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Role of Banana Peel and Eggshell Extracts as Organic Fertilizers in Improving Growth and productivity of Zucchini (*Cucurbita pepo* L.)

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Abstract

The objective of this study was to evaluate the effect of banana peel extract and eggshell powder as organic fertilizers on the growth and yield of squash (*Cucurbita pepo* L.). The experiment was conducted during the 2024–2025 summer growing season in the Zab region of Hawija, Iraq, using a completely randomized block design (CRBD) with three replications. Three concentrations of banana peel extract (200, 250, and 300 g/L) and eggshell powder (200, 250, and 300 g/L) were used to evaluate their effects on vegetative growth and productivity. The results showed significant differences among the treatments, with the highest values recorded for plant height (123.63 cm), number of leaves (28 leave plant⁻¹), dry weight (43.92 g leave plant⁻¹), number of fruits (7.66 fruits plant⁻¹), and total yield (22.21 tons leave plant⁻¹) were recorded when using 300 g/L of banana peel extract. Similarly, the use of eggshell powder at a rate of 300 g/L resulted in the highest values for plant height (121.63 cm), number of leaves (28 leave plant⁻¹), dry weight (45.62 g leave plant⁻¹), number of fruits (8.66 fruits plant⁻¹), and total yield (25.21 t/ha). The interaction between banana peel extract and eggshell powder significantly improved growth and yield characteristics, with the combined treatment at a dose of 300 + 300 g/L yielding the highest values for plant height (83.0 cm leave plant⁻¹), number of leaves (33 leave plant⁻¹), dry weight (45.0 g leave plant⁻¹), and number of fruits (6 fruits leave plant⁻¹).

Keywords: Banana peel; Eggshell; Organic fertilizer; Zucchini; Yield

Introduction

Modern agricultural practices are increasingly focused on developing safe, reliable, and sustainable sources of organic fertilizer in response to growing concerns regarding the environmental and health impacts of excessive chemical fertilizers (Setia Anatolana *et al*, 2024). Researchers have shown significant interest in using various types of organic waste as potential sources of organic fertilizer because they contain high amounts of essential nutrients needed by plants, including potassium, phosphorus, and calcium, all of which are critical to healthy plant growth and development (Aliyu *et al*, 2024; Ahmad Nordin *et al*, 2022). For example, banana skins contain large amounts of potassium and phosphorus, which promote flowering processes, increase photosynthesis, and contribute to the overall formation of the plant's structure, whereas eggshells provide inexpensive, natural sources of calcium, which help strengthen the cell walls of fruits and improve the quality and resistance of the fruit to physiological disorders (Aliyu *et al*, 2024; Ahmad Nordin *et al*, 2022). Prior research has found that applying organic fertilizers made from banana peels and eggshells can increase growth and yield of many crops like amaranth and chili peppers through the height of the plants, the number of plants' leaves, and weight (Aliyu *et al.*, 2024; Effect of banana peel and eggshell powder on chili pepper crop, 2023). However, there is not much research about using banana peel and egg shell organic extracts with zucchini (*cucurbita pepo L.*) which is a crop of great economic and nutritional value around the world. Therefore, the objective of this study is to evaluate how well banana peels and eggshells function as an organic fertilizer to improve vegetative growth and yield of zucchini; as well as to determine if these materials can be used sustainably in lieu of conventional chemical fertilizers.

Materials and Methods

The study of the effects of three levels of banana peel extract (200 g L⁻¹, 250 g L⁻¹, and 300 g L⁻¹) and three levels of eggshell powder (200 g L⁻¹, 250 g L⁻¹, and 300 g L⁻¹) on the growth and yield of Zucchini (*Cucurbita pepo L.*) was carried out in the summer growing season of 2024-2025 at Al-Zab Subdistrict, Al-Hawija District in Iraq. The experimental design was a randomized complete block design (RCBD) with 3 replicates and 4 plots for each replicate giving 12 plots total; each plot (experimental unit) had 3 rows and 4m long, spaced with 1m between the rows and 50 cm between the plants. The soil was prepared by ploughing/levelling and smoothing and was divided according to how they will be tested. Seed were sown directly on March 17 at a rate of 2 seeds per hill. Organic fertilisers were applied by spreading compost around the plants' root zones. A banana peel extract was prepared as a liquid organic fertiliser and applied by watering the soil, whilst eggshell powder was finely ground and mixed into the soil surrounding the plants' roots. The fertilisers were applied three times during the growing season to ensure a continuous supply of nutrients. The first application was made two weeks after seed germination, the second 21 days after the first, and the third 21 days after the second. Equal amounts of each treatment concentration were applied to all plants in accordance with the experimental design. Vegetative growth and yield parameters, including plant height, number of leaves, dry weight plant⁻¹, number of fruits plant⁻¹, and total yield, were recorded at harvest. The data were subjected to statistical analysis according to a completely randomised block design, and treatment means were compared at a significance level of 0.05.

Fertilizer Preparation:

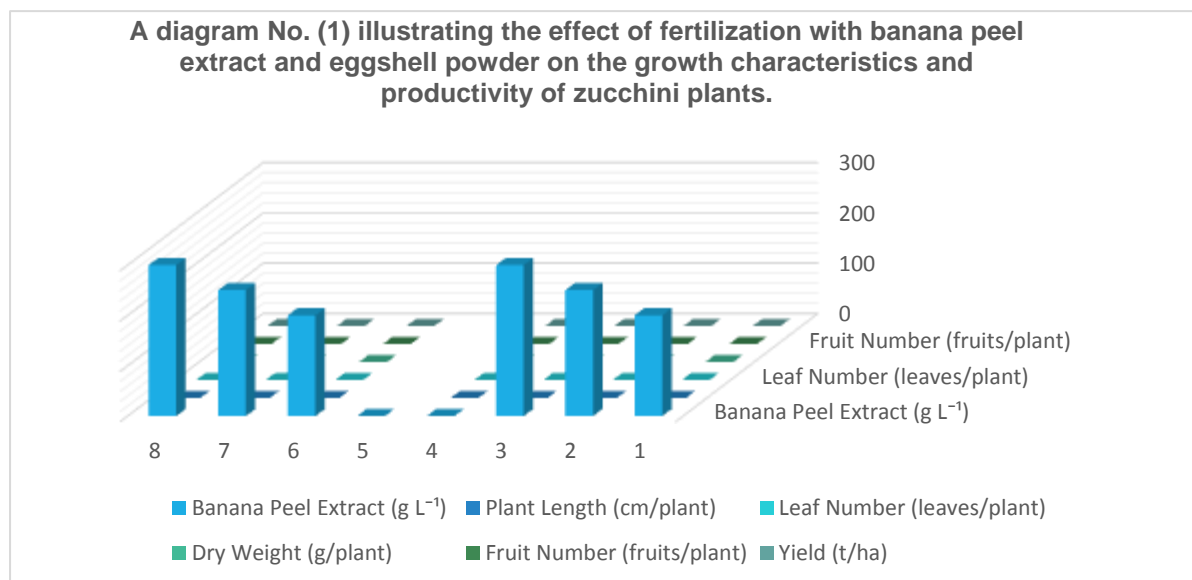
Banana peel fertilizer production begins with collecting clean, undamaged banana peels, drying them out in an oven (at 50-60°C) for 24-48 hours for preservation and grinding purposes. The dried banana peel is then ground into a powder. To create liquid fertilizer, combine 1 part powdered banana peel with 5 parts water and add a small amount of yeast to promote organic decomposition/fermentation. Mix daily for 1 week and then filter the resulting solution for use as a soil drench to irrigate

plants. Eggshell fertilizer production is done by collecting eggshells, washing them thoroughly to remove any remaining organic material, and allowing them to air dry. After being dehydrated, the shells were ground down into a fine powder that can be used as a direct application mixed with soil around the root zone, acting as both a solid and slow-release calcium source, and improving soil reaction (i.e., pH) over time..

Results and Discussion

Table No. (1) Effect of fertilization with banana peel extract and eggshell powder on the growth characteristics and yield of the zucchini plant.

Banana Peel Extract (g L ⁻¹)	Plant Length (cm/plant)	Leaf Number (leaves/plant)	Dry Weight (g/plant)	Fruit Number (fruits/plant)	Yield (t/ha)
200	71.66 c	27 b	36.71 c	4.66 c	19.20 c
250	96.66 b	28 a	38.33 b	6.00 b	21.11 b
300	123.63 a	28 a	43.92 a	7.66 a	22.21 a
Egg shell (g L ⁻¹)	Plant Length (cm/plant)	Leaf Number (leaves/plant)	Dry Weight (g/plant)	Fruit Number (fruits/plant)	Yield (t/ha)
200	81.66 c	27 b	37.71 c	4.36 c	19.11 c
250	98.66 b	28 a	39.36 b	6.70 b	23.11 b
300	121.63 a	28 a	45.62 a	8.66 a	25.21 a



Plant Height (cm leaf plant⁻¹):

The results shown in Table 1 indicate a significant increase in plant height at the third fertilization level (300 gL⁻¹), suggesting superior plant growth compared to other fertilization treatments. This superiority can be attributed to the synergistic effects of the nutrients supplied by the banana peel extract and eggshell powder, which improved nutrient uptake and stimulated physiological processes associated with cell division and cell elongation. Potassium, abundant in the banana peel extract, plays a crucial role in activating enzymes involved in carbohydrate metabolism, energy production, and protein synthesis. Furthermore, potassium contributes to the transport of nitrate (NO₃⁻) from the roots through the xylem to the leaves, where photosynthesis occurs, thus promoting vegetative growth and plant vigor. The interaction between nutrient availability and physiological activity may have contributed significantly to the remarkable plant height observed at the higher fertilization levels, particularly with the most effective treatment formulations.

Number of leaves (leaf leaf plant⁻¹):

The data in Table 1 indicate a significant advantage for the third fertilization treatment (300 g), which recorded the highest average number of leaves (35.72 leaves leaf plant⁻¹). This improvement may be related to the high magnesium content of banana peels. Magnesium enhances nitrogen uptake for protein synthesis, contributes to chlorophyll formation, activates various enzyme systems, and stabilizes ribosomes involved in protein biosynthesis. These physiological improvements likely promoted root growth and lateral branching, ultimately leading to increased leaf formation. Furthermore, the

interaction between the banana peel extract and eggshell powder may have improved nutrient availability and utilization efficiency, thus promoting vegetative growth and leaf production (Al-Hasnawi, 2011).

Yield (tons/hectare):

The results shown in Table 1 indicate a significant increase in unit yield at the third fertilization level (300 gL⁻¹), which achieved the highest yield (21.11 tons/hectare). This increase can be attributed to the increased availability of magnesium, which improves root uptake of essential macronutrients such as potassium (K), phosphorus (P), and nitrogen (N). Consequently, photosynthetic efficiency and nutrient utilization are enhanced, ensuring sufficient metabolic activity and the production of assimilated substances necessary for improved fruit growth and productivity. Furthermore, the interaction between the fertilization treatments may have positively contributed to maximizing nutrient uptake and physiological performance, resulting in superior crop responses (Talukder *et al.*, 2009; Al-Hasnawi, 2011).

Number of fruits (fruits plant⁻¹):

The third fertilization level (300 g) showed a significant increase in the number of fruits, producing 7.66 fruits leaf plant⁻¹, as shown in Table 1. This improvement may be related to enhanced nutrient availability, particularly potassium (K), phosphorus (P), and nitrogen (N), as well as increased photosynthetic activity and nutrient uptake. These improvements positively impacted the physiological and nutritional status of the plants, increasing their flowering potential and fruit set. Furthermore, the interaction between banana peel extract and eggshell powder may have enhanced the plant's nutritional

balance and metabolic activity, contributing to increased fruit production (Talukder *et al.*, 2009; Al-Hasnawi, 2011).

Dry weight plant⁻¹ (g/plant):

The second and third fertilization levels (250 g and 300 g) showed significantly higher dry weight values, registering 38.33 and 43.92 g/plant, respectively. This increase can be explained by the role of magnesium in carbohydrate metabolism and osmotic regulation, particularly under

less-than-ideal environmental conditions, leading to improved metabolic efficiency and maintenance of cell turgor. This physiological improvement contributes to enhanced vegetative growth and biomass accumulation. Furthermore, the interaction between the fertilization treatments likely contributed to enhanced nutrient uptake and dry matter accumulation, reflecting the synergistic effect of banana peel extract and eggshell powder on plant formance (Taha, 2016).

Table No. (2) Shows the interaction between banana peel and Eggshell Extracts on Vegetative Growth, Yield, and Fruit Number of Zucchini (*Cucurbita pepo* L.)

Banana Peel Extract (g L ⁻¹)	Egg shell (g L ⁻¹)	Plant Length (cm/plant ⁻¹)	Leaf Number (leaves/plant ⁻¹)	Dry Weight (g/plant ⁻¹)	Fruit Number (fruits/plant ⁻¹)	Yield (t/ha ⁻¹)
200	200	71.7 b	27 b	36 b	4 b	19.2 b
	250	74.5 b	28 b	38.0 b	4 b	20.0 b
	300	76.2 ab	29 b	39.5 ab	5 ab	21.0 ab
250	200	75.0 b	29 b	38.8 b	5 b	20.5 b
	250	78.3 ab	30 ab	41.2 ab	5 ab	22.0 ab
	300	80.0 a	31ab	42.5 a	6 a	23.5 a
300	200	78.0 ab	30 ab	41.0 ab	5 ab	22.0 ab
	250	81.0 a	32 a	43.0 a	6 a	24.0 a
	300	83.0 a	33 a	45.0 a	6 a	25.0 a

This study demonstrated that foliar spraying of banana peel and eggshell extracts significantly improved the growth, yield, and physiological characteristics of zucchini (*Cucurbita pepo* L.) compared to the control group. The highest values for plant height (83.0 cm), number of leaves (33 leaves plant⁻¹), dry weight (45.0 g plant⁻¹), and yield (25.0 t/hectare) were recorded at the highest combined concentration (300 + 300 g/L), indicating a strong synergistic effect between the two extracts. These improvements are primarily attributed to the rich nutrient content of the banana peel and eggshell extracts, particularly potassium, magnesium, and calcium, which promote photosynthesis, enzyme activity, and cell expansion (Akbar *et al.*, 2022; Nasir & Yabalak, 2021). The intermediate

treatment also showed significant improvement compared to the control group, confirming a concentration-dependent response. Previous studies have shown that banana peel extract promotes vegetative growth and yield in cucurbits due to its high potassium and magnesium content (Sun *et al.*, 2019; Shahrajabian *et al.*, 2021). Similarly, eggshell powder provides a valuable source of calcium, which strengthens cell walls and improves fruit formation (Li *et al.*, 2020).

Conclusion:

The use of eggshell-based fertilizers and banana peel extracts have been shown to greatly increase both the amount of growth and yield achieved with zucchini plants. There were considerable improvements in the height of the plants,

leaf count, dry mass of the plant, number of fruit produced, and overall zucchini yield produced when higher rates of the two amendments were applied. While banana peels supplied potassium and other essential minerals, the eggshells provided calcium which strengthened the plant cell structure and reduced the acidity of the soil. In conclusion, these results indicate that agro-waste based fertilization provides an effective and sustainable means of increasing the production of zucchini.

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