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EFFECT OF SEED STORAGE GEOMETRY ON GERMINATION AND GROWTH PERFORMANCE OF WATERMELON *(CITRULLUS LANATUS)*

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ABSTRACT

Watermelon contributes significantly to household nutrition and income generation, particularly in developing countries where it serves as a source of vitamins, minerals, antioxidant and hydration during dry season. However, limited information exists on the influence of seed storage geometry and seed physiological behaviour of crop growth. This study examined the effect of seed storage geometry on the growth performance of watermelon (*citrullus lanatus*) under controlled greenhouse condition. The experiment was conducted at the Federal University of Agriculture, Abeokuta (FUNAAB), Ogun State, Nigeria. This study assess the effectiveness of eight seed storage treatment which include; pyramid, small icosahedron, big icosahedron, vertical hexahedron, horizontal hexahedron, poly icosahedron, ambient (control) and refrigerator (control). The seed were stored for two, four and six months. The treatment were arranged in a Complete Randomized Design (CRD) with three replications. The key agronomic parameters which include; germination count, germination percentage, leaf area, vine length, number of leaves, fresh weight and dry matter production were measured at 2 and 4 WAP. There was significant differences (P<0.05) between the treatment of storage for different growth data collected, especially after storage for a long time. Therefore, seeds that were stored under ambient condition alongside horizontal and vertical hexahedron structure showed higher growth performance when measured parameters. While seed stored in pyramid and small Icosahedron structure result in low growth performance. This finding presented the important of adopting geometry seed storage structure has a potential to increase agricultural productivity.

Keywords: Geometry, Seed, Storage, Growth, Watermelon

INTRODUCTION

Seed deterioration is one of the problem farmer's encounter in cultivation of vegetables such as watermelon (*Citrullus lanatus* L.) as a result of improper storage condition (Priyantha et al., 2021). There is a need to investigate the appropriate structure for storing watermelon seeds to prevent poor growth. Although, previous studies have investigated the effect of temperature, humidity and storage duration on seed quality, limited attention has been given to the influence of geometry seed storage structure on seed physiological performance and subsequent crop growth, particularly watermelon (Gebeyehu, 2020).

Seed quality is one of the most important factors influencing crop establishment, growth and yield in agricultural production systems (Finch-Savage, 2020). High quality seeds enhance germination, seedling vigour and crop performance, thereby improving the efficiency of other agricultural inputs such as fertilizers and agrochemicals (Javed et al., 2022).

Seed storage conditions play a critical role in maintaining seed viability and vigor (De Vitis et al., 2020). According to watermelon research by (Taylor, 2020), a seed is a matured ovule containing an embryo, stored food reserves and protective seed coat necessary for plant development. Therefore, seeds serve as the foundation of agricultural productivity and the availability of quality seed is essential for sustainable crop production and food security (Chauhan et al., 2020). The use of high quality seeds ensures adequate plant population, improved germination percentage and enhanced field performance even under varying environmental condition (Javed et al., 2022).

Watermelon contributes significantly to household nutrition and income generation, particularly in developing countries where it serves as a source of vitamins, minerals, antioxidant and hydration during dry season. Despite its global importance, watermelon productivity is often constrained by poor seed quality, inadequate storage conditions and environmental stress factors, which negatively affect germination, growth and fruit yield (Dube et al., 2021).

Geometric seed storage shapes may influence seed arrangement, aeration, moisture distribution and temperature regulation within storage environment, thereby affecting seed viability and plant development (Bakhtavar and Afzal, 2020). Therefore, this study aimed is evaluate the effect of geometry seed storage structure on the growth performance of watermelon under controlled environment which is important for improving seed management practices and enhancing crop productivity.

MATERIALS AND METHODS

Description of the Study Area

The study was carried out in greenhouse at Federal University of Agriculture, Abeokuta (FUNAAB), Ogun State, Nigeria. A place known for its rich farming activities. Abeokuta featured a tropical climate zone with an average annual rainfall of 1200 – 1500mm per annum and temperature ranging from 24^{o}c to 33^{o}c. the soil is sandy loam and well drain fertile, suitable for cultivation of crops. The greenhouse provide a control environment to minimize external viabilities.

Seed Source

Certified Watermelon seeds (Zuma F1) were obtained from jubilee seeds company, Nigeria. The seeds were selected based on uniform size and absence of viability damage to ensure experimental consistency.

Construction of Seed Storage Geometry Structures

Six geometry seed storage structures; pyramid, small icosahedron, big icosahedron, vertical hexahedron, horizontal hexahedron, and poly icosahedron, were constructed for the experiment. Each structure was fabricated using treated hardwood frame of 30cm x 30cm in size. The internal surface of all were lined with high density polyethylene sheets to minimize moisture exchange. Galvanized steel sheets to enhance structural durability, prevent pest infestation and reduce physical damage. All joints and edges were sealed using waterproof silicone sealant to ensure near airtight storage condition.

Seed Arrangement
A total of 240 seeds were used in the study. 30 seeds were allocated to 8 treatments. Seeds were uniformly distributed in single layers within perforated paper envelopes and placed at the geometric centre of storage unit. This arrangement was to ensure homogeneous exposure of seeds to the internal micro environment of each geometric structure.

Experimental Design Storage Treatment
The experiment was arranged as factorial combination of eight storage treatments and three storage duration (2, 4 and 6 months) laid out in Completely Randomized Design (CRD) with three replications. The storage treatment comprised of pyramid, small icosahedron, big icosahedron, vertical hexahedron, horizontal hexahedron, poly icosahedron, ambient storage and refrigerator storage. Seeds were stored under their respective conditions for the designation periods. Ambient storage was maintained at approximately 22^0C under laboratory condition while refrigerator storage was maintained at 4^oC at the end of each storage duration.

Seed Sowing and Green House Management
After each storage period, seeds were sown individually into 10L of plastic pots filled with sterilized sandy loam soil. Seeds were planted at a depth of 3cm. Pots were arranged in the greenhouse conditions and watered regularly to maintain adequate soil moisture throughout the experimental period. Standard agronomic practices were uniformly applied across all treatment.

Data Collection
Data were collected on germination and vegetative growth parameters on a standard crop evaluation and the following parameters were assessed.

i. Number of leaves per plant were counted
ii. Leaf area were measured
iii. Vine length were measured
iv. Fresh weight were recorded
v. Dry weight were obtained

Statistical Analysis
Data collected were subjected to analysis of variance (ANOVA) using Statistical Analysis Software (SAS, version 9). Mean separation was performed using Duncan's Multiple Range Test (DMRT) at a 5% significance level.

RESULTS AND DISCUSSION

Table1: Effect of Different Seed Storage Geometry on Growth Performance of Watermelon After Two (2) Months of Storage

TREATMENTS	LEAF AREA(cm^2) 2WAP	LEAF AREA (cm^2) 4WAP	VINE LENGHT(cm) 2WAP	VINE LENGTH (cm) 4WAP	NO OF LEAVES 2WAP	NO OF LEAVES 4WAP	FRESH WEIGHT (g) 4WAP	DRY WEIGHT (g) 4WAP
Pyramid	42.73	79.33	7.05	9.67	4.83	6.00	4.01	0.52
Small Icosahedron	35.77	62.97	6.25	9.67	4.67	6.00	3.05	0.43
Big Icosahedron	51.17	86.87	7.85	9.50	5.50	7.67	8.09	1.04
Vertical Hexahedron	40.63	72.27	7.22	10.67	5.33	7.00	9.91	0.82
Horizontal Hexahed.	62.83	114.47	7.65	11.33	5.83	7.67	7.24	0.83
Poly Icosahedron	40.20	61.03	6.13	11.17	4.67	8.00	5.14	0.79
Ambient (ctrl)	43.77	79.37	7.60	17.00	5.17	8.67	10.94	1.05
Refrigerator (ctrl)	59.60	100.57	8.28	11.33	5.83	6.67	8.59	0.82
LSD (0.05)	41.33	52.16	3.31	8.22	1.66	2.69	6.23	0.59

Means followed by the same letter (s) in the same column are not significantly different at 5% probability (DMRT)

Mean of Experiment 1 is Represented in Table 1
There were no significant differences ($P > 0.05$) among treatment for leaf area, vine length, number of leaves and dry weight at both sampling periods. This suggests that short-term seed storage in the various geometric structures had a minimal influence on early vegetative growth and biomass accumulation of watermelon seedlings. Therefore significant differences ($p < 0.05$) were observed in fresh weight at WAP. Seeds stored under ambient conditions produced the highest fresh weight (10.94 g), while seed stored under ambient condition may be attributed to the maintenance of favourable physiological conditions that preserved seed vigor during storage. Seed vigor is critical determinant of seedling establishment and biomass production, as vigorous seeds generally produce stronger seedling with greater growth potential. Similar observations were reported by (De vitis et al., 2020), who reported that appropriate storage condition are essential for maintaining seed viability and seedling performance.

Table 2: Effect of Different Seed Storage Geometry on Growth Performance of Watermelon after Four (4) Months of Storage

TREATMENTS	LEAF AREA(cm^2) 2WAP	LEAF AREA (cm^2) 4WAP	VINE LENGHT(cm) 2WAP	VINE LENGTH (cm) 4WAP	NO OF LEAVES 2WAP	NO OF LEAVES 4WAP	FRESH WEIGHT (g) 4WAP	DRY WEIGHT (g) 4WAP
Pyramid	4.13	8.50	3.73	6.67	2.67	7.00	4.10	0.59
Small Icosahedron	3.16	9.97	4.83	6.83	3.17	7.67	2.85	0.52
Big Icosahedron	5.00	11.17	5.50	11.50	3.67	10.33	11.68	1.41
Vertical Hexahedron	8.83	17.37	6.00	12.83	3.50	12.00	9.56	0.96

TREATMENTS	LEAF AREA(cm²) 2WAP	LEAF AREA (cm²) 4WAP	VINE LENGHT(cm) 2WAP	VINE LENGTH (cm) 4WAP	NO OF LEAVES 2WAP	NO OF LEAVES 4WAP	FRESH WEIGHT (g) 4WAP	DRY WEIGHT (g) 4WAP
Horizontal Hexahed.	6.07	14.97	5.67	10.33	3.33	8.67	10.54	1.35
Poly Icosahedron	4.23	11.37	6.00	8.33	3.83	8.67	7.86	0.79
Ambient (ctrl)	7.73	19.03	6.83	19.33	4.17	14.00	13.60	1.25
Refrigerator (ctrl)	8.33	17.93	6.00	13.33	4.00	10.33	8.73	1.33
LSD (0.05)	4.82	7.39	1.64	5.47	1.01	4.57	7.52	0.74

Means followed by the same letter (s) in the same column are not significantly different at 5% probability (DMRT)

Mean of Experiment 2 is Represented in Table 2

Significant differences ($P < 0.05$) were observed for leaf area, vine length, number of leaves, fresh weight and dry weight. Seeds under ambient condition produced the highest leaf area (19.03 cm^2), vine length (19.33 cm), number of leaves (14.00) and fresh weight (13.60 g) at 4 WAP. These indicate that storage geometry maintained seed performance as storage duration increased. The pyramid and small icosahedron treatment generally recorded the lowest values for must growth parameters. The higher performance observed under ambient storage suggests better preservation of seed vigor and metabolic activity, resulting in enhanced seedling growth. Similarly, the vertical hexahedron treatment showed relatively high values for leaf area and vine length. These indicate that potential effectiveness in maintaining seed quality during medium term storage. The improved growth performance observed in these treatments may be associated with favourable internal storage conditions that reduced seed deterioration and maintained physiological integrity. These findings agree with the reports of (Taylor, 2020), who demonstrated that storage conditions significantly affect seed quality, seedling establishment and subsequent plant growth. These results also support the assertion of (Dadline et al., 2023) that storage environment influences moisture regulation and seed preservation.

Table 3: Effect of Different Seed Storage Geometry on Growth Performance of Watermelon after Six (6) Months Of Storage

TREATMENTS	LEAF AREA(cm²) 2WAP	LEAF AREA (cm²) 4WAP	VINE LENGHT(cm) 2WAP	VINE LENGTH (cm) 4WAP	NO OF LEAVES 2WAP	NO OF LEAVES 4WAP	FRESH WEIGHT (g) 4WAP	DRY WEIGHT (g) 4WAP
Pyramid	35.83	50.57	8.33	15.33	3.67	6.67	4.20	0.41
Small Icosahedron	30.63	46.53	6.23	14.33	3.67	7.33	3.19	0.48
Big Icosahedron	40.17	62.83	8.00	14.00	5.33	7.33	7.28	0.94
Vertical Hexahedron	33.97	55.87	7.67	16.67	4.00	7.33	8.37	0.78
HorizontalHexahed.	55.50	73.10	6.83	16.00	4.00	7.67	5.81	0.80
Poly Icosahedron	34.43	47.30	10.00	14.00	4.00	8.33	5.11	0.60
Ambient (ctrl)	39.00	62.13	7.33	22.00	5.33	7.00	5.93	0.56
Refrigerator (ctrl)	54.63	73.97	8.17	13.17	4.33	6.00	6.61	1.22
LSD (0.05)	34.08	53.75	2.88	6.23	1.46	2.29	3.30	0.52

Means followed by the same letter (s) in the same column are not significantly different at 5% probability (DMRT)

Mean of Experiment 3 is Represented in Table 3

Significance differences ($P < 0.05$) were observed for vine length, number of leaves at 2 WAP, fresh weight and dry weight. Leaf area did not differ significantly among the treatments. The ambient control treatment produced the longest vine length at 4 WAP (22.00 cm), while the poly icosahedron treatment recorded the greatest vine length at 2 WAP (10.00cm). Fresh weight was highest in the vertical hexahedron treatment (8.37 g), whereas the refrigerator control recorded the highest dry weight (1.22 g). However, the small icosahedron treatment consistently recorded the lowest values for most growth parameters. the highest performance of vertical hexahedron and refrigerator treatments after prolonged storage indicate their ability to maintain seed physiological quality and reduce deterioration over time. the poor performance observed in the pyramid and small icosahedron treatment may indicate less effective preservation of seed quality extended storage. Similar findings were reported by (Gebeyehu et al., 2020), who observed that prolonged storage under unfavourable condition can significantly reduce seed vigor and crop performance.

Discussion

The result of this study demonstrated that the influence of seed storage geometry on watermelon growth performance varied with storage duration (Kehinde et al., 2020). Minimal treatment effect were observed after two month of storage, suggesting that short-term storage had little impact on seed quality regardless of storage structure. However, as storage duration increased to four and six months, significant differences emerged among treatment for several growth parameters, indicating that the effect of storage geometry became more pronounced over time. Across the storage periods, the ambient control treatment consistently produced favorable growth responses. Particularly for vine length, leaf area, number of leaves and fresh weight (Petoumenou, 2023). Similarly, the vertical hexahedron treatment performed well fresh weight after prolonged storage, while the refrigerator control recorded the highest dry weight after six month of storage. In contrast, the pyramid and small icosahedron treatment generally recorded lower values for several growth parameters, especially after extended storage period. The observed differences among treatment suggest that storage geometry may influence the maintained of seed quality during storage (Gebeyehu, 2020). However, the mechanism responsible for these differences could not be established in the present study because environmental conditions within the storage structures, such as temperature, relative humidity and seed moisture content, were not monitored (Delouche et al., 2021). Therefore, the result should be interpreted as evidence of an association between storage geometry and subsequently plant growth. These findings indicate that storage duration plays critical role in determining the effect of storage geometry on watermelon seed performance (Jahun and Babajide, 2024). The higher performance observed in ambient storage and selected geometric structures suggests their potential usefulness for maintaining seed quality during medium to long term storage. Further studies incorporating seed physiological assessment and storage microclimate measurement are required to better understanding the processes underlying these responses.

CONCLUSION

The study demonstrated that seed storage geometry influenced the growth performance of watermelon, particularly after prolonged storage. Ambient storage condition consistently supported favourable seedling growth, while vertical hexahedron storage showed potential for maintaining biomass accumulation after extended storage. In contrast, pyramid and small icosahedron structure were generally less effective. These findings suggest the adoption of storage geometry may influence seed quality preservation and subsequently crop establishment. Further studies incorporating seed physiological assessment and storage microclimate measurement are required to better understanding the processes underlying these responses.

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