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Evaluating the Efficiency of Vermicompost and Fermented Farmyard Manure on the Growth and Productivity of Squash (*Cucurbita pepo* L.)

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***Abstract* - This study was carried out during the 2024–2025 growing season in the Hazano area of Idlib Governorate, northern Syria, to evaluate the relative efficiency of three organic growing media - vermicompost, fermented farmyard (poultry) manure, and a 1:1 mixture of the two — applied at four fertilization levels (0, 1, 2 and 3 kg/m²) on the growth and productivity of squash (*Cucurbita pepo* L.) cv. Sirina F1. The experiment was laid out in a randomized complete block design (RCBD) with three replicates, and six principal vegetative and yield traits were assessed. The results revealed clear differences in plant response among treatments, with the organic mixture outperforming the single media in most growth and yield indicators. The greatest plant height (74.77 cm) was recorded for the mixture at 3 kg/m², compared with 39.70 cm for the unfertilized control, and the mixture also achieved the highest mean leaf number (22.49 leaves per plant). For yield traits, fermented farmyard manure gave the highest mean fruit weight (111.24 g at 2 kg/m²), whereas the mixture produced the greatest number of fruits (48.27 fruits per plant at 3 kg/m²). Total productivity was markedly highest under the mixture, reaching 8006.47 kg/dunum at 3 kg/m² versus 3508.57 kg/dunum for the control. Increasing the fertilization level produced a steady improvement in most traits, and a significant interaction between medium type and fertilization level was detected for most characteristics. The combined application of the organic mixture at 3 kg/m² is therefore recommended for sustainable squash production under local conditions.**

Keywords: Squash (*Cucurbita pepo* L.), Vermicompost, Fermented Farmyard Manure, Vegetative Growth, Productivity, Organic Farming, Sustainable Agriculture.

I. INTRODUCTION

Squash (*Cucurbita pepo* L.) is one of the most important horticultural crops grown on a wide scale across many agricultural regions, owing to its high nutritional value, rapid growth and good productivity. The crop is believed to have originated in the mountainous regions of northern Mexico and the southern and western United States; archaeological remains dating back to about 7000 BC indicate the presence of squash in Mexico.

Squash is cultivated worldwide on an area of about 5 million dunums, roughly half of which lies in Asia. In Syria, the cultivated area is estimated at about 40 thousand dunums with a production of approximately 60 thousand tons. The crop is grown in all Syrian governorates, with Latakia ranking first in production and cultivated area, followed by Tartous and then Aleppo [1].

Squash is grown for its tender fruits, which are consumed at the stage of economic maturity in many forms — cooked, stuffed with rice, fried, and otherwise. The fruits are easily digestible and of high nutritional value, containing about 5–8% dry matter composed of 3–5% carbohydrates, about 1% protein, 0.6% fibre and roughly 0.5% mineral salts (chiefly potassium 238 mg, phosphorus 29 mg, calcium 28 mg, magnesium 9 mg, sodium 2 mg and iron 0.4 mg), in addition to vitamins (vitamin A 40 mg, vitamin C 30 mg, vitamin B1 0.03 mg, vitamin B2 0.12 mg and vitamin B3 0.6 mg). The seeds are rich in fats (46%) and protein (34%), as well as carbohydrates (10%) and fibre (3%), and also contain the glycoside santonin, which acts as an intestinal anthelmintic. The fruits further possess medicinal importance, being beneficial for patients suffering from heart disease, arteriosclerosis and high blood pressure, and helping to protect the mucous membrane lining the stomach and intestines because of their high content of pectic substances [2], [3].

Modern agriculture faces growing challenges associated with the deterioration of soil fertility, declining crop productivity and the adverse environmental impacts of the intensive use of chemical fertilizers. Against this background, there is a pressing need to adopt sustainable agricultural practices that rely on natural and safe sources to improve soil properties and promote plant growth. Among these sources, organic fertilizers occupy a prominent place, given their effective role in improving soil structure, increasing its

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organic-matter content and stimulating beneficial soil microorganisms.

Among the organic growing media available, vermicompost (produced through the decomposition of organic matter by microorganisms) and the nutrient-rich excreta of farm animals (farmyard manure) are among the most widely used sources in organic farming. Moreover, combining vermicompost with animal manure may provide a balanced medium that integrates the benefits of both, with a positive reflection on plant growth and yield improvement.

The present study seeks to evaluate the effect of the organic growing medium (vermicompost, fermented farmyard manure, and the mixture of the two) on the growth and yield of squash through a field experiment designed to compare the performance of each medium in terms of its effect on vegetative growth and production. It further aims to provide practical recommendations to farmers regarding the best organic practices that can be adopted to improve squash production in a sustainable and environmentally friendly manner. The study derives its importance from its contribution to supporting the global trend towards organic farming, providing alternatives to chemical fertilizers and enhancing food security by improving the productivity of horticultural crops using locally available natural resources.

II. LITERATURE SURVEY

Soil is the fundamental element of the agricultural process, representing the living medium in which plants grow and from which they obtain nutrients and water. With increasing environmental stresses and the deterioration of soil fertility resulting from the excessive use of chemical fertilizers, the need has arisen to enhance the soil by natural and safe means, among them organic fertilizers and vermicompost.

Vermicompost is defined as a stable, high-quality organic product formed through a complex biological decomposition of organic waste carried out by a synergistic, symbiotic activity between certain species of earthworms and their associated microorganisms.This biological process is distinguished by being a cold process in which temperatures do not rise to the levels reached in conventional composting, thereby preserving the vitality of beneficial microorganisms and preventing the loss of volatile nutrients such as nitrogen, which yields a richer and more valuable final product [4].

Vermicompost consists of a complex, interconnected blend of organic compounds, nutrients and living organisms, which together constitute the distinctive value of this organic fertilizer. Chemically, analysis reveals a balanced content of essential nutrients: it contains nitrogen — mainly in readily absorbable nitrate and ammonium forms — at 1.5–2.5%, available phosphorus at 1–2%, and soluble potassium at 1–2.Its value is not confined to nutrients, but extends to a high content of organic matter and humus ranging between 40–60%, which makes it an excellent amendment for the physical and chemical properties of the soil by increasing its capacity to retain water and nutrients and to form stable aggregates [5].

The most distinctive aspect of vermicompost is its richness in active biological components. It harbours a rich and diverse microbial community comprising organic-matter-decomposing bacteria, nitrogen-fixing bacteria, beneficial fungi and actinomycetes, which together form a miniature ecosystem that enhances soil health [6]. More importantly, analytical studies have demonstrated the presence of a set of natural plant hormones and bio-stimulants in vermicompost, such as auxins (IAA), gibberellins and cytokinins, which are produced naturally by the activity of worms and microorganisms and play a pivotal role in stimulating plant growth and increasing its resistance to stresses [7].

The production of vermicompost passes through several successive and overlapping stages, beginning with the preparation of the worms' feeding medium from diverse organic wastes such as crop residues, food-processing by-products and fermented animal manure. This is followed by a pre-processing and initial-decomposition stage, in which the organic matter undergoes preliminary breakdown for two to four weeks in order to reduce toxic compounds, lower the temperature and prepare the medium to receive the worms. The principal stage — worm-assisted decomposition — then begins, during which the worms, through their feeding and metabolic activity, perform a number of vital functions including the ingestion and fragmentation of organic matter, the secretion of decomposing enzymes in their digestive tract, the conversion of elements into absorbable forms, and the activation and proliferation of associated microorganisms [8]. The maturation stage lasts from two to three months, during which decomposition is completed, the chemical properties stabilize, the microbial community proliferates, and the complex humic compounds that confer on vermicompost its distinctive characteristics are formed [9].

The benefits of vermicompost extend to multiple environmental and agricultural domains. Environmentally, it contributes effectively to reducing the volume of organic waste by up to 60%, thereby easing the burden on landfills and reducing the greenhouse-gas emissions arising from their anaerobic decomposition, while also conserving natural resources through the recycling of nutrients in a closed system [10]. Agriculturally, its effect includes improving soil fertility and productivity by enhancing organic-matter and nutrient content, raising water-holding capacity, improving physical

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structure, and increasing the use efficiency of added fertilizers, with a positive reflection on plant growth and productivity [11].

Numerous scientific studies have been conducted for the precise evaluation of the effectiveness of vermicompost under different agricultural conditions. In a study by Bachman and Metzger [12], vermicompost was used in the cultivation of ornamental plants, where a clear improvement in vegetative growth and an increase in the soil's water-holding capacity were observed, indicating the effectiveness of vermicompost as an alternative to commercial growing media (such as peat and others).

Omololu *et al.* [13] studied the effect of different types of farm-animal manure on okra and found that cattle manure was the most effective in improving growth and production. In a study by Wilson *et al.* [14], the effect of different types of vermicompost on potato productivity and soil nutrient availability was evaluated; the results showed that the type of vermicompost used directly affects the availability of nitrogen and potassium, with mature vermicompost improving nutrient uptake while immature vermicompost led to nitrogen immobilization. Combining vermicompost with animal manure contributed to a balanced improvement of soil fertility, and the study recommended using organic vermicompost as a sustainable agricultural input to improve soil properties and reduce dependence on chemical fertilizers.

A study by Hashimi *et al.* [15] on greenhouse tomato showed that organic fertilizers improved fruit number and weight and reduced disease compared with chemical fertilizers.The Food and Agriculture Organization [16] confirmed in its report that the use of vermicompost and farm-animal manure contributes to improving soil properties and reducing emissions, and is part of a sustainable-agriculture strategy.

A study by Anwar *et al.* [17] on spinach showed that the use of vermicompost produced from cattle manure and poplar leaves had a clear effect in improving spinach growth and nutrient uptake. In a study by El-Mogy *et al.* [18] on lettuce, the effects of different organic fertilizers (vermicompost, rabbit manure and poultry manure) were compared with mineral fertilizer; the results showed that vermicompost was superior in improving soil fertility, increasing vegetative growth and enhancing post-harvest storage quality compared with animal excreta and chemical fertilizers, and the study concluded that vermicompost is a sustainable and effective option for improving lettuce production without harming soil or environmental quality.

In a field study by Joshi *et al.* [19], earthworm vermicompost was used in wheat cultivation to evaluate its effect on growth and production; the results showed that vermicompost increased plant height, the number of spikes and grain yield compared with the control, demonstrating its effectiveness in improving agricultural performance, and the study indicated that a low dose of vermicompost was sufficient to achieve good economic results, reinforcing its role as a sustainable alternative to chemical fertilizers. A long-term study on wheat likewise showed that the use of vermicompost led to a 30% increase in yield compared with the control, with a marked improvement in grain quality, higher protein content and greater water-use efficiency [11].

A study by Kumbar *et al.* [20] showed that the use of organic fertilizers such as poultry manure and vermicompost had a markedly positive effect on the growth and yield of hot pepper: poultry manure accelerated vegetative growth during the early stages, with increases in plant height and leaf number indicating its effectiveness in supplying nutrients rapidly, whereas vermicompost improved fruit quality in terms of size, colour and nutritional content as a result of improving the physical and chemical properties of the soil and increasing its microbial activity. Inorganic fertilizers, by contrast, gave good short-term productivity results but were less sustainable, and the study recommended adopting an integrated nutrition system combining organic and inorganic fertilizers to achieve high productivity and improved fruit quality while preserving soil and agro-environmental sustainability. A study by Adhikari *et al.* [21] showed that organic fertilizers improved soil structure, increased microbial activity and raised the soil's water-holding capacity, whereas chemical fertilizers gave rapid productivity results but did not improve soil properties as efficiently and were less sustainable in the long term.

In a study conducted at the University of Anbar, Al-Janabi [22] addressed the effect of adding sawdust vermicompost on some physical properties of gypsiferous soil and on the growth and yield of wheat. The experiment was carried out on two soils differing in their gypsum content in order to evaluate the ability of vermicompost to improve soil structure and enhance agricultural production; the results showed that vermicompost contributed effectively to lowering the soil bulk density, improving aeration and increasing the soil's moisture-retention capacity. A significant improvement in the vegetative-growth indicators of wheat — such as plant height and the number of tillers — was also observed, in addition to a clear increase in grain yield compared with treatments without vermicompost, confirming that sawdust vermicompost is an environmentally and economically sound option for improving the properties of gypsiferous soils and for raising crop productivity, thereby supporting the trend towards sustainable agriculture in regions of fragile, organically poor soils.

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Al-Jayyar [23] presented a comprehensive review of the effect of vermicompost on the physical, chemical and biological properties of soil, confirming that mature compost increases the stable organic matter in the soil and improves the balance of water and air, leading to increased crop productivity and quality. In a field experiment in Sharqia Governorate, Abdel-Hakam *et al.* [24] studied the effect of foliar spraying with algal extracts, vermicompost and biofertilization on wheat productivity; the results showed that the interaction between vermicompost and algal extracts at certain concentrations led to a significant increase in yield and its components over both growing seasons.

Several recent studies have demonstrated the effectiveness of organic vermicompost in improving the production of beans, especially in arid and semi-arid regions. In a study by Al-Tawarah *et al.* [25] in Jordan, the effect of vermicompost on the growth of common beans and their nutrient content was evaluated; it was found that amending the soil with 50% vermicompost led to a substantial improvement in growth and moisture retention, which was reflected positively in productivity. In another study in India, Masram *et al.* [26] compared different types of organic vermicompost on the French-bean crop and found that animal-based vermicompost was the most effective in increasing the number and weight of pods and also improved soil properties under low-moisture conditions. In Egypt, a study by Aboseif *et al.* [27] showed that the use of organic vermicompost in the western Delta region improved the production of broad bean, with a clear increase in the soil's water-holding capacity and an improvement in its fertility compared with conventional chemical fertilization.

In a study by Suvendran *et al.* [28], the effect of vermicompost on plant growth under different irrigation conditions was evaluated; the results showed that vermicompost contributed to improving soil fertility and increasing crop growth, raised the organic-matter concentration and helped in moisture retention, with a positive reflection on agricultural productivity. In organic farming, a study by Gil-Martínez *et al.* [29] showed that combining vermicompost with cover-crop soil mulching enhanced soil fertility and increased microbial diversity and activity, contributing to improved soil quality and to the sustainability of agricultural production in the short and medium term. In a study by Rahman and Badr [30] in Iraq, the effect of vermicompost fortified with nano-NPK on soil fertility and potato growth was evaluated; the results showed a marked improvement in nutrient availability and an increase in organic matter, which was reflected positively in plant growth.

Oyege and Bhaskar [31] showed that vermicompost improves soil structure by increasing microbial activity and reduces the need for chemical fertilizers, thereby supporting sustainable-agriculture practices. The study by García-Santiago *et al.* [32] focused on the nutritional value of vermicompost, finding it to be rich in organic matter, micronutrients and plant hormones, which makes it effective in improving soil fertility and reducing environmental pollution, especially in low-input agricultural systems. Taken together, these studies show that the use of different organic media (vermicompost and fermented farmyard manure) contributes effectively to improving soil properties and increasing the growth and productivity of agricultural crops, which reinforces the importance of the present research in studying the effect of vermicompost and fermented farmyard manure on the growth and productivity of squash under local cultivation conditions.

III. PROBLEM DEFINITION AND OBJECTIVES

Agricultural practices based on organic inputs — foremost among them vermicompost and fermented farmyard manure — constitute a cornerstone for promoting the overall health of agricultural systems, contributing effectively to stimulating the biological life of the soil and improving its physical and chemical properties, with a positive reflection on the growth of sensitive crops such as squash. These practices also emerge as sustainable and environmentally responsible alternatives to conventional chemical options, helping to reduce pollution and achieving a practical balance between productivity requirements and the conservation of natural resources.

It is worth noting that each organic medium has a distinctive imprint on the course of plant growth, varying according to its components and the nature of its decomposition, which necessitates precise comparisons aimed at monitoring these differences and identifying response patterns across the various growth stages. The importance of this comparison also stems from the urgent need to determine the most efficient treatment for improving qualitative yield indicators — whether in terms of fruit number, size or weight — in addition to raising nutritional value, which represents a strategic objective for achieving the highest economic and environmental return from squash cultivation and contributes to formulating practical, applicable recommendations for organic-production programmes.

In light of the foregoing, the present research aims to:

1. Study the effect of organic vermicompost and fermented farmyard manure (applied separately or in combination) on the vegetative and reproductive growth of the squash crop.
2. Compare the effect of the three treatments on growth indicators (plant height, number of leaves) and

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production (number of fruits, fruit weight, total productivity) of the squash crop.
3. Provide practical agronomic recommendations on the best organic growing medium that can be used to cultivate squash under local conditions.

IV. MATERIALS AND METHODS

a) Study Site and Climatic Conditions

The experiment was carried out during the 2024–2025 growing season in an agricultural field within the Hazano area of Idlib Governorate, located about 25 km north of Idlib, at latitude 36.0896° and longitude 36.7250°. Figure 1 shows the experimental site after preparation. Prior to planting, an analysis of the site soil was performed to determine its nature and fertilization requirements; Table 1 presents the results of the soil analysis.

Figure 1: General view of the experimental field site in the Hazano area, Idlib Governorate, northern Syria

Table 1: Chemical Properties of the Soil Used in the Study

Parameter	Unit	Result	Minimum	Maximum	Evaluation
pH	pH value	7.0	6.0	7.0	Suitable
Organic matter	%	1.8	3.0	4.0	Low
Total nitrogen	kg/dunum	250.0	225	325	Suitable
Available nitrogen	kg/dunum	7.50	–	–	–
Total phosphorus	kg/dunum	23.50	100	175	Low
Available phosphorus	kg/dunum	0.89	–	–	–
Total potassium	kg/dunum	60.60	39	78	Suitable
Available potassium	kg/dunum	10.10	–	–	–
Clay fraction	%	39.0	20	40	Suitable
Cation exchange capacity	mmol+/kg	494.0	100	250	High
Soil texture class: Clay loam					

Reference ranges represent typical agronomic thresholds for the evaluation of cultivated soils.

b) Plant Material

The squash seeds used in the study were of the cultivar Sirina F1 (*Cucurbita pepo* L.), an early, high-yielding American cultivar (Figure 2).

Figure 2: Squash hybrid Sirina F1 used in the experiment

c) Agricultural Requirements and Inputs

The following inputs and equipment were used in the experiment:

- An agricultural tractor.
- A chisel plough.
- A drip-irrigation network.
- A water tank of 1 m³ capacity.
- Fertilizers and pesticides.
- A pesticide sprayer.
- Black plastic (mulch) to cover the planting rows.
- Agricultural vermicompost, produced on a private farm (Al-Ibrahim, Homs).
- Fermented farmyard manure (local poultry droppings).

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d) Experimental Treatments

The plants were grown in red clay-loam soil according to the open-field cultivation model. The experiment comprised two experimental factors:

First factor — the growing medium: three treatments were used, namely vermicompost (locally sourced), fermented organic manure (poultry manure), and a mixture comprising both vermicompost and fermented farmyard manure in equal proportions (1:1).

Second factor — the amount of organic matter: four levels of each growing medium were applied, namely 3 kg, 2 kg, 1 kg and 0 kg (control), per square metre.

e) Work Steps and Field Management

1. The land was prepared by suitable ploughing and levelling at the end of April 2025.
2. The experimental organic fertilizers were applied according to the experimental plan on 28 April 2025 and incorporated into the surface layer (20 cm depth) using a rotary hoe (Figure 3).

Figure 3: Preparation and distribution of the organic growing media over the experimental plots before incorporation into the soil

3. The drip-irrigation network was laid out and prepared immediately before planting, then tested to ensure the soundness and operation of the drippers.
4. Squash seeds were sown on 5 May 2025 on rows spaced 40 cm between plants and 125 cm between rows.
5. The drip-irrigation network was operated immediately after planting for one full hour, with monitoring throughout the irrigation period.
6. Germination dates and the number of germinated seeds were recorded, and the germination percentage was calculated to verify the viability and soundness of the seeds.
7. Irrigation was followed up regularly at a rate of one irrigation every three days, beginning with one hour of irrigation and increasing gradually (adding a quarter of an hour at each irrigation) until it reached four hours of irrigation (8 L/plant/irrigation).
8. Preventive fungal and insecticidal spraying was carried out at a rate of one weekly spray using specialized pesticides.
9. Fruit harvesting began on 12 June 2025 and continued until 14 August 2025 (Figure 4 and Figure 5).

Figure 4: Squash plants during the production stage under the organic-medium treatments

Figure 5: Squash fruits at the marketable maturity stage

f) Studied Traits

1. Plant height (cm): the plant height was measured from the soil surface to the end of the main stem using a metric measuring tape.
2. Number of leaves per plant: the leaves of all plants were counted, and the average number of leaves per plant was then calculated for all treatments.
3. Fruit weight (g): all fruits harvested from the plants were weighed, and the average weight of a single fruit was calculated for all treatments.
4. Number of fruits per plant: all fruits harvested from all plants were counted, and the average number of fruits per plant was calculated for all treatments.
5. Total productivity per dunum: the total productivity per unit area (the dunum, 1 dunum = 1000 m²) was

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calculated for all studied treatments by computing the productivity of each plant and multiplying it by the number of plants per dunum (according to the number used in the study).

6. Length of the growing season (days): the number of days from planting until the end of the production season and the last harvest was calculated.

g) Experimental Design and Statistical Analysis

All treatments were distributed according to a randomized complete block design (RCBD). The plants were grown on rows spaced 40 cm between plants and 125 cm between rows, with three replicates per experimental plot. The total number of experimental plots was therefore: growing media (3) × organic-fertilizer levels (4) × replicates (3) = 36 experimental plots, each plot containing 10 plants, so that the total number of plants studied was 360 plants.

The results were analysed on the computer using the statistical analysis software SigmaStat-10 (Systat Software Inc., San Jose, CA, USA), and the means were compared using the least significant difference (LSD) test at the 5% significance level.

V. RESULTS AND DISCUSSION

a) Effect of the Treatments on Plant Height

The results of the study (Table 2) show a clear effect of both the growing medium and the fertilizer concentration on the plant height of squash, with the statistical analysis revealing a substantial variation in the plant's response to these treatments. Regarding the effect of the growing medium, the mixture treatment was significantly superior, with a mean height of 62.45 cm, followed by the vermicompost treatment with a mean of 54.19 cm, which in turn was significantly superior to the farmyard-manure treatment that ranked last and recorded the lowest mean plant height of 49.13 cm. This superiority of the mixture is attributed to its improvement of the physical and chemical properties of the soil, which provides an ideal environment for root growth and nutrient uptake.

As for the means of the fertilizer concentrations, the results showed a clear gradient in the plant's response: the 3 kg/m² concentration was superior, with a mean height of 63.70 cm, then 2 kg/m² with a mean of 61.17 cm, then 1 kg/m² with a mean of 56.46 cm, while the control treatment without additions recorded the lowest mean height of 39.70 cm. The differences were significant among all fertilizer levels used. This gradient in response confirms the sensitivity of squash to fertilization and the necessity of providing appropriate nutrient levels to achieve optimal growth.

Analysing the interaction between the two factors, it was found that the mixture treatment at the third fertilizer level (3 kg/m²) was significantly superior to all other treatments, recording the highest plant-height value of 74.77 cm. In contrast, the control treatment without additions recorded the lowest plant-height value of 39.70 cm.

These results are consistent with the study of Al-Khafaji [33], which demonstrated the superiority of combined organic treatments over single treatments, where the organic mixture in that study recorded a plant height of 75.3 cm compared with 55.8 cm for single farmyard manure. The results also agree, in terms of the plant's response to fertilizer concentrations, with the study of Mohammed and Ahmed [34], which showed that increasing the fertilizer concentration up to 3 kg/m² led to a marked improvement in plant height, rising from 40.5 cm in the treatment without additions to 65.2 cm at the highest concentration.

Table 2: Effect of the Experimental Treatments on the Plant Height of Squash (cm)

Growing Medium	Fertilization Concentration (kg/m²)				Mean of Media
	0	1	2	3	
Vermicompost	39.70	56.73	58.57	61.77	**54.19^{b}**
Fermented farmyard manure	39.70	48.97	53.27	54.57	**49.13^{c}**
Mixture (1:1)	39.70	63.67	71.67	74.77	**62.45^{a}**
Mean of Concentrations	**39.70^{d}**	**56.46^{c}**	**61.17^{b}**	**63.70^{a}**	**55.26**

LSD (0.05): Growing medium = 0.92; concentration = 1.13; interaction = 2.04. Means of a main effect followed by the same letter are not significantly different at the 0.05 probability level.

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b) Effect of the Treatments on the Number of Leaves

The results shown in Table 3 reveal a complex interaction between the type of growing medium and the fertilization levels in their effect on the number of leaves per plant. In terms of the effect of the growing medium, the mixture treatment was superior, achieving the highest mean leaf number of 22.49 leaves, followed by the vermicompost treatment, which was significantly superior to the farmyard-manure treatment, with values of 19.98 and 18.08 leaves, respectively. The superiority of the mixture is consistent with the complementarity of its two components and with the improvement it brings to the biological condition of the soil.

As for the effect of the fertilization levels, the results showed a gradual improvement in leaf number with increasing fertilization level, where the 3 kg/m² level achieved the highest mean of 22.98 leaves per plant, significantly superior to the lower levels. The 2 kg/m² level was also significantly superior to the 1 kg/m² level, with values of 22.06 and 20.87 leaves per plant, respectively. All of the foregoing levels were significantly superior to the 0 kg/m² level (control), which achieved the lowest leaf number of 14.83 leaves per plant. This response pattern is consistent with the findings of the study by Chen and Lee [35], in which increasing the fertilization level improved the vegetative growth of squash plants, with no significant differences observed between the intermediate fertilization levels.

On analysing the interaction between the two factors, the mixture treatment at the third fertilization level emerged as the best treatment of all, achieving 26.07 leaves and outperforming the remaining treatments. In contrast, the mixture treatment at the first fertilization level recorded the lowest value among the fertilized treatments (24.00 leaves). This complex interaction between the two factors confirms the importance of selecting the appropriate composition of the growing medium together with the optimal fertilization level, as the study of Garcia *et al*. [36] showed that the response to fertilization differs substantially according to the properties of the growing medium used.

Table 3: Effect of the Experimental Treatments on the Number of Leaves per Squash Plant

Growing Medium	Fertilization Concentration (kg/m²)				Mean of Media
	0	1	2	3	
Vermicompost	14.83	20.53	21.87	22.70	**19.98[b]**
Fermented farmyard manure	14.83	18.07	19.23	20.17	**18.08[c]**
Mixture (1:1)	14.83	24.00	25.07	26.07	**22.49[a]**
Mean of Concentrations	**14.83[c]**	**20.87[b]**	**22.06[b]**	**22.98[a]**	**20.18**

LSD (0.05): Growing medium = 0.47; concentration = 0.54; interaction = 0.93. Means of a main effect followed by the same letter are not significantly different at the 0.05 probability level.

c) Effect of the Treatments on Fruit Weight

The results of Table 4 show a clear effect of both the growing medium and the fertilization level on the fruit weight of squash, with the statistical analysis revealing an influential interaction between these two factors. Regarding the effect of the growing medium, the farmyard-manure treatment was significantly superior, with a mean fruit weight of 100.00 g, whereas the differences between the vermicompost and mixture treatments were not significant, with fruit weights of 93.00 and 91.59 g per fruit, respectively. This clear superiority of farmyard manure is attributed to its balanced content of nutrients — including nitrogen, phosphorus and potassium — which play a key role in the synthesis of carbohydrates and the filling of fruits.

As for the effect of the fertilizer concentrations, the results showed a marked improvement in fruit weight with fertilizer addition, where the 2 and 3 kg/m² concentrations were superior (with no significant difference between them), with a mean fruit weight of 101.40 and 99.17 g, respectively. The 1 kg/m² concentration ranked next with a mean of 93.80 g per fruit, while the control treatment (zero concentration) recorded the lowest mean weight of 85.08 g per fruit. This gradient in response demonstrates the efficiency of the plant in benefiting from the intermediate fertilization levels to achieve the best results.

Analysing the interaction between the two factors, it was found that the farmyard-manure treatment at the 2 kg/m² concentration achieved the highest fruit weight of 111.24 g, whereas the control treatment (zero concentration) recorded the lowest fruit weight of 85.08 g.

These results are consistent with those reported by the study of Thompson and Miller [37], which demonstrated the superiority of farmyard manure in improving the productive traits of squash, where it achieved a mean fruit weight of 108.3 g compared with 95.6 g for the vermicompost treatment. The results concerning the response of fruit weight to fertilizer

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concentrations also match the findings of the study by Garcia *et al.* [38], which showed that fertilization at a level of 2.5 kg/m² achieved the highest fruit weight of 115.2 g, with a slight decrease at higher fertilization levels.

Table 4: Effect of the Experimental Treatments on the Fruit Weight of Squash (g)

Growing Medium	Fertilization Concentration (kg/m²)				Mean of Media
	0	1	2	3	
Vermicompost	85.08	92.10	97.98	96.84	**93.00^{b}**
Fermented farmyard manure	85.08	102.59	111.24	101.10	**100.00^{a}**
Mixture (1:1)	85.08	86.72	94.99	99.56	**91.59^{b}**
Mean of Concentrations	**85.08^{c}**	**93.80^{b}**	**101.40^{a}**	**99.17^{a}**	**94.86**

LSD (0.05): Growing medium = 3.35; concentration = 2.73; interaction = 5.78. Means of a main effect followed by the same letter are not significantly different at the 0.05 probability level.

d) Effect of the Treatments on the Number of Fruits per Plant

The results of Table 5 show a profound effect of both the growing medium and the fertilization level on the number of fruits of squash, with the statistical analyses revealing a clear variation in the performance of the different treatments. Regarding the effect of the growing medium, the mixture treatment was significantly superior, with a mean of 39.66 fruits, followed by the vermicompost treatment with a mean of 33.93 fruits, and with a significant difference from the farmyard-manure treatment, which gave the lowest number of fruits with a mean of 27.50 fruits. This marked superiority of the mixture can be attributed to its ability to provide a balanced environment in terms of aeration, moisture retention and nutrient availability, which is reflected positively in the efficiency of the plant in forming and retaining the greatest number of fruits.

As for the effect of the fertilizer concentrations, the results showed a steady improvement in fruit number with increasing fertilization level, where the 3 kg/m² concentration was superior with a mean of 39.79 fruits, followed by 2 kg/m² with a mean of 36.18 fruits, then 1 kg/m² with a mean of 34.06 fruits, while the control treatment (zero concentration) recorded the lowest mean of 24.77 fruits. The differences were significant among all concentrations. This gradient in response confirms the importance of balanced fertilization in enhancing the productive capacity of squash, with the improvement continuing as the fertilization level increased up to the highest concentration tested.

Analysing the interaction between the two factors, it was found that the mixture treatment at the 3 kg/m² concentration was significantly superior to all other treatments, recording the highest number of fruits of 48.27 fruits, whereas the control treatment (zero concentration) recorded the lowest number of fruits of 24.77 fruits.

5 fruits compared with 28.3 fruits for the single farmyard-manure treatment.8 fruits in the treatment without additions to 42.6 fruits at the highest concentration.

Table 5: Effect of the Experimental Treatments on the Number of Fruits per Squash Plant

Growing Medium	Fertilization Concentration (kg/m²)				Mean of Media
	0	1	2	3	
Vermicompost	24.77	35.17	36.73	39.07	**33.93^{b}**
Fermented farmyard manure	24.77	26.23	26.97	32.03	**27.50^{c}**
Mixture (1:1)	24.77	40.77	44.83	48.27	**39.66^{a}**
Mean of Concentrations	**24.77^{d}**	**34.06^{c}**	**36.18^{b}**	**39.79^{a}**	**33.70**

LSD (0.05): Growing medium = 1.10; concentration = 0.82; interaction = 2.12. Means of a main effect followed by the same letter are not significantly different at the 0.05 probability level.

e) Effect of the Treatments on the Length of the Growing Season

The results of Table 6 show a tangible effect of both the growing medium and the fertilization level on the length of the growing season of squash, with the statistical analysis highlighting differing response patterns among the treatments. Regarding the effect of the growing medium, the farmyard-manure treatment recorded a higher mean growing-season length of 97.00 days, whereas the other two treatments showed

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no significant difference, with both vermicompost and the mixture recording a mean of 94.00 days. This differing performance indicates that farmyard manure contributed to prolonging the vegetative-growth and production period of squash, perhaps because of the continuous availability of nutrients that supports the continuity of vegetative growth.

As for the effect of the fertilizer concentrations, the results revealed an unexpected response pattern, where the addition of fertilizer at its various concentrations shortened the duration of the growing season compared with the control treatment, the growing-season length being 92.33, 93.00 and 93.67 days for the 1, 2 and 3 kg/m² concentrations, respectively, while the control treatment (zero concentration) achieved the longest growing-season period at 101.00 days. This decrease in the length of the growing season with fertilizer addition may reflect a stimulation of early maturity as a result of improving the nutritional status of the plant.

Analysing the interaction between the two factors, it was found that the control treatment (zero concentration) gave the longest growing-season length across all growing media, with a mean of 101.00 days, whereas the mixture treatment at the 1 kg/m² concentration recorded the lowest value of 91.00 days. These results indicate that the response of the growing-season length is influenced in a complex manner by the interaction between the type of growing medium and the fertilization level.

5 days compared with 92.8 days in the non-organic treatments. The results concerning the effect of fertilization in shortening the growth duration also agree with the findings of the study by Anderson and Davis [39], which showed that balanced fertilization accelerated the maturity of squash fruits by 15% compared with non-fertilized plants.

Table 6: Effect of the Experimental Treatments on the Length of the Growing Season of Squash (days)

Growing Medium	Fertilization Concentration (kg/m²)				Mean of Media
	0	1	2	3	
Vermicompost	101.00	89.00	93.00	93.00	**94.00[b]**
Fermented farmyard manure	101.00	95.00	95.00	97.00	**97.00[a]**
Mixture (1:1)	101.00	93.00	91.00	91.00	**94.00[b]**
Mean of Concentrations	**101.00[a]**	**92.33[d]**	**93.00[c]**	**93.67[b]**	**95.00**

LSD (0.05): Growing medium = 0.52; concentration = 0.41; interaction = 1.04. Means of a main effect followed by the same letter are not significantly different at the 0.05 probability level.

f) Effect of the Treatments on Total Productivity

The results of Table 7 show a profound effect of both the growing medium and the fertilization level on the total productivity of squash per unit area, with the statistical analyses revealing a clear variation in the crop's response to the different treatments. Regarding the effect of the growing medium, the mixture treatment was superior, with a mean productivity of 6125.69 kg/dunum, followed by the vermicompost treatment with a mean of 5301.63 kg/dunum, while the farmyard-manure treatment recorded the lowest mean yield of 4595.73 kg/dunum; the differences were significant among all treatments. This marked superiority of the mixture is attributed to its ability to provide an integrated environment that supports the efficiency of nutrient uptake and improves the physical properties of the soil, which is reflected positively in the total productivity of the crop.

As for the effect of the fertilizer concentrations, the results showed a steady improvement in yield with increasing fertilization level, where the 3 kg/m² concentration was superior with a mean yield of 6568.62 kg/dunum, followed by 2 kg/m² with a mean of 6030.42 kg/dunum, then 1 kg/m² with a mean of 5256.47 kg/dunum, while the control treatment (zero concentration) recorded the lowest mean yield of 3508.57 kg/dunum; the differences were significant among all concentrations. This positive gradient in response confirms the sensitivity of the squash crop to fertilization and the necessity of providing appropriate nutrient levels to achieve maximum productivity.

Analysing the interaction between the two factors, it was found that the mixture treatment at the 3 kg/m² concentration was superior to all other treatments, recording the highest yield of 8006.47 kg/dunum, whereas the control treatment (zero concentration) recorded the lowest yield of 3508.57 kg/dunum across all growing media.

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Table 7: Effect of the Experimental Treatments on the Total Productivity of the Squash Crop (kg/dunum)

Growing Medium	Fertilization Concentration (kg/m²)				Mean of Media
	0	1	2	3	
Vermicompost	3508.57	5396.97	5996.87	6304.13	**5301.63[b]**
Fermented farmyard manure	3508.57	4482.30	4996.80	5395.27	**4595.73[c]**
Mixture (1:1)	3508.57	5890.13	7097.60	8006.47	**6125.69[a]**
Mean of Concentrations	**3508.57[d]**	**5256.47[c]**	**6030.42[b]**	**6568.62[a]**	**5341.02**

LSD (0.05): Growing medium = 112.71; concentration = 97.64; interaction = 243.20. Means of a main effect followed by the same letter are not significantly different at the 0.05 probability level.

VI. CONCLUSION

The organic mixture (vermicompost plus fermented farmyard manure) was markedly superior in enhancing vegetative growth, recording the highest mean plant height (62.45 cm) and leaf number (22.49 leaves), as well as the greatest number of fruits (39.66 per plant) and the highest productivity per unit area (6125.69 kg/dunum). Single fermented farmyard manure excelled in fruit weight (100.00 g) and gave the longest growing season (97 days). Increasing the fertilization level steadily improved most traits, with the highest level (3 kg/m²) being generally superior. The interaction analysis showed that the combined treatment (mixture + 3 kg/m²) was superior in most traits, attaining the highest productivity (8006.47 kg/dunum), fruit number (48.27), leaf number (26.07) and plant height (74.77 cm).

VII. FUTURE SCOPE

1. It is recommended to adopt organic fertilizers (vermicompost and fermented farmyard manure) as an effective and sustainable alternative to chemical fertilizers in horticultural-crop production systems, given their integrated environmental and economic advantages.
2. The organic mixture composed of vermicompost and fermented farmyard manure should be applied at a concentration of 3 kg/m² as an optimal fertilization programme to achieve the highest values of productivity and crop quality, based on its significant superiority in improving growth and yield indicators.
3. In-depth studies should be conducted to evaluate the efficiency of applying organic-fertilization techniques to a wider range of horticultural crops, with a focus on identifying the physiological and biochemical mechanisms responsible for the improvement in productive traits.
4. A series of research trials should be implemented aiming to determine the optimal ratios and threshold concentrations of organic matter that achieve the maximum economic return while preserving long-term soil fertility.
5. Investment should be directed towards developing and modernizing the local production techniques of vermicompost in line with international quality standards, in order to ensure the provision of a high-quality product in quantities suitable for local needs at competitive prices.

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