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Effect of using organic fertilizers in greenhouses on yield, quality and antioxidant content of cucumber. A Review Article

Rawaa Mohammed Ibrahim[1], Rawa Abdul-Hussein[1], Zainab J. Al-Mousawi[1], Wisam Mohammed Abd[2*]

[1]*Unit of Medicinal and Aromatic Plant Research – College of Agricultural Engineering Sciences – University of Baghdad*

[2]*Department of Soil Sciences and Water Resources – College of Agricultural Engineering Sciences – University of Baghdad*

[*] *Corresponding author: E-mail: wisam@coagri.uobaghdad.edu.iq*

ABSTRACT

Globally, cucumber is a popular vegetable grown for its nutrients, large amount of water, and economic value. More people interested in sustainable and healthy farming have encouraged use of organic fertilizers. The study provides a summary of recent results about how using organic and integrated fertilizers affects cucumber growth, yields, quality and antioxidants. It has been seen that using organic fertilizers increases growth of plants, leads to better flowering and fruiting, improves soil texture and boosts microbial activity. The quality of fruit is enhanced by organic ingredients, for factors such as its size, weight, texture, length of stay on shelves and antioxidants it contains. Moreover mixture of plant nutrients in organic and inorganic fertilizers leads to results where nutrients are quickly accessible and soil remains fertile for a long period. Sciences also analyze how antioxidant production is increased through a better supply of nutrients and more impressive physiological reactions. The review stresses that by using organic fertilizers on crops, you can boost production and protect environment and food produced. It would be beneficial to study how best to use mixture of fertilizers and followed by tracking their effects over time.

KEYWORDS: (*Cucumis sativus L.*); Organic Fertilizers; Fruit Quality; Sustainable Agriculture.

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استخدام الأسمدة العُضْوِيَّةَ فِي الْبُيُوتِ الْمَحْمِيَّة في انْتَاجِيَّة وُجُودة الْخِيَار وَمُحْتَوَاه مِنْ مُضَادَّات الأكسدة: مقالة مراجعة

روعة محمد ابراهيم[1]، روى عبدالحسين[1]، زينب جارالله الموسوي[1]، وسام محمد عبد[2]
وحدة بحوث النباتات الطبية والعطرية - كلية علوم الهندسة الزراعية -جامعة بغداد
قسم علوم التربة والموارد المائية - كلية علوم الهندسة الزراعية -جامعة بغداد.

الملخص

يُعد الخيار (***Cucumis sativus L.***)من المحاصيل البستنية واسعة الانتشار ذات الأهمية الغذائية والاقتصادية العالية. ومع تزايد الاهتمام بالممارسات الزراعية المستدامة والصديقة للبيئة، حظيت الأسمدة العضوية باهتمام كبير كبديل فعال للأسمدة الكيميائية. تهدف هذه المراجعة إلى تسليط الضوء في تأثير الأسمدة العضوية والتسميد المتكامل على نمو الخيار وصفاته الإنتاجية والنوعية، مع التركيز على محتواه من مضادات الأكسدة. أظهرت الدراسات الحديثة أن استخدام الأسمدة العضوية يُحسّن النمو الخضري، ويزيد من عدد الأزهار والثمار، ويُعزز خصوبة التربة والنشاط الميكروبي فيها. كما تبين أن الأسمدة العضوية تؤثر إيجابيًا في الصفات النوعية للثمار مثل الحجم والوزن والطعم والملمس وفترة التخزين والقيمة الغذائية، بما في ذلك ارتفاع محتوى مضادات الأكسدة. وقد بيّنت نتائج التسميد المتكامل – الذي يجمع بين العضوي والكيماوي – أنه يحقق توازناً بين التزويد السريع بالعناصر الغذائية وتحسين خصوبة التربة على المدى البعيد. كذلك تُناقش الآليات الممكنة وراء زيادة إنتاج مضادات الأكسدة، مثل تعزيز الامتصاص الغذائي وتحفيز العمليات الفسيولوجية للنبات. تخلص هذه المراجعة إلى أن استخدام الأسمدة العضوية يمثل خيارًا واعدًا لتعزيز إنتاجية الخيار وجودته، مع المحافظة على صحة التربة والبيئة، وتوصي بمزيد من الدراسات المستقبلية حول فعالية البرامج التسميدية المختلفة على المدى الطويل.

الكلمات المفتاحية: الخيار؛ الأسمدة العضوية؛ جودة الثمار؛ الزراعة المستدامة؛

1. INTRODUCTION

1.1 Background and Importance of Organic Fertilizers

More people in different countries are choosing organic methods of farming over use of

chemicals. Fertilizers obtained from plants, animals, or microorganisms enrich crops with vital nutrients and also boost soil structure, increase activity from microorganisms, and last for a long time. Because organic supplements release nutrients over time, they lower possibility of losing nutrients or causing harm to the environment. They are important in sustainable farming because they help soil grow healthier and can store more important nutrients (Serri et al., 2021) and (Adekiya et al., 2022) . Research evidence indicates that using organic fertilizers may increase plant growth, enhance overall yield, and boost antioxidant activity as well as promote many other positive changes in cucumber (Babatunde et al., 2022). By following this approach, we can raise productivity as well as ensure food safety and protect environment.

1.2 Significance of Greenhouse Vegetable Production

The use of greenhouses is valuable to boost productivity and dependability of growing vegetables. Since greenhouses are controlled, you can regulate temperature, humidity, and light, which play a big role in good crop results. In this environment, climate changes and pests are reduced, which allows farms to stay productive for longer and to have regular productions (Sallam et al., 2021). Using greenhouses becomes very important when places have strong environmental challenges or not much land available. If used with organic fertilizer, greenhouse systems increase the use of nutrients and help vegetables develop preferred tastes and nutritional benefits (Zapata-Sifuentes et al., 2022) and (Adu and Obabire, 2023). Because of this, greenhouses are being viewed more often as a sustainable way to produce a lot of plants.

1.3 Overview of Cucumber as a Crop (Nutritional, Economic Importance)

Many parts of world cultivate cucumber (Cucumis sativus L.) because it keeps people hydrated, is crisp, and holds nutrients like vitamins, phenolics, and antioxidants. Economically, cucumbers are very popular crops used for local markets and exports, and are usually planted in greenhouses to fit the buyer's needs and schedules (Mahmood and Bashar, 2018). Since melons grow fast and respond well to being farmed, they are perfect for commercial horticulture. Even though cucumbers have few calories, they are very good for your health because their antioxidant elements reduce stress in the body and strengthen the immune system (Jang et al., 2021) and (López-Morales et al., 2022). Since consumers are choosing cucumbers with extra nutrition, farming ways that enhance yields and improve the quality of cucumbers, especially with organic methods, are becoming more popular.

1.4 Aim and Scope of Review

This paper seeks to discuss and evaluate the use of organic fertilizers in cucumber greenhouse farming with special attention to how they affect both crop yields and the cucumber's quality and

nutritious content. The findings of several recent studies are used in this article to point out the pros and cons of organic fertilization in controlled areas. The area examines organic and inorganic fertilization, talks about different organic fertilizers and their role in cucumber growth and chemical features. The aim of this review is to let researchers, greenhouse managers, and agricultural policy makers know about the effectiveness of organic additives in sustainable vegetable farming (Adekiya et al., 2022), (Mohamed et al., 2023) and (Vojnović et al., 2024).

2. Organic Fertilizers: Types and Characteristics

2.1 Definition and Classification of Organic Fertilizers

Organic fertilizers result from plant, animal, or microbial matter and give nutrients to crops while making soil healthier. Unlike the inorganic soluble nutrients offered by synthetic fertilizers, most of nutrients in organic fertilizers are not easy to absorb and they might need help from microbes to be used (Bergstrand, 2022). Depending on what they come from, organic fertilizers are commonly put into plant-based, animal-based, and microbial-based types (Bamdad et al., 2022). They are grouped this way to identify their nutrient composition and manners in which they interact with soil. They come in several forms, for example solid (compost, manure) and liquid such as compost teas and organic leachates, all needing different application methods (Bondarenko et al., 2021). Compost use has risen in greenhouses, as it makes the soil remain fertile for a long time and supports strong crop growth (Jaafar and Abdulrasool, 2025).

2.2 Common Organic Fertilizers Used in Greenhouses (compost, and vermi compost)

Many types of organic fertilizers are applied in greenhouse vegetable production, but compost, farmyard manure and vermi compost are used most often. Circumstances and research show that nutrients in deteriorated organic materials create rich compost for soil, which also stimulates soil microorganisms and increases its water retention ability (Du et al, 2022). Manures from animals like poultry or cattle should be used, as these provide nitrogen, phosphorus, and potassium, yet they need to be properly composted to reduce risks and dangers for plants (Karagöz, 2021). Thanks to earthworms digesting organic waste, vermicompost is considered highly nutritious and it stimulates the development of hormones needed for plant growth (Shaji et al., 2021). They have been applied in greenhouses to supply nutrients as well as improve soil structure and increase the number of helpful microorganisms. It has been found that such fertilizers assist in making plants grow and making the fruits more nutritious and with better quality, and this is especially true in cucumbers (Rashmi et al., 2020) and (Bergstrand, 2022).

Table 1. Comparison of Common Organic Fertilizers Used in Greenhouse Cucumber Cultivation

Fertilizer Type	Main Nutrients	Nutrient Release Rate	Additional Benefits	Suitability for Cucumber
Compost	*N, P, K (low–moderate)*	*Slow to moderate*	*Improves soil structure and microbial activity*	*High – enhances root development and yield*
Animal Manure (e.g., cow, poultry)	*N, P, K (variable by type)*	*Moderate*	*Increases organic matter, boosts microbial biomass*	*High – effective for vegetative growth and fruiting*
Vermicompost	*N, P, K, micronutrients, enzymes*	*Slow and steady*	*Rich in beneficial microbes and hormones*	*Very High – improves fruit quality and resistance*
Green Manure	*Primarily Nitrogen*	*Moderate (after decomposition)*	*Enhances soil nitrogen and biomass*	*Moderate – useful in pre-planting soil enrichment*
Bone Meal	*High in Phosphorus*	*Slow*	*Promotes root and flower development*	*Moderate – good during early growth stages*
Fish Emulsion	*High in Nitrogen (quick-acting)*	*Fast*	*Stimulates leafy growth*	*High – suitable during vegetative stage*
Seaweed Extracts	*Micronutrients, growth hormones*	*Rapid (foliar or soil)*	*Boosts stress tolerance and antioxidant levels*	*High – improves yield and quality*

2.3 Nutrient Release Mechanisms and Soil Impact

An important aspect of organic fertilizers is that nutrients are provided step by step, mainly through activities of bacteria and fungi. This process provides nutrients at right time for plants, makes nutrition more balanced and results in less pollution than it is common with chemical fertilizers (Shaji

et al., 2021). In addition, organic fertilizers benefit soil by including organic matter, raising cation exchange capacity, making soil retain more water and improve its air content (Singh et al., 2020) and (Ali and Abdullah., 2024). They also promote growth of different microorganisms and help cause enzymatic actions vital for breaking down nutrients and stopping spread of diseases (Du et al., 2022) and (Timofeeva et al., 2022). After several years of applying organic fertilizers, soil's characteristics become better, leading to continuous growth and healthier surroundings (Lu, 2020). Having nutrient-rich soil is very beneficial for greenhouse farming, since there is frequent crop planting and open soil tends to run out quickly (Bamdad et al., 2022) and (Bergstrand, 2022).

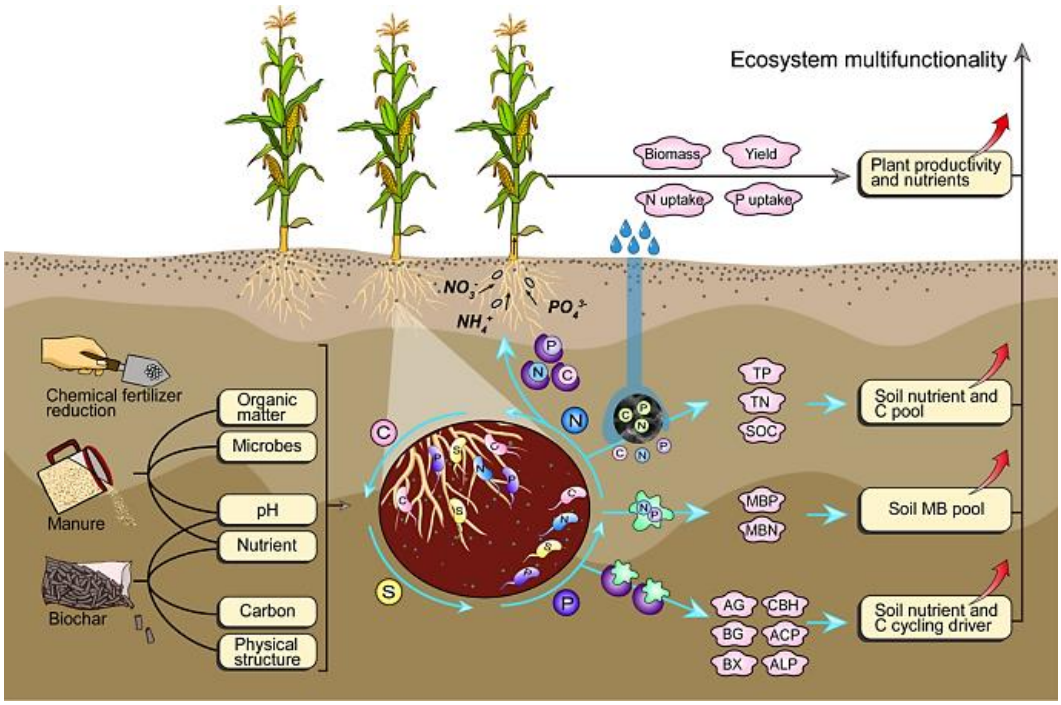

Figure.1 *Impact of organic Nutrients on soil Nutrition*

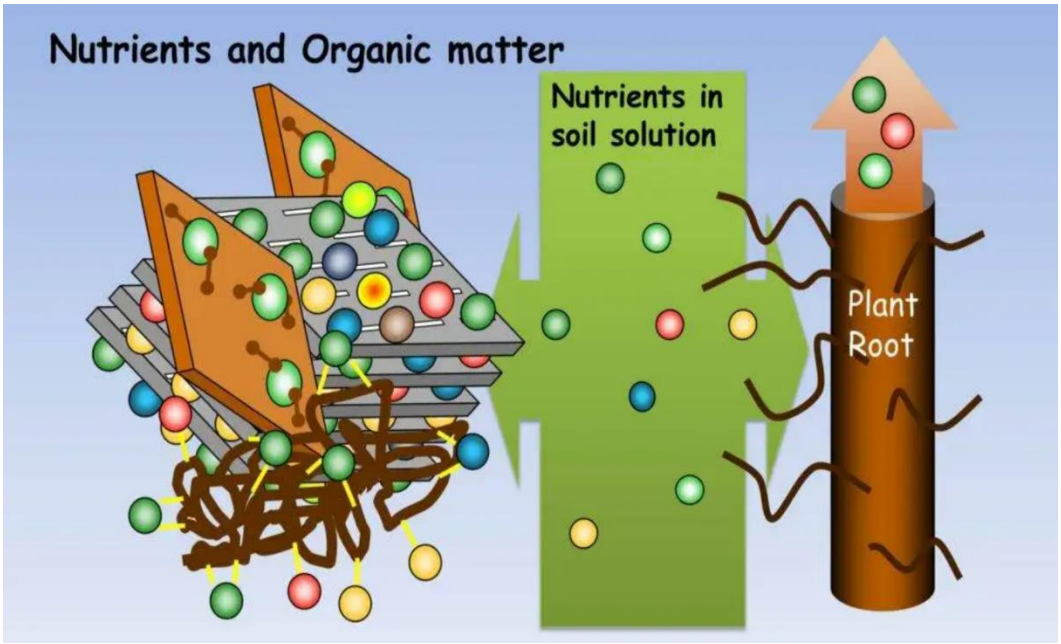

Figure.2 *Cation Retention on Soil Clay*

3. Greenhouse Cultivation of Cucumber

3.1 Controlled Environment and Its Role in Yield Improvement

Greenhouses make it possible to closely control conditions, which can boost cucumbers' growth and their quality. Through controlling temperature, humidity, light, and CO_2 levels, greenhouses decrease the effects of changes in external climate, helping produce crops all through the year (Pal et al., 2020). These conditions guarantee that all plants mature at the same speed and increase the time during harvest, giving more benefits to those who grow crops in harsh or short climates. Japanese greenhouses have proven that increasing the environmental quality directly produces more fruits, bigger yields, and a longer flowering season (Maeda and Ahn, 2021). Having crops in a greenhouse lowers chances of diseases and damage from pests and keeps them safe from weather like strong winds or heavy rain, thus boosting their use of resources and reducing damages (Mohammed and Lahuf, 2023). The fact that greenhouses are controlled means cucumbers receive right amounts of temperature and moisture, since they are sensitive to changes.

3.2 Factors Affecting Cucumber Growth in Greenhouses

A number of elements affect how well and how fast cucumbers grow and yield in greenhouses. The requirements are related to daylight exposure, irrigating medium properly, the kind of substrate used, temperature regulation and taking care of pests. Change right amount of PAR helps the vegetation and fruits thrive, while consistent irrigation using drip systems ensures plants are watered accurately and becomes less vulnerable to diseases. Making sure temperature is right is needed, as if temperature goes up or down from 20°C to 28°C, it may affect how plants set fruits or flower. Also, the amount of air spaces, nutrients contained in medium and number of microbes in soil can affect the health of roots and nutrients they absorb (Taha et al., 2020). Other things that influence plant shape and quantity of yield include fertilizing, managing diseases and pruning. What is more, keeping crops in greenhouses for a long period can modify both microbial makeup and performance of the soil, which might reelect in changes in nutrient cycling and disease incidence (Liu et al., 2020). To ensure sustainable growing, these different elements should be managed together.

Table 2. Factors Affecting Cucumber Growth in Greenhouses

Factor	Description
Daylight Exposure (PAR)	Proper photosynthetically active radiation (PAR) enhances vegetative and fruit development.
Irrigation	Drip irrigation ensures accurate watering, reduces disease risk, and maintains uniform soil moisture.
Substrate Type	Influences root aeration, microbial activity, and nutrient availability.
Temperature Regulation	Ideal range (20°C to 28°C); deviations affect flowering and fruit setting.
Pest and Disease Management	Essential for protecting plant health and ensuring continuous productivity.
Fertilization Practices	Influences yield quantity and fruit quality. Requires balance between organic and inorganic sources.
Pruning and Crop Training	Helps in managing plant architecture and maximizing light interception.
Soil Microbial Composition	Long-term greenhouse cropping alters microbial activity and nutrient cycling, potentially increasing disease incidence.

3.3 Role of Fertilization in Greenhouse Systems

Fertilization greatly contributes to getting the best productivity out of cucumbers grown in greenhouses. Greenhouse soils or substrates are used a lot and rarely receive natural replenishment, so it's important to give plants right and balanced nutrition to help them continue to grow. Using organic and inorganic fertilizers together has been useful in ensuring enough nutrients for the soil and maintaining its health (Sallam et al., 2021). As an illustration, getting the most food and high-quality results from cucumbers calls for combining poultry manure with mineral fertilizers. Fertilizers, aside from nitrogen, phosphorus and potassium, contribute to keeping right amount of micronutrients, necessary for flowering and producing fruits. In addition, greenhouses use fertigation so that proper nutrients are fed to plants at appropriate times. However, too many or uneven fertilizers can harm land, on top of making water unsafe, which is why it is better to use optimal amounts at specified times (Taha et al., 2020). So, it is important to manage nutrients wisely in greenhouses, meet crop's needs and link them with other farming techniques for sustainable cucumber harvest.

4. Impact of Organic Fertilizers on Cucumber Yield

4.1 Effects on Vegetative Growth

Increased soil structure, higher nutrient amount, and stimulated activity in soil microorganisms are all contributed by organic fertilizers to better vegetative growth of cucumber plants (Al-Azzawi and Al-Ibadi, 2017). Different studies prove that adding poultry manure, vermicompost, and compost to soil promotes healthy plant growth with more leaves and increased height (Singh et al., 2020). Thanks to slow nutrient release from organic fertilizers, mostly related to nitrogen, plants begin to grow and develop well. Bio-organic fertilizers help to make soils under continuous cucumber cropping stronger and retain more water (Adekiya et al. 2022) and (Chen et al., 2024) spotted that cucumber plants grown in organic fertilized soilless media recorded higher chlorophyll and biomass levels than other treatments. Generally, use of organic fertilizers boosts the main features that are needed for growing good cucumbers.

4.2 Effects on Flowering and Fruiting

Organic fertilizers also help cucumbers produce flowers earlier, generate more flowers, and put on more fruits. Micronutrients, including boron and zinc, come from organic matter and have vital effects on flower growth and pollen strength. In their findings, Sahu et al. (2020) discovered that when farmyard manure and biofertilizer were used together, the number of flowers, fruits, and the size of the fruits both improved. A similar finding was shown by(Zahid et al. ,2021) that including poultry manure and urea in fruit spray made cucumbers firmer and helped them keep longer after harvest. The results relate to better timed nutrients in fruiting stage and stronger connections between microbes in area near plant roots. It was noted by Wang et al. (2023) that the use of organic fertilizer led to the presence of good microorganisms that play a role in nutrient cycling, which helps the plant support flowering and fruit development.

4.3 Comparative Studies with Inorganic Fertilizers

Studies have shown that in long run, organic fertilizer has greater benefits, yet inorganic fertilizers usually produce quicker results. The study done by(Marliah et al. ,2020) revealed that blending organic fertilizers with inorganic fertilizers resulted in a larger cucumber yield than applying just organic or inorganic products separately. Although chemical fertilizers give plants the nutrients they need quickly, this may result in both nutrients being washed away from soil and soil damage as time goes by. In addition, organic fertilizers increase quality of soil over time, helping both produce and health of soil. The authors point out that nutrient management strategies involving nature and chemicals led to better vigor in cucumber plants and greater yield and safer ways of farming. It was reported by (Singh et al. ,2020) that organic and integrated fertilization methods resulted in

improvement of sugar concentration and less nitrate accumulation in fruit. It seems that using organic fertilizers along with inorganic ones leads to more sustainable cucumber growing and extra ecological benefits in the long run.

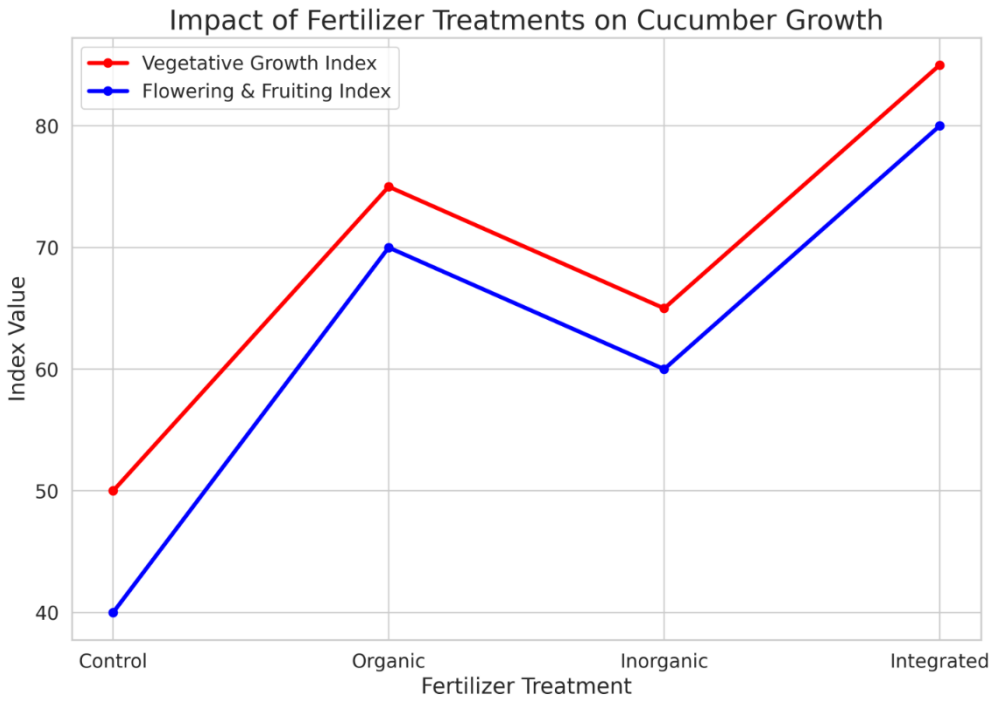

Figure.3 Impact of Fertilizer Treatments on Cucumber Growth

5. Effect on Quality Traits of Cucumber

5.1 Fruit Size, Shape, and Weight

The way nutrients are applied governs physical features of cucumber, specifically how big fruit is, how it is shaped and what its weight is. According to studies, poultry manure, compost, and vermicompost organic fertilizers bring about more regular-sized fruits and, on average, weightier fruits. This is because essential nutrients are easier for fruits to absorb at important developmental stages (Sahu et al., 2020) and (Zahid et al., 2021). It was found that mixing poultry manure with urea enhanced size and weight of cucumber fruit more than when chemical fertilizer was used by itself. In same manner, (Singh et al. ,2020) found that using combined nutrient methods helped improve the shape of fruits and cut down number of deformed ones, which made more of the produce suitable for market.(Adekiya et.al, 2022) pointed out that cucumbers grown organically with soilless media had not only heavier fruit but also uniform sizes, which is vital for commercial use. Consequently, a positive change happens when nutrients are supplied and soil's quality is maintained through organic practices.

5.2 Taste, Texture, and Shelf Life

Besides making food look better, organic fertilization increases sensory qualities such as taste,

texture and shelf life of what we grow. If cucumbers are grown organically, they usually feel crisper and taste better, because having less nitrate allows more plant carbohydrates to develop (Singh et al., 2020). According to (Wang et al. ,2023), using both organic and blend fertilizers increased the shelf life and firmness of fruits after harvest, mainly due to better diversity among soil microbes. Less application of chemicals makes fruit more attractive to those who care about their health (Chen et al., 2024). Authors(Zahid et al. ,2021) mentioned that cucumber fruits treated with poultry manure stayed fresh for a longer time and maintained their market value, showing a low occurrence of softening and yellowing. As result of these findings, organic fertilizers seem to enhance consumer-preferred features in cucumbers, making them more valuable and better to eat.

5.3 Nutritional Quality Parameters

The amount of vitamins, minerals and antioxidants there are in cucumbers depends largely on what kind of fertilizer is used. Cucumbers fertilized with organic and bio-organic fertilizers have high levels of potassium, calcium, magnesium, and also more bioactive compounds known as phenolics and flavonoids (Mi et al., 2022). The authors of (Mi et al. ,2022) found that cucumbers grown using organic fertilizers had more sugar and less nitrate in comparison to cucumbers from conventionally farm fields.(Wang et al. ,2023) also reported that better nutritional value of cucumber could be credited to how rhizosphere microbes reacted positively to organic fertilizer application. Such movements make plants more efficient at getting nutrients and higher concentrations of secondary molecules. In addition, (Singh et al. ,2020) pointed out that integrated nutrient management can improve both vitamin C content and total soluble solids of cucumber fruits. So, organic and integrated fertilizers increase yields and make food healthier as well.

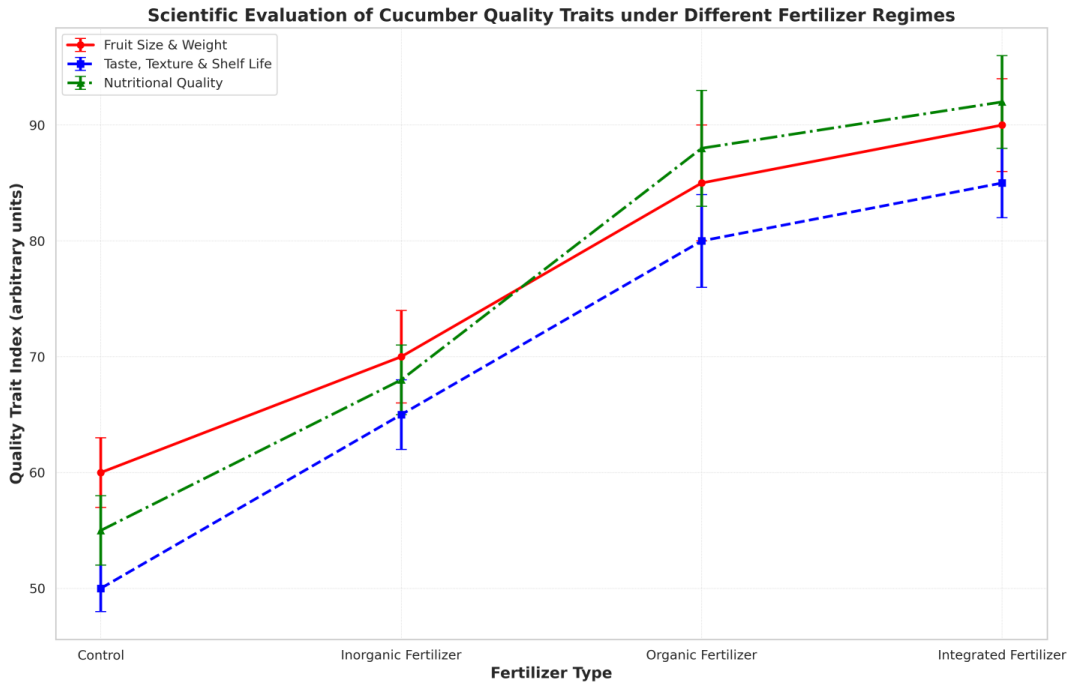

Figure 4. Evaluation of Cucumber Quality Traits under Different Fertilizer Regimes

6. Influence on Antioxidant Content in Cucumber

6.1 Overview of Antioxidants in Vegetables

Since antioxidants are obtained from plants, they work by counteracting bad effects of free radicals in your body and help defend against serious diseases. Besides boosting health, compounds such as ascorbic acid (vitamin C), phenolic compounds, and flavonoids also increase shelf life and the aroma of cucumber. The way agronomic measures are applied, especially fertilization, has a major effect on these compounds (Serri et al., 2021). Most of the time amount of antioxidants in cucumbers depends on metabolism of plant and how much nutrients are available to it. For this reason, increasing the antioxidant properties of cucumbers using sustainable nourishment is now a major goal in today's horticulture (Zapałowska et al., 2023).

6.2 Effect of Organic Fertilizers on Antioxidant Levels

USe of organic fertilizers seems to increase the antioxidant content found in cucumbers. According to studies, organic supplies together with mycorrhizae or seaweed extracts lead to a greater accumulation of phenolic compounds, flavonoids, and vitamin C in cucumber fruit compared to when only normal fertilizers are used (Hassan et al., 2021) and (López-Morales et al., 2022). As an example, López-Morales et al. (2022) noticed that using organic fertilizers rich in mycorrhizal fungi on cucumbers increased the total antioxidant activity by 28% in comparison to cucumbers fertilized with chemicals. (Hassan et al. ,2021) also showed that using seaweed extract improved the chemistry of cucumbers, such as antioxidants, and did not reduce their crop yields. This matches what was seen in other crops, such as melons, as (Bileva et al,2020) pointed out that organic fertilization affects the antioxidant content of fruit.

6.3 Possible Mechanisms for Increased Antioxidant Production

There are many body and chemical reasons that lead to higher antioxidant levels under organic fertilization. When given secondary metabolites such as phenolics and flavonoids, plants experience a moderate stress response that helps them produce secondary metabolites needed to protect plant from these factors (Serri et al., 2021). Thanks to organic fertilizers, there are better conditions for both microscopic life in the soil and movement of nutrients, resulting in better uptake of minerals such as zinc, iron, and manganese, which work with antioxidants in plant tissue (Zapałowska et al., 2023). Having mycorrhizae increases ability of roots to take in nutrients and strengthens defense in the plant (López-Morales, et al., 2022). According to (Hassan et al. ,2021), substances extracted from things like seaweed have natural hormones and minerals that can promote use of antioxidants in body. All these aspects support use of organic and bio-based fertilizer in cucumbers, which benefits their nutritional aspects and environment.

Table 3. Influence on Antioxidant Content in Cucumber

Factor	Description	Observed Effect
Overview of Antioxidants	Antioxidants like vitamin C, phenolic compounds, and flavonoids enhance health, shelf life, and aroma in cucumbers.	Content depends on plant metabolism and nutrient availability.
Organic Fertilizers	Use of organic fertilizers (e.g., mycorrhizae, seaweed extracts) versus chemical fertilizers.	Increased accumulation of antioxidants in cucumber fruits.
Mycorrhizal Fungi	Organic fertilizer with mycorrhizae.	Increased total antioxidant activity by 28% compared to chemical fertilizers.
Seaweed Extracts	Use of seaweed extract in fertilization.	Enhanced antioxidant content without affecting yield.
Organic Fertilization in Other Crops	Similar effects observed in other fruits such as melons.	Increased antioxidant content with organic fertilization.
Mechanism: Moderate Plant Stress	Stress from organic treatments encourages secondary metabolite (antioxidant) production.	Stimulates antioxidant pathways (e.g., phenolics, flavonoids).
Mechanism: Improved Nutrient Uptake	Enhanced root function and nutrient absorption with organic inputs and mycorrhizae.	Better uptake of micronutrients like Zn, Fe, Mn, which support antioxidant synthesis.
Mechanism: Natural Bioactive Compounds	Seaweed extracts provide hormones and minerals.	Promote plant resilience and antioxidant formation.

CONCLUSION

Improvements in way cucumbers (Cucumis sativus L.) are fed help improve their crop yields and enhance what nutrients they offer. This review points out that combining organic fertilizers, bio-organic coverings and right proportion of chemicals greatly boosts growth of plants, yield, and quality and health of soil and fruits. Important changes reported are bigger, more evenly-sized fruits, higher weights, enhanced taste, texture and a long-retained shelf life, showing higher value to buyers and better appeal to consumers. The presence of organic fertilizers and bio stimulants promotes cucumbers' health, as they are rich in important minerals and essential antioxidants like phenolics and vitamin C.

Careful organics treatment of plants leads to higher antioxidants because it triggers special metabolic processes, boosts their uptake of nutrients and helps benefit the soil's microorganisms. All in all, these results point out that healthy and sustainable cucumber farming require organic and integrated fertilization strategies.

As a result, adopting organic or integrated systems for nutrients helps improve quality of cucumbers, keep the soil healthy, and reach sustainability goals. Studies should aim to improve certain organic products, study their impacts on soil's microbes over a long period, and look at reactions of different types of crops to such products for greater effectiveness in various farming areas.

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