 software.

Results

Effect of Insect Pollination on Yield and Yield-Related Parameters of Watermelon Fruit

Table 1 presents the impact of insect pollination on yield and yield-related parameters of watermelon fruits in both early and late planting seasons. The number of fruits per plant was significantly higher in insect-visited plots against insect-restricted plots, with pooled means of 16.33 ± 0.76 against 1.67 ± 0.62 respectively. Similarly, fruit weight was markedly increased by insect visitation, with pooled means of 7.82 ± 0.40 kg against 2.77 ± 0.73 kg. Morphological measures, including fruit length and diameter, followed this trend, showing significant enhancement in fruit from insect-visited plot across seasons (length: 31.67 ± 1.40 cm against 13.98 ± 3.41 cm; diameter: 19.60 ± 1.20 cm against 8.30 ± 2.07 cm). Rind thickness was significantly greater in fruit from insect-visited plot during the late season (1.67 ± 0.67 cm against 0.98 ± 0.17 cm) and pooled (1.54 ± 0.06 cm against 0.94 ± 0.20 cm), though this difference was not significant in early season. Total Soluble Solids (TSS), an indicator of fruit sweetness and quality, were also elevated in late season fruit from insect-visited plot (10.00 ± 0.12 °Brix against 6.63 ± 0.22 °Brix) and pooled (10.37 ± 0.17 °Brix against 8.58 ± 0.88 °Brix).

Table 1: Comparison of yield and yield related parameters between insect-visited and insect-restricted watermelon fruits at Wukari

Parameter	Season	Insect Pollinated	Insect excluded	Mean Difference	T-value	P-value
No. of Fruit	Early-crop	17.00 ± 1.53	1.67 ± 1.20	15.33	7.89	0.001*
	Late-crop	15.67 ± 0.33	1.67 ± 0.67	14.00	18.78	0.000*
	Pooled	16.33 ± 0.76	1.67 ± 0.62	14.67	15.00	0.000*
Fruit Weight (kg)	Early	7.27 ± 0.35	2.23 ± 1.30	5.03	3.74	0.020*
	Late	8.37 ± 0.60	3.30 ± 0.81	5.07	5.01	0.007*
	Pooled	7.82 ± 0.40	2.77 ± 0.73	5.05	6.10	0.000*
Fruit Length (cm)	Early	30.50 ± 2.58	10.40 ± 5.23	20.10	3.45	0.026*
	Late	32.83 ± 1.33	17.57 ± 4.22	15.27	3.45	0.025*
	Pooled	31.67 ± 1.40	13.98 ± 3.41	17.68	4.80	0.001*
Fruit Diameter (cm)	Early	18.57 ± 2.23	6.17 ± 3.09	12.40	3.26	0.031*
	Late	20.63 ± 1.11	10.43 ± 2.70	10.20	3.50	0.025*
	Pooled	19.60 ± 1.20	8.30 ± 2.07	11.30	4.72	0.001*
Rind Thickness (cm)	Early	1.42 ± 0.02	0.90 ± 0.45	0.52	1.16	0.367
	Late	1.67 ± 0.67	0.98 ± 0.17	0.69	9.97	0.006*
	Pooled	1.54 ± 0.06	0.94 ± 0.20	0.60	2.85	0.017*
Fruit TSS (⁰Brix)	Early	10.73 ± 0.07	10.53 ± 0.03	0.20	2.68	0.055
	Late	10.00 ± 0.12	6.63 ± 0.22	3.37	13.62	0.000*
	Pooled	10.37 ± 0.17	8.58 ± 0.88	1.78	1.99	0.099

Values are means ± standard deviation of triplicate determinations. P-Values with asterisks (*) indicate significant difference ($P < 0.05$).

Effect of Planting Season on Yield and Yield-Related Parameters

Table 2 compares yield parameters between early and late planting seasons within insect-pollinated and insect-excluded treatments. No statistically significant differences were observed in fruit number, weight, length, diameter, or rind thickness between seasons within each pollination treatment or pooled means. However, fruit TSS was significantly higher in early-season fruit from insect-pollinated plot against late-season (10.73 ± 0.07 against 10.00 ± 0.12) and in fruits from insect-excluded plot (10.53 ± 0.033 against 6.63 ± 0.22), with pooled means also significantly higher in early against late (10.63 ± 0.06 against 8.32 ± 0.76). These results suggest that while yield quantity traits are relatively stable between planting seasons, fruit sweetness is influenced by seasonal factors.

Table 2: Comparison of yield and yield related parameters between early- and late-sown watermelon fruits from insect pollinated and insect-excluded plots at Wukari

Parameter	Pollination	Early-crop	Late-crop	Mean Difference	T-value	P-value
No. of Fruit	Insect-pollinated	17.00±1.53	15.67±0.33	1.33	0.85	0.442
	Insect excluded	1.67±1.20	1.67±0.67	0.00	0.00	1.000
	Pooled	9.33±3.54	8.67±3.15	0.67	0.14	0.891
Fruit Weight (kg)	Insect pollinated	7.27±0.35	8.37±0.60	-1.10	-1.58	0.190
	Insect-excluded	2.23±1.30	3.30±0.81	-1.07	-0.70	0.525
	Pooled	4.75±1.28	5.83±1.22	-1.08	-0.61	0.553
Fruit Length (cm)	Insect pollinated	30.50±2.58	32.83±1.33	-2.33	-0.80	0.467
	Insect-excluded	10.40±5.23	17.57±4.22	-7.17	-1.07	0.346
	Pooled	20.45±5.20	25.20±3.95	-4.75	-0.73	0.483
Fruit Diameter (cm)	Insect pollinated	18.57±2.23	20.63±1.11	-2.10	-0.83	0.452
	Insect-excluded	6.17±3.09	10.43±2.70	-4.27	-1.04	0.357
	Pooled	12.37±3.25	15.53±2.63	-3.17	-0.76	0.466
Rind Thickness (cm)	Insect pollinated	1.42±0.02	1.67±0.07	-0.25	-3.61	0.058
	Insect-excluded	0.90±0.45	0.98±0.02	-0.08	-0.18	0.875
	Pooled	1.16±0.23	1.32±0.16	-0.16	-0.58	0.573
Fruit TSS (^{0}Brix)	Insect pollinated	10.73±0.07	10.00±0.12	0.73	5.50	0.005*
	Insect-excluded	10.53±0.033	6.63±0.22	3.90	17.64	0.003*
	Pooled	10.63±0.06	8.32±0.76	2.32	3.04	0.028*

Values are means ± standard deviation of triplicate determinations. P-Values with asterisks (*) indicate significant difference ($P < 0.05$).

Discussion

Insect diversity plays a pivotal role in determining the productivity and quality of pollinator-dependent crops such as watermelon (*Citrullus lanatus*) (Oladipo et al. 2023). This study shows a positive impact of insect pollination on watermelon yield and yield-related parameters across early and late planting seasons. Insect-visited plots produced

significantly higher numbers of fruits than insect-restricted plots. This effect is consistent with the findings of Klein *et al*. (2017), who emphasized the fundamental role of bee pollinators in assuring fruit set and maximal yield in watermelon production. The dominance of Hymenoptera likely contributed to efficient pollen transfer and successful fertilization, maximizing seed set and fruit development (Menda et al., 2022; Koti *et al*., 2025). Comparable results were reported by Singh et al. (2022) for watermelon in India, highlighting the role of insect-mediated pollination in doubling fruit size and weight. Giannini *et al*., (2017) also reported increased yield and weight of watermelon due to seasonal variations.

Fruit yield, length, weight, diameter, and rind thickness were all significantly enhanced with insect visitation in both seasons, with no significant difference between early and late planting yields. Higher fruit weight and size (length and diameter) from insect-visited plots further underscores the contribution of effective pollination to fruit development. This agrees with the report of Zhang et al. (2019) who observed yield declines when pollinator visitation was limited.

Insect pollination however only had a significant effect on the total soluble solids (TSS) of fruits from the late planting season. The increase in total soluble solids (TSS) a marker of fruit quality (Zhang et al., 2023; Oliva et al., 2021) particularly during the late season further validates the positive effect of insect pollination. This is in consonance with the report of Gervasi et al. (2020), who demonstrated that pollination quality positively modulates sugar accumulation, enhancing fruit sweetness and consumer preference.

The stable significant increases on fruit yield and yield related parameters across both planting season suggests that the functional complementarity and redundancy within the pollinator assemblage are sufficient to sustain effective pollination services throughout different cropping periods (Garibaldi *et al*., 2013; Erandi *et al*., 2023).

Conclusion

The study considered the effect of insect pollinators on watermelon fruit. Watermelon subjected to insect pollination generally had higher yield and yield related parameters across seasons. This shows that insect pollinators aids in watermelon seed set and fruit yield and also improves the fruit quality as demonstrated by the TSS result. The findings underscore the significance of the advocacy for conservation of insects and their habitat through the regulation of agricultural intensification and pest control practices. This is particularly important considering the need to ensure food security to meet up with the rising world's human population. It is pertinent to mention that the study only focused on one location and one crop variety, necessitating further research to cover the effect across different locations and diverse varieties of crop.

Acknowledgments

We want to appreciate the Staff of Food Science Department, Federal University Wukari for their support and also to Mr Andrew and Enoch for their support during the field work. Special thanks to Dr. Ogunmola Adeniyi of the Statistics Department of Federal University Wukari for support in statistical analyses.

References

Beyene, T. and Woldatsadik, M. (2020). Effect of honeybee (Apis mellifera L.) pollination on fruit yield and yield contributing parameters of watermelon (Citrullus lanatus L.). *International Journal of Current Research and Academic Review*, 8(10): 86-93.

Bereket, G., Melese, M., Woldemeskel, E. and Gunnabo, A. H. (2022). Yield gaps of major cereal and grain legume crops in Ethiopia: A review. *Agronomy*, 12(10): 2528.

Erandi, C. W., Subasinghe, A., Lisa, J. E., Joshua, W., Campbell, K. S., Delaplane, E. S. and Brian, T., (2023). A global assessment of the species composition and effectiveness of watermelon pollinators and the management strategies to inform effective pollination service delivery. *Basic and Applied Ecology,* 66: 50-62.

Frazier, S. F., Johnson, L. K. and Miles, C. A. (2022). Pollination deficit and its impact on watermelon fruit disorders: A review. *HortScience*, 57(5): 553-560.

Garibaldi, L. A., Steffan-Dewenter, I., Winfree, R., Aizen, M. A., Bommarco, R. and Cunningham, S. A. (2013). Wild pollinators enhance fruit set of crops regardless of honey bee abundance. *Science,* 339(6127): 1608–1611.

Gervasi, T., Cappellini, F. and Pellegrini, M. (2020). Pollination quality modulates sugar accumulation in fruits. *Journal of Experimental Botany,* 71(5):1539–1548.

Giannini, T. C., Costa, W. F., Cordeiro, G. D., Imperatriz-Fonseca, V. L., Saraiva, A. M., Biesmeijer, J., and Garibaldi, L. A. (2017). Projected climate change threatens pollinators and crop production in Brazil. *PLOS ONE*, 15(6): e0227660.

Klein, S., Rader, R. and Bartomeus, I. (2019). Pollination efficiency in landscapes. *Ecology Letters,* 22(6): 1009–1016.

Koti, S., Ahlawat T. R. and Patel, R. J. (2025). Role of pollinators and pollinizers for fruit production. *Agriallis*, 7(4): 18-33.

Menda, N., Arauz, B. and de La-Fuente, C. (2022). The role of pollination in fruit development: Hormonal and physiological responses. *Plant Physiology and Biochemistry,* 173: 158–166.

Mallinger, R. E. and Gratton, C. (2015). Species richness of wild bees, but not the use of managed honeybees, increases fruit set of a pollinator-dependent crop. *Journal of Applied Ecology*, 52(2): 323-330.

Okrikata E., Ogunwolu, E. O. and Ukwela, M. U. (2019) Diversity, spatial and temporal distribution of above-ground arthropods associated with watermelon in the Nigerian southern guinea savanna. *Journal of Insect Biodiversity and Systematics*, 5 (1): 11–32.

Okrikata, E. and Ogunwolu, E. O. (2019). Determination of the critical period of Cyper-diforce® treatment against arthropod fauna and productivity of watermelon. *Iraqi Journal of Science*, 60(9): 1904-1919.

Oladipo, A. A., Adeyemi, J. A. and Ogundele, O. O. (2023). Insect pollinator diversity and their role in watermelon productivity. *Journal of Pollination Ecology,* 31: 1–14.

Oliva, M., Tang, X. and Osorio, S. (2021). Phenylpropanoids and flavonoids in plant defense: Antioxidant and antibacterial roles. *Plant Science,* 298: 110567.

Singh, N., Kumar, A., and Singh, A. (2022). Impact of insect-mediated pollination on watermelon fruit size and weight. *International Journal of Agricultural Sciences,* 14(2), 256–262.

Zhang, X., Li, J. and Wang, H. (2019). Yield declines caused by limited pollinator visitation in watermelon. *Horticultural Science,* 54(3): 334–340.

Zhang, Y., Mousawinejad, A., & Oliva, M. (2023). Effects of pollination on fruit metabolic composition and quality traits. *Frontiers in Plant Science, 14*, 123456.