

Organic Fertilizers: Alternative or Complement to Chemical Fertilizers

Boshra Khozam¹, Mohammad Manhal Al-Zoubi², Tammm Yaghi^{3,*}

¹Al-Wataniya Private University, Hama 013, Syria.

²General Commission for Scientific Agricultural Research, Natural Resources Research Administration, Damascus 011, Syria.

³Department of Biochemistry and Molecular Biology, Faculty of Biology, University of Bucharest, Bucharest 050107, Romania.

How to cite this paper: Boshra Khozam, Mohammad Manhal Al-Zoubi, Tammm Yaghi. (2026). Organic Fertilizers: Alternative or Complement to Chemical Fertilizers. *International Journal of Food Science and Agriculture*, 10(1), 68-79.
DOI: 10.26855/ijfsa.2026.03.008

Received: January 24, 2026

Accepted: February 20, 2026

Published: March 25, 2026

Corresponding author: Tammm Yaghi, Department of Biochemistry and Molecular Biology, Faculty of Biology, University of Bucharest, Bucharest 050107, Romania.

© 2026 by the author(s).

This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution-NonCommercial-NoDerivatives (CC BY-NC-ND) license, which permits non-commercial use, distribution, and reproduction in any medium, provided the original work is properly cited and is not modified or adapted.

<https://creativecommons.org/licenses/by-nc-nd/4.0/>

Abstract

Organic fertilizers, derived from the decomposition of plant and animal materials, are considered a sustainable option for improving soil structure and fertility over the long term. In contrast, chemical (synthetic) fertilizers provide readily available nutrients that are rapidly absorbed by plants, leading to immediate increases in productivity; however, they may negatively affect soil health over time. This study compiles results from 12 long-term field experiments (2006-2021) conducted across various regions of Syria to evaluate the agricultural effectiveness of organic fertilizers as either alternatives or supplements to chemical fertilizers in diverse farming systems. The duration of each experiment ranged from one to four years and involved the use of different types of organic fertilizers, biochar, and biogas slurry at varying application levels compared with commonly used mineral fertilizers. The results indicated that integrated application of organic and chemical fertilizers produced yields equal to or greater than chemical fertilizers alone in 75% of cereal and legume experiments. Meanwhile, organic fertilization alone was optimal for improving fruit quality indicators and soil organic matter in perennial crops. The findings support context-specific integrated nutrient management strategies, where organic fertilizers form the foundation of soil health and can reduce reliance on mineral fertilizers without compromising yield in many systems.

Keywords

Organic fertilizers; chemical fertilizers; biogas slurry; plant traits; biochar; soil health

1. Introduction and Literature Review

The use of chemical fertilizers has played a pivotal role in enhancing agricultural productivity and meeting the food demands of the growing global population [1]. Chemical fertilizers are essential for achieving high-yield crop production; however, the intensive and poorly regulated use of these fertilizers has raised significant environmental concerns [2]. Several researchers have expressed concern regarding the potential side effects of excessive fertilizer use on the environment. Given the importance of added plant nutrients in increasing agricultural production, any conclusions about the relationship between intensive fertilizer use and environmental quality must be based on sound evidence [3].

The overuse of chemical fertilizers has led to numerous environmental problems affecting soil, water, and air, in addition to indirect impacts on human health and living organisms [4]. Overuse contributes to the deterioration of soil physical, chemical, and biological properties. The accumulation of nutrients such as nitrogen and phosphorus in large quantities can disrupt the natural balance of soil elements, negatively affecting beneficial microbial activity. Furthermore, certain fertilizers may increase soil acidity or salinity over time, thereby reducing soil fertility and

adversely affecting plant growth [5].

Excessive fertilizer application also leads to water pollution. When fertilizers are applied in amounts exceeding plant requirements, a portion is leached through irrigation or rainfall into rivers, lakes, and groundwater. This process results in eutrophication, where excessive nutrient enrichment promotes algal blooms that deplete oxygen levels in water, thereby threatening aquatic life [6].

Moreover, excessive use of chemical fertilizers can harm biodiversity in both agricultural and natural ecosystems. Elevated nutrient concentrations may favor the dominance of certain plant species over others, disrupting ecological balance. Nutrient runoff into aquatic environments also threatens organisms such as fish and invertebrates due to reduced oxygen levels [7].

Intensive use of nitrogen fertilizers contributes to the emission of greenhouse gases such as nitrous oxide (N_2O), a potent gas with a high global warming potential. This gas is considered a significant contributor to climate change. Additionally, some nitrogen compounds may volatilize into the atmosphere, contributing to the formation of fine particulate matter that negatively affects air quality and human health [8].

Previous studies have indicated that the improper use of chemical fertilizers can negatively affect plant resistance to diseases by altering phenolic compounds within plants [9]. It may also influence the accumulation of harmful substances... This, in turn, may affect their marketability and export potential [10]. Agricultural experts have also observed that relying solely on chemical fertilizers to achieve high crop yields does not ensure sustainability. Crop response to chemical fertilizers largely depends on soil organic matter content, which plays a crucial role in improving soil physical and chemical properties [11].

Studies examining the environmental impacts of chemical fertilizers over both short and long terms have shown that, in the long term, soil pollution results from the use of nitrogen, phosphorus, and potassium fertilizers, while water pollution is mainly associated with nitrogen and phosphorus fertilizers. Air pollution is also linked to nitrogen and potassium fertilizers. In the short term, nitrogen fertilizers have a strong impact on soil, water, and air pollution, whereas phosphorus fertilizers primarily affect soil and water, and potassium fertilizers generally show no significant short-term negative effects [12].

Therefore, maintaining the physical, chemical, and biological properties of soil is essential for soil health and improving crop quality [13]. To mitigate the environmental impacts of chemical fertilizers, experts advocate for sustainable agricultural practices such as balanced fertilizer application based on soil and crop requirements, precision agriculture, and the use of organic fertilizers and green manure. Modern technologies such as soil analysis and remote sensing can also be integrated to enhance nutrient use efficiency and minimize environmental losses [4].

Organic fertilizers are considered a key component of sustainable agriculture. They are derived from natural sources such as plant residues, animal manure, and compost. Global interest in these fertilizers has increased due to environmental concerns associated with chemical fertilizers and their impacts on soil and water [14].

Recent agricultural studies indicate that organic fertilizers increase soil organic matter and improve its physical structure, enhancing its capacity to retain water and nutrients. They also improve soil aeration and promote the formation of stable aggregates, which support better root growth and more efficient nutrient uptake [15].

In addition, organic fertilizers can enhance microbial diversity in the soil, including beneficial bacteria and fungi that play a vital role in decomposing organic matter and releasing nutrients for plant uptake. A recent study demonstrated that the use of organic fertilizers alters microbial community structure and increases soil resilience to environmental disturbances [16].

Analytical studies have shown that organic fertilizers may improve crop quality in terms of nutritional value. One study found that their application increased the content of beneficial compounds such as sugars, lycopene, and proteins in crops, while potentially reducing nitrate concentrations in fruits [16].

Organic fertilizers are also characterized by their slow release of nutrients compared to chemical fertilizers, which reduces the risk of nitrogen leaching into surface and groundwater. Their use can reduce reliance on synthetic fertilizers and thereby decrease associated environmental pollution [17].

However, the slow release of nutrients may also be considered a limitation, as nutrient availability depends on microbial activity and environmental conditions such as temperature and moisture. This may sometimes result in insufficient nutrient availability during critical growth stages [14]. Additionally, the relatively low nutrient concentration in organic materials requires farmers to apply larger quantities to achieve effects comparable to chemical fertilizers, which may increase transportation and application costs in some cases [18].

Although organic fertilizers are generally more environmentally friendly, excessive or improper use may still lead to nitrate accumulation in soil or leaching into water, posing environmental risks similar to those associated with chemical fertilizers [19]. Furthermore, their production and preparation may be complex or inconsistent in

quality, making them less convenient in some modern agricultural systems [18].

Soil properties that respond rapidly to natural or human-induced factors are considered reliable indicators of soil health [20]. In this context, some farmers integrate organic, biological, and inorganic amendments in soil fertilization practices to maintain and improve soil fertility. This approach is known as Integrated Nutrient Management (INM) [21].

Numerous global studies indicate that integrated nutrient management is considered an effective strategy for achieving sustainable agricultural production. It enhances crop productivity, improves soil fertility, stimulates microbial activity, and reduces the environmental impacts associated with chemical fertilizer use. For example, a study on rice–wheat systems demonstrated that INM was found to significantly increase grain yield and improve farmers' economic returns [22]. Another recent study conducted in India on an oat–legume intercropping system showed that INM improved productivity, energy-use efficiency, and reduced the carbon footprint of the agricultural system [23].

Long-term studies have also demonstrated that INM significantly improves soil properties. In a 38-year experiment on a rice–wheat system, INM increased soil carbon stocks by up to 58% compared to the use of chemical fertilizers alone [24]. Other studies have shown that combining organic manure with mineral fertilizers enhances soil organic matter and improves its physical and chemical properties, leading to increased soil fertility and sustainable agricultural production [25].

Soil microorganisms play a critical role in nutrient cycling. Recent research has shown that INM increases microbial diversity and biomass in soil, enhancing organic matter decomposition and nutrient availability for plants [26]. Another study reported that combining farmyard manure with chemical fertilizers increased microbial biomass and improved enzyme activity associated with nutrient cycling [27].

Many studies confirm that integrated nutrient management is a key approach for achieving sustainable agriculture, as it improves nutrient use efficiency and reduces nutrient losses to the environment [25]. It also helps reduce greenhouse gas emissions associated with intensive agricultural systems while improving the efficiency of natural resource use [24].

The impact of sheep manure at three levels (0, 3, and 5 tons/ha) and phosphate fertilizer at three levels (0, 50, and 75 kg P/ha) was investigated regarding the growth and yield of the “Cypriot” faba bean cultivar.

The interaction treatments between sheep manure and phosphate fertilizer—specifically (5 tons/ha sheep manure + 75 kg P/ha) and (5 tons/ha sheep manure + 50 kg P/ha)—demonstrated significant superiority over all other treatments across most studied traits. These traits included:

(Plant height, Number of branches, Vegetative dry weight per plant, Leaf chlorophyll content, Mean weight of 1000 green seeds, Total yield (kg/ha).

The researcher attributed these results to the role of organic fertilizer in improving soil structure, increasing porosity, and balancing aeration. Furthermore, it enhances fertilizer use efficiency and increases the availability of water and mineral nutrients. By altering soil water movement dynamics, plants can access the appropriate amount of added phosphate via irrigation water. This enables the uptake of phosphate within the root zone, thereby reducing fertilizer losses typically caused by leaching and soil fixation [28].

Research results regarding the fertilization of pomegranate trees with mineral and organic fertilizers (cow manure, goat manure, and plant compost) indicated that plant compost yielded the highest tree productivity, reaching 42.30 kg. It also resulted in the highest values for fruit quality parameters, including: Fruit weight, Juice percentage, and juice weight. Total Soluble Solids (TSS). Sugar percentage [29].

It was noted that applying nitrogen fertilizer at a level of 160 kg N/ha (Urea) in combination with 20 tons/ha of sheep manure for fertilizing “Sham 6” wheat in salt-affected soils contributed to achieving the best economic results for the crop [30].

2. Justification and Objectives of the Study

Soils in the Mediterranean region are often low in organic matter due to the prevailing arid and semi-arid climate. These regions also face multiple environmental challenges, including soil degradation, pollution, drought, and desertification. Despite the existence of individual studies on improving soil fertility and properties, there is still a need for more comprehensive, long-term, multi-crop studies conducted within specific agro-ecological zones.

Such studies should evaluate the use of different types of organic fertilizers, biochar, and biogas slurry in agricultural soils to provide practical recommendations for farmers. The ultimate goals are to improve soil fertility and properties, reduce environmental pollution, decrease reliance on chemical fertilizers, increase crop productivity, and mitigate issues such as drought and soil degradation in the region.

3. Materials and Methods

3.1 Selection and Description of Studies

A series of studies was conducted at agricultural research centers (General Commission for Scientific Agricultural Research) across several Syrian cities, including Raqqa, Tartous, Latakia, Homs, Safita, Masyaf, and As-Suwayda. These studies, conducted over multiple years, focused on the application of organic and chemical fertilizers across multiple crops, including wheat, saffron, potato, peanut, thyme, and maize, as well as fruit trees such as orange, olive, and apple. The experiments evaluated the effects of various fertilizer types, including:

Sheep manure, Cattle manure, Goat manure, Poultry manure, Biogas slurry, Biochar, Green manure, Plant compost, Chemical fertilizers. These treatments were assessed for their impact on plant characteristics, crop productivity, and selected soil properties (Table 1).

Table 1. Data on research conducted

N	Crop Name	Location	Years of research	Experimental Design	Experimental Treatments	Characteristics studied	Reference
1	Durum and Soft Wheat	Raqqa	2021-2020	Split Piece Design	-Sheep manure fertilizer -Chemical fertilizer -Fertilizer (50% organic + 50% chemical) -Fertilizer (75% organic + 25% chemical)	- Plant height - Thousand-grain weight - Grain yield - Number of flowers	[31]
2	Saffron	Tartus	2020	Split Pieces	- Cow manure at three levels (15-30-45) tons/hectare - Chemical fertilizer - Three levels of corm planting rate (40-50-60) corms/m ²	- Wet and dry weight of stigmas - Optimal ratios of active ingredients (crocin, picrocin, and safranal)	[32]
3	Potatoes	Tartus	2020	Split Pieces	- Two levels of cow manure (2.5-5) kg/m ² , equivalent to (25-50) tons/hectare - Two levels of biochar (made from peanut shells) (1.2)% by weight of the soil - Other treatments combining cow manure and biochar	Potato yield	[33]
4	Peanuts	Tartus	2019-2018	Complete Random Blocks	- Three levels of biogas fertilizer (6-8-10) L/m ² - Chemical fertilizer - Cow manure - Sheep manure - Poultry droppings - A mixture of the three above - Chemical fertilization - Potassium humate	- Plant height - Leaf surface area index - Dry weight - Number of pods - Biological yield - Fruit yield - Oil content	[34]
5	Valencia Oranges	Latakia		Complete Random Blocks	- Potassium humate with an organic fertilizer mixture - Three foliar spray treatments with the following elements: (boron, zinc, manganese, iron). The first with chemical fertilization, the second with an organic fertilizer mixture, and the third with potassium humate. - Cow manure + chemical fertilizer	- Fruit weight - Total soluble solids - Juice acidity - Fruit vitamin C content	[35]

Table 1 Continued

N	Crop Name	Location	Years of research	Experimental Design	Experimental Treatments	Characteristics studied	Reference
6	Thyme	Latakia	2019-2016	Complete Random Blocks	<ul style="list-style-type: none"> - Cow manure + chemical fertilize - Cow manure - Poultry manure - Cow manure + poultry manure - Two treatments of green manure (broad beans, vetch) 	<ul style="list-style-type: none"> - Average plant height (cm) - Average number of branches - Average plant weight - Oil weight and percentage - Length of vegetative growth - Number of flowers on branches and in the inflorescence - Sex ratio - Percentage of fruit set 	[36]
7	Thymus vulgaris	Masyaf and Saqita		Split Pieces	<ul style="list-style-type: none"> - Sheep manure and green manure - Chemical fertilizer 	<ul style="list-style-type: none"> - Soil pH - Soil content of organic matter, zinc, and boron - Fruit set rate - Average fruit weight - Average fruit size 	[37]
8	Daibli Olives	As-Suwayda	2016-2015	Random Blocks	<ul style="list-style-type: none"> - Control without additives - Spray with boric acid solution - Spray with zinc sulfate solution - Spray with boric acid solution and zinc sulfate - Goat manure - Three treatments of goat manure. The first treatment was with boric acid solution, the second with zinc sulfate, and the third with both boric acid solution and zinc sulfate. - Control without additives - Three levels of biogas fertilizer (4, 6, and 8 L/m²) - Two phosphorus fertilization treatments (66.7% and 100%) of the recommended fertilizer application rate - Six treatments involving the interaction of biogas fertilizer and phosphorus fertilization, where each biogas treatment was applied with each phosphorus fertilization treatment 	<ul style="list-style-type: none"> - Soil pH - Soil content of organic matter, zinc, and boron - Fruit set rate - Average fruit weight - Average fruit size 	[38]
9	Starking Delicious Apples	Tartus	2016-2015	Complete Random Blocks	<ul style="list-style-type: none"> - Control without additives - Three levels of biogas fertilizer (4, 6, and 8 L/m²) - Two phosphorus fertilization treatments (66.7% and 100%) of the recommended fertilizer application rate - Six treatments involving the interaction of biogas fertilizer and phosphorus fertilization, where each biogas treatment was applied with each phosphorus fertilization treatment 	<ul style="list-style-type: none"> - Productivity indicators from the vegetative parts and green pods - Percentage of organic matter, total nitrogen, available phosphorus, and available potassium in the soil. - Oil content in the fruit. - Olive yield. 	[39]
10	Peanuts	Homs	2016-2015	Complete Random Blocks	<ul style="list-style-type: none"> - Cow manure - Sheep manure - Olive pomace compost - Chemical fertilizer 	<ul style="list-style-type: none"> - Percentage of organic matter, total nitrogen, available phosphorus, and available potassium in the soil. - Oil content in the fruit. - Olive yield. 	[40]

Table 1 Continued

N	Crop Name	Location	Years of research	Experimental Design	Experimental Treatments	Characteristics studied	Reference
11	Olives (Qaisi variety)	Tartus	2015-2013	Complete Random Blocks	- Two levels of chemical fertilizer (12 and 24 kg nitrogen/hectare) - Three levels of biogas (6, 8, and 10 L/m ²) - Six treatments involving the interaction of biogas fertilizer and chemical fertilizer, where each biogas treatment was applied with each chemical fertilizer treatment. - View without fertilization - Control without additives	- Percentage of organic matter, phosphorus, and available potassium in the soil - Plant height - Number of leaves - Productivity - Oil content in the fruit	[41]
12	Yellow Corn	Homs	2013-2011	Experimental Design	- Three levels of sheep manure (20-40-60) m ³ /hectare - Chemical fertilizer	- Productivity (oil and olives) - Oil specifications	[42]

3.2 Data Extraction and Synthesis Methodology

The studies selected for analysis were those that included the use of sheep and cattle manure, due to their availability and relatively low cost, in addition to other organic and inorganic fertilizers.

Data were extracted from the original research studies, with all experimental treatments documented. However, in presenting the results, emphasis was placed on the following treatments: organic fertilizers, chemical fertilizers, biogas slurry, biochar, and their interactions. The primary focus was on crop productivity, while plant traits and soil properties were considered secondary evaluation parameters.

Although the experimental designs varied among studies (including split-plot and randomized complete block designs) and different statistical analysis methods were applied, all studies shared a common approach:

Measurements were collected and analyzed using analysis of variance (ANOVA)

Least Significant Difference (LSD) values were calculated at:

5% significance level for field measurements

1% significance level for laboratory measurements

This allowed for comparison between treatment means. The results were then synthesized and discussed accordingly.

3.3 Climatic and Soil Context

The climatic conditions across the study regions are characterized by a Mediterranean climate. Annual rainfall varies depending on location, ranging between 215 and 1065 mm/year. The rainy season generally begins in September and continues until March, with the majority of precipitation occurring between December and February.

Table 2. Some data about research sites

N	Research locations (city names)	Average rainfall mm/year	Soil type	Percentage of organic matter (%)	Total nitrogen%	Available phosphorus mg/kg	Potassium available mg/kg
1	Raqqa	215	Lime clay loam	0.99	-	9.7	425
11+9+4+3+2	Tartus	840	Siltic	1.38	0.122	5	166
6+5	Latakia	728	Siltic clay	2.2	-	6.5	180
7	Masyaf and Safita	1065	Lime clay	1.46 2.56	0.074 0.132	8.435 9.13	36.44 55.17
8	As-Suwayda	535	Clay	1.5	-	25.75	155
10	Homs	439	Clay	1.4	0.014	9.9	109
12	Homs	390	Clay	1.25	-	34.9	710

As shown in Table 2, Soil organic matter content was low to moderate (0.99-2.56%). Total nitrogen content ranged from low to moderate (0.014-0.132%), while available phosphorus ranged from low to very high (5-34.9 mg/kg), and available potassium ranged from low to very high (36.44-710 mg/kg). Most soils were predominantly clayey in texture.

4. Results

4.1 Crop Yield Response

Crop yield responses varied depending on crop type and fertilization strategy. Integrated fertilization systems generally produced yields comparable to chemical fertilization in annual crops.

In wheat, integrated treatments achieved yields up to 4.7 t ha⁻¹, close to chemical fertilization (5.06 t ha⁻¹), with no significant differences in some cases [7], as presented in Table 3. Similarly, in maize and peanut, combining organic inputs such as biogas slurry with mineral fertilizers significantly improved productivity compared to individual applications [18, 20], as shown in Figures 1 and 2.

In contrast, perennial and high-value crops responded more positively to organic fertilization alone, which was particularly effective. Saffron showed significant increases in flower number and stigma yield under organic treatments [10], while olive productivity increased substantially under manure application compared to chemical fertilization [19].

In potato, the combined application of organic fertilizer and biochar resulted in the highest yield (62.7 t ha⁻¹), highlighting the synergistic effect of organic amendments and soil conditioners [12].

These results suggest that integrated fertilization may be more suitable for annual crops, whereas organic fertilization alone can be highly effective in perennial systems.

Table 3. Effect of fertilization strategies on wheat grain yield (t ha⁻¹)

Fertilization treatment	Sham 9	Research 11	Sham 10	Research 8	Mean yield	Significance
Organic fertilization	2.46	3.36	3.89	3.40	3.28	c
Chemical fertilization	4.87	3.92	5.15	6.32	5.06	a
50% Organic + 50% Chemical	4.40	4.21	5.62	4.57	4.70	ab
75% Organic + 25% Chemical	5.20	4.10	3.71	4.55	4.39	b

Notes. Different letters indicate significant differences at $p \leq 0.05$. LSD = 0.63; CV = 17%.

4.2 Crop Quality Parameters

Organic fertilization was reported to improve crop quality across multiple studies. In citrus, organic treatments increased fruit weight, total soluble solids, and vitamin C content compared to mineral fertilization [14].

In aromatic and medicinal crops, such as thyme and saffron, organic fertilization enhanced the accumulation of secondary metabolites. Thyme showed higher essential oil content under poultry manure treatment [15], while saffron exhibited increased concentrations of crocin, picrocrocin, and safranal under organic fertilization regimes [10], as shown in Table 4.

Similarly, organic fertilization improved fruit quality parameters in apple, including fruit weight and fruit set percentage, particularly when combined with micronutrient applications [17].

Table 4. Effect of organic fertilization on saffron yield and quality parameters

Treatment	Flowers (no./m ²)	Stigma yield (dry, g/m ²)	Crocin (%)	Picrocrocin (%)	Safranal (%)
Mineral fertilization	8.89	0.032	166.57	49.82	27.99
15 t/ha manure	14.56	0.057	191.24	59.02	36.47
30 t/ha manure	16.11	0.062	191.35	59.44	37.11
45 t/ha manure	16.22	0.063	191.52	60.34	36.98

Notes. Values are treatment means. Organic treatments significantly outperformed mineral fertilization at $p \leq 0.05$.

4.3 Soil Property Responses

Organic fertilization consistently improved soil properties. The application of manure and compost increased soil organic matter and enhanced the availability of essential nutrients, including nitrogen, phosphorus, and potassium [19].

In apple production systems, organic amendments significantly reduced soil pH and increased the availability of micronutrients such as zinc and boron [17]. Additionally, long-term applications of organic fertilizers improved soil structure and water retention capacity, contributing to sustainable soil management [4].

The use of biogas slurry also increased soil fertility by enhancing organic matter content and nutrient availability, particularly when combined with mineral fertilization [18, 20].

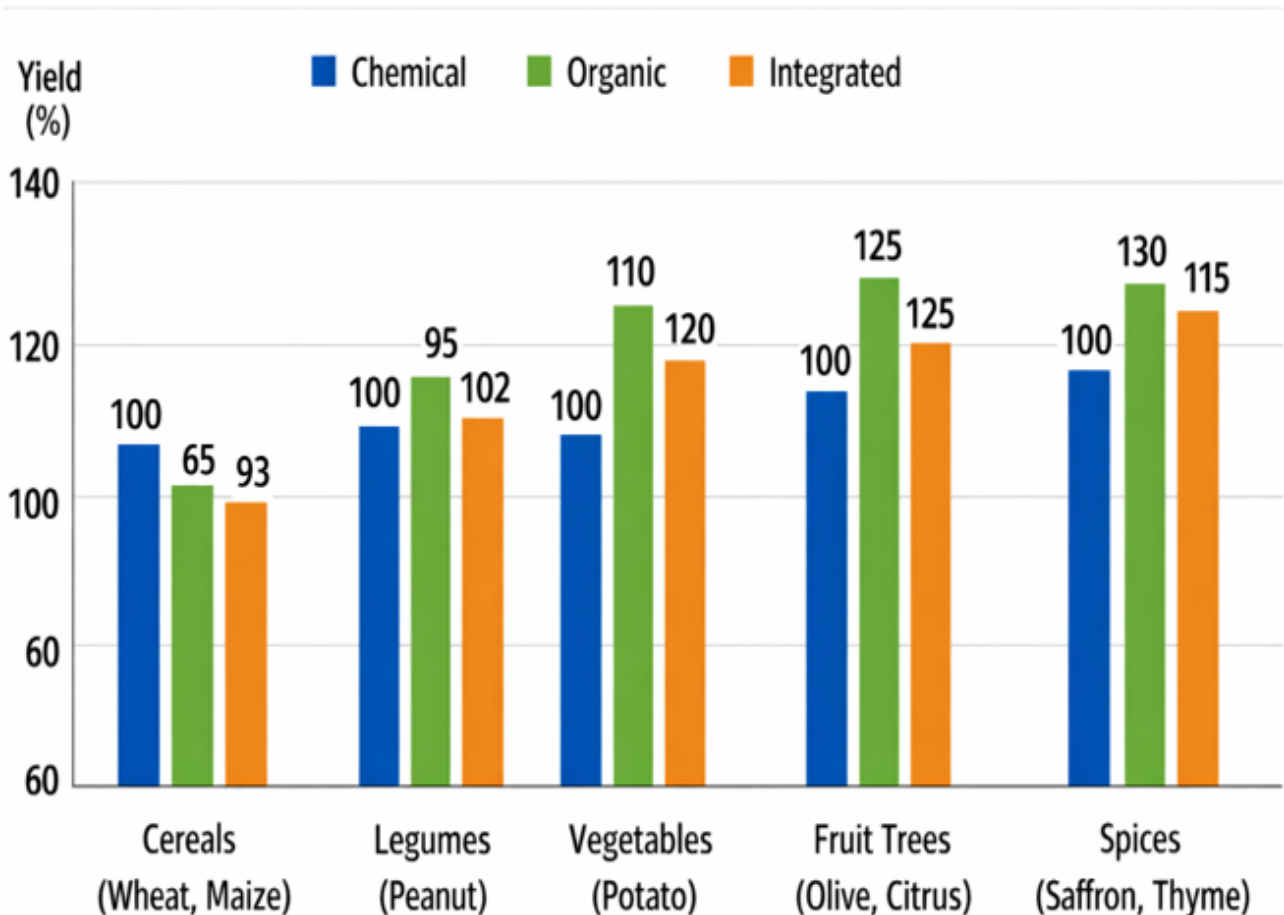


Figure 1. Relative crop yield response (%) under different fertilization strategies across crop groups.

4.4 Case Studies of Representative Systems

Several representative systems illustrate the variability in crop response:

- Wheat: Integrated fertilization maintained high yields while reducing chemical fertilizer use [7].
- Saffron: Organic fertilization significantly improved both yield and quality [10].
- Olive: Organic fertilization enhanced productivity, oil content, and soil fertility over the long term [19].

These examples demonstrate that fertilization strategies should be adapted to crop type and production goals.

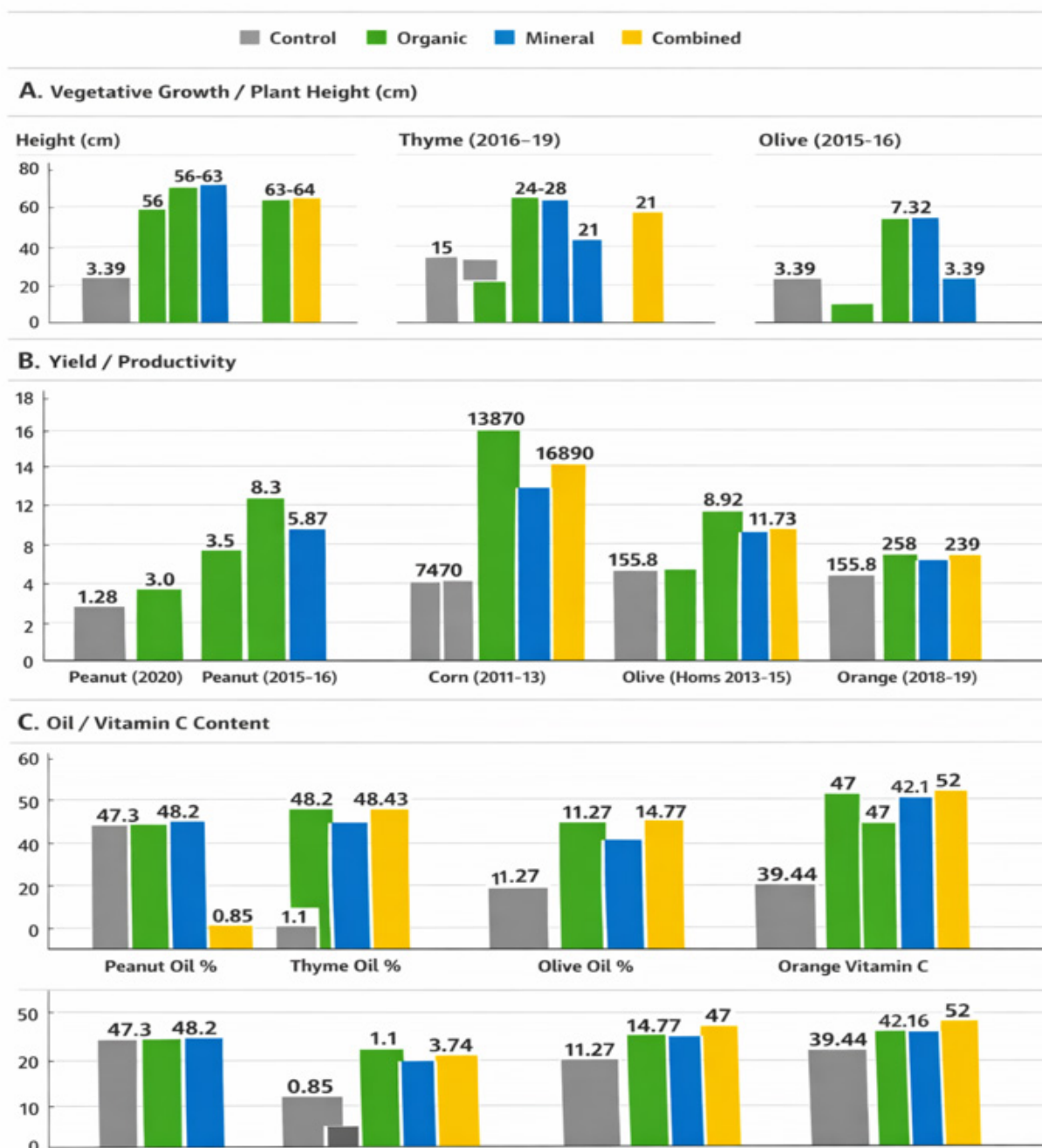


Figure 2. Comparative Effects of Fertilization on Crop Productivity and Quality.

Across crops (peanut, corn, thyme, olive, orange, apple), organic fertilizers and biogas consistently improved vegetative growth, yield, oil content, and fruit quality, while combinations with mineral fertilization often provided synergistic effects. Foliar spraying (B, Zn) enhanced soil nutrient content and fruit set in fruit trees.

5. Discussion

By studying the previously mentioned research, we note that the treatments of organic fertilizer and chemical fertilizer were used separately or by adding them together, and through the results of these researches, we note that some research concluded that using the two types of fertilizers together (organic and chemical) led to improved productivity and some plant characteristics in the researches that were carried out on (wheat research No. 1, apples No. 8, and yellow corn No. 11), while we note that using organic fertilizer alone achieved the best

productivity and improvement in some plant characteristics and some soil characteristics (saffron research No. 2, Valencia orange research No. 5, thyme research No. 6, Al-Daibeli olive research No. 7, Al-Qaisi olive No. 10, Al-Daibeli olive No. 12), and we also note that when using biogas fertilizer in the peanut research (research No. 4) at a rate of 10 L/m², it had the same effect as chemical fertilizer on productivity and plant characteristics, while when it was used at a rate of 8 L/m² (research No. 9), the mixed treatment of fertilizer outperformed the biogas-chemical fertilizer combination in the remaining treatments, as for research No. (3) Potatoes achieved the highest production using 5 kg/m² of organic fertilizer with 2% biochar added to it. The results of all these studies indicate the important role played by organic matter, whether in improving productivity or plant characteristics, or improving soil properties, in addition to its important environmental impact. It is important to mention here that organic fertilizer is not an immediate benefit, but rather constitutes a key to any sustainable agricultural system. This is consistent with what the researcher (Azzam, 2019) concluded that organic fertilizer works to improve soil properties to make optimal use of added fertilizers and the ready amount of water and mineral elements for the plant. However, based on the results of most studies, we note that chemical fertilizer cannot be dispensed with completely, but its quantities can be reduced by using organic fertilizer side by side with it.

Therefore, chemical fertilizer is an important complement to organic fertilizer in terms of productivity. However, if our priority is the characteristics of the plant and soil, we find that the most important role is for organic fertilizer.

6. Conclusions

Organic fertilizers play a fundamental role in sustainable agriculture by improving soil properties, crop quality, and environmental outcomes. However, they cannot fully replace chemical fertilizers in high-demand production systems.

Integrated fertilization emerges as the most effective strategy, allowing reduced reliance on chemical inputs while maintaining productivity. The optimal approach depends on crop type and management objectives, with organic fertilization forming the foundation of resilient agricultural systems.

Acknowledgements

The authors gratefully acknowledge all researchers, technicians, and staff of the General Commission for Scientific Agricultural Research (GCSAR), Syria, for their contributions to the field experiments and data collection that made this study possible.

Funding

No external funding was received.

Conflict of interest

The author declares no conflicts of interest.

Data and materials availability

All sources cited are publicly available.

References

- [1] Tilman D, Cassman KG, Matson PA, Naylor R, Polasky S. Agricultural sustainability and intensive production practices. *Nature*. 2002;418(6898):671-677.
- [2] Australian Bureau of Agricultural and Resource Economics and Sciences. Agricultural commodities and trade data.
- [3] Food and Agriculture Organization. Effects of intensive fertilizer use on the human environment. Rome: FAO; 1972.
- [4] Food and Agriculture Organization. The state of the world's biodiversity for food and agriculture. Rome: FAO; 2019.
- [5] United States Environmental Protection Agency. Nutrient pollution: the effects of excess nitrogen and phosphorus in water. Washington, DC; 2023.
- [6] National Oceanic and Atmospheric Administration. What is eutrophication? causes and environmental impacts; 2022.
- [7] United Nations Environment Programme. Global environment outlook. Nairobi: UNEP; 2021.
- [8] Intergovernmental Panel on Climate Change. Climate change 2022: mitigation of climate change. Cambridge: Cambridge Univ

Press; 2022.

- [9] Macheix JJ, Fleuriot A, Billot J. Fruit phenolics. Boca Raton: CRC Press; 1990. 378 p.
- [10] El-Khawaga AS, Maklad MF. Effect of combination between bio and chemical fertilization on vegetative growth, yield and quality of valencia orange fruits. *HortScience J Suez Canal Univ.* 2013;1:269-279.
- [11] Galantini J, Rosell R. Long-term fertilization effects on soil organic matter quality and dynamics under different production systems in semiarid pompeian soils. *Soil Tillage Res.* 2006;87:72-79.
- [12] Alom K, Akbar D, Xu CY, Dong TH. Assessing environment impacts of chemical fertilizers consumption in Australia: state-level evidence; 2025.
- [13] Țopa DC, Căpșună S, Calistru AE, Ailincăi C. Sustainable practices for enhancing soil health and crop quality in modern agriculture: a review; 2025.
- [14] Nikalje R, Jadhav S, Kajulkar S, Panmand P. Formulation and evaluation of organic fertilizer. *Int J Res Sci Innov.* 2025.
- [15] Li Y, et al. Effects of organic fertilizer type and application rate on soil–microbe interactions, yield, and quality of greenhouse tomato. *Plants.* 2024.
- [16] Zhou S, Chang T, Zhang Y, et al. Effects of organic fertilizer supply on soil properties, tomato yield, and fruit quality: a meta-analysis. *Sustainability.* 2023;15(3).
- [17] Zhang X, et al. Effects of different combinations of organic fertilizers on the yield and quality of leafy vegetables. *Sci Rep.* 2025.
- [18] Ersek K. Advantages and disadvantages of using organic fertilizer. *Soil Sci News.* 2021. <https://soilsciencenews.ca/8-advantages-and-disadvantages-of-using-organic-fertilizer/>.
- [19] Li S, Li J, Zhang B, Li D, Li G, Li Y. Effect of different organic fertilizers application on growth and environmental risk of nitrate under a vegetable field. *Sci Rep.* 2017;7:17019. <https://doi.org/10.1038/s41598-017-17219-y>.
- [20] Raghavendra M, Sharma MP, Ramesh A, Richa A, Billore SD, Verma RK. Soil health indicators: methods and applications. 2020. pp. 221-253.
- [21] Food and Agriculture Organization. Integrated nutrient management. Rome: FAO; 2024.
- [22] Agegnehu G, Bass AM, Nelson PN, Bird MI. Integrated nutrient management in crop production: a review. *Agronomy.* 2019;9(2):71.
- [23] Biswas S, Das R, Jana K, Puste A. Integrated nutrient management on oat–grasspea intercropping system: evaluation of productivity, economics, energetics and carbon footprint. *Sci Rep.* 2024;14:19414.
- [24] Zhang X, et al. Impact of long-term integrated nutrient management on soil carbon sequestration and greenhouse gas emissions in rice–wheat systems. *Agric For Meteorol.* 2025.
- [25] Agegnehu G, et al. Comparative performance of integrated nutrient management using compost, fertilizers, and biofertilizers for improving soil properties and crop yields. *Agronomy.* 2020;10(10):1503.
- [26] Singh A, et al. Impact of integrated nutrient management on soil microbiome diversity and soil health in rice-based cropping systems. *Rhizosphere.* 2025;33:101048.
- [27] Rao KK, et al. Long-term impact of integrated nutrient management on sustainable yield index and soil quality in rice. *Arch Agron Soil Sci.* 2022;69(7):1-15.
- [28] Azzam MR. The effect of sheep manure and phosphate fertilizer on the growth and yield of broad beans. *Syrian J Agric Res.* 2019;6(3):263-271.
- [29] Sharm F. The effect of adding different types of organic and mineral fertilizers on the characteristics and productivity of pomegranate trees. *Syrian J Agric Res.* 2022;9(3):290-299.
- [30] Al-Hamad IA, Al-Jarbu AR. The effect of several levels of fermented sheep manure and levels of nitrogen fertilization and their interaction on some growth and productivity characteristics of wheat plants. *Syrian J Agric Res.* 2021;8(3):220-235.
- [31] Al-Khalaf AA, et al. The effect of organic and chemical fertilization on some morphological and grain productivity characteristics of durum and soft wheat varieties. *Syrian J Agric Res.* 2022;9(3):230-240.
- [32] Ahmad L, et al. Effect of organic fertilization and corm planting rate on saffron flower productivity and the percentage of active ingredient therein. *Damascus Univ J Agric Sci.* 2023;39(3):17-30.
- [33] Ibrahim M, et al. Effect of levels of organic fertilizer and biochar on the productive characteristics of potato plants. *Syrian J Agric Res.* 2021;8(3):143-153.
- [34] Othman T, et al. Effect of mineral fertilizer and liquid biogas fertilizer on some vegetative growth characteristics and productivity of peanut crop. *Syrian J Agric Res.* 2022;9(1):220-234.
- [35] Omran K, et al. Effect of organic and mineral fertilizer on some characteristics of valencia orange fruit juice. *Damascus Univ J Agric Sci.* 2023;39(3):43-60.
- [36] Riya L, Saleh M. Effect of organic fertilization on productivity and oil percentage for the common thyme plant. *Syrian J Agric*

Res. 2021;8(5):28-35.

- [37] Qatma G, et al. The effect of organic farming systems on some soil properties and productivity indicators of the dheibli olive variety. *Syrian J Agric Res.* 2019;6(3):31-43.
- [38] Kiwan S, et al. The effect of adding organic waste and foliar spraying with boron and zinc on some soil properties, fruit set rate, and quality characteristics of apples in the starking delicious variety. *Syrian J Agric Res.* 2018;5(2):177-188.
- [39] Mida L, et al. The effect of adding different levels of phosphorus fertilization and biogas fertilizer on some soil fertility properties and peanut productivity. *Syrian J Agric Res.* 2020;7(5):336-349.
- [40] Al-Sayed D, et al. The effect of different types of organic fertilizers on some soil properties and productivity of the qaisi olive variety in Homs governorate. *Syrian J Agric Res.* 2018;5(4):217-226.
- [41] Mida L, et al. A study of the effect of different levels of nitrogen fertilizer and biogas fertilizer on the productivity of yellow corn and some soil properties. *Syrian J Agric Res.* 2016;4(2):120-128.
- [42] Al-Jardi AK, et al. The effect of organic fertilization on the productive and qualitative characteristics of olive oil of the al-duaibali variety in Homs governorate, Syria. *Syrian J Agric Res.* 2020;7(6):320-335.