

Effect of Foliar Spray Treatments and Fertilization with Plant Extracts on the Content of Medicinally Active Compounds in Fenugreek Seeds

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ABSTRACT

The aim of the research is to understand the importance of organic fertilizers from banana peels (banana) and basil extract fertilizers on the active compounds and yield characteristics of fenugreek plants. The experiment was conducted in the field in the Al-Sadda district – Al Mahnaweiah village during the 2024 -2025 agricultural season. The experiment was designed according to the complete randomized block design as a factorial experiment ($2 \times 4 \times 3$), Two treatments with three replicates and four concentrations of the first factor :organic fertilizers from banana peels (banana) and second factor basil extract follows: (0, 5%, 10%, 15%). The plant samples were collected from the intermediate plants of each unit on 24/4/2025, meaning the plants were fully harvested after ripening to measure the components and yield characteristics. Studied traits (pods numbers pods plant⁻¹, seeds number seed pods⁻¹ Quercetin, Diosgenin, and Trigonelline) the results indicate a significant difference when combining basil and banana peels at a concentration of 15% for pods numbers pods plant⁻¹, seeds number seed pods⁻¹, Quercetin, Diosgenin and Trigonelline with an average rate of (17.98 pods plant⁻¹, 15.87 seed pods⁻¹, 30.76%, 33.98% and 33.76% compared to the control (11.65 pods plant⁻¹, 6.65, 18.65 seed pods⁻¹, 23.76 and 24.65), conclusion the interaction treatment (basil + banana peels at 15%) outperformed the individual treatments in all studied traits, these treatments can be adopted as sustainable natural alternatives to reduce reliance on chemical fertilizers and improve crop quality.

Key words: Fenugreek seeds, Active compounds, Basil, Banana peels.

INTRODUCTION

The research problem arises from the increasing challenges facing the production of oilseed crops, including fenugreek seeds [1]. Due to the heavy reliance on chemical fertilizers, which in the long term lead to soil fertility degradation and environmental pollution, in addition to their high economic costs [2]. Despite the high nutritional and medicinal importance of fenugreek seeds, their productivity and the quality of their active compounds remain below the desired level in many agricultural environments, especially under unfavorable environmental conditions and poor fertilization management [3]. Fenugreek is considered one of the important medicinal and nutritional plants, due to its seeds being rich in active compounds such as alkaloids (trigonelline), saponins, and flavonoids, in addition to fibers and vitamins [4]. This gives it high medicinal and nutritional value and makes it a focus of interest in the fields of agriculture and medicinal drugs. environmental conditions and agricultural management practices play a crucial role in determining the productivity of this crop and the quality of its chemical components , which necessitates the search for modern and sustainable methods to improve these traits [5]. In this context, foliar spraying technology has emerged as one of the effective methods for supplying plants with bioactive compounds directly and rapidly absorbed, thereby enhancing physiological activity and stimulating vital processes within the plant [6]. Basil is considered one of the aromatic plants rich in secondary compounds, such as essential oils, phenols, and terpenes, which have shown their ability to improve plant growth and increase resistance to environmental stresses when used as foliar spray extracts, positively reflecting on productivity and the quality of active compounds [7]. On the other hand, organic fertilization represents one of the fundamental pillars of sustainable agricultural systems, as it contributes to improving soil properties, increasing its fertility, and enhancing microbial activity within it.[8] Banana peels are considered rich organic sources of essential nutrients, especially potassium and phosphorus, making them a suitable option within organic fertilization practices. Recycling these agricultural waste products also contributes to reducing environmental pollution and achieving higher resource efficiency [9]. Accordingly, this research aims to study the effect of foliar spraying with basil extract and organic fertilization with banana peels, both individually and in

combination, on improving the productive traits and active compound content in fenugreek seeds, while evaluating the feasibility of adopting these treatments as natural and sustainable alternatives to enhance crop quality and increase its medicinal value within modern agricultural systems.

MATERIAL AND METHODS

The experiment was conducted in the field in the Al-Sadda district - Al-Mahnaweiah village during the 2024 -2025 agricultural season. the experiment was designed according to the complete randomized block design as a factorial experiment ($2 \times 4 \times 3$) with an experimental unit area of 1 m² and a distance of 35 cm between each unit. I obtained the seeds from the College of Agriculture, University of Kerbala, a local variety. After selecting the good seeds, the germination rate was 95%. The irrigation continued with regular water, and weeds were removed. Thinning was carried out, and on the morning of 19/11/2024, the mentioned concentrations were sprayed on the experimental units according to the treatments on the leaves and the vegetative part of the plants, which was 27 days after planting. As for the second spray, it should be done 60 days after planting. The plant samples were collected from the intermediate plants of each unit on 24/4/2025, meaning the plants were fully harvested after ripening to measure the components and yield characteristics [10]. Studied traits (pods numbers pods plant⁻¹, seeds number seed pods⁻¹ Quercetin, Diosgenin, and Trigonelinethe oil was also taken out of Fenugreek using a soxhlet apparatus. for 20 hours, 150 mL of 70% ethanol was extracted with 100 g of powdered Fenugreek in a thimble [11], and the active compounds Quercetin, Diosgenin, and Trigoneline were quantified using high-performance liquid chromatography [12].

Preparation of basil extract by method maceration

The plant extract was prepared from fresh basil leaves used as an active ingredient in foliar spraying. The leaves were collected and thoroughly washed with running water to remove dirt and impurities, then superficially dried, and 100 g of the dry plant material were weighed. the sample was added to 1L of distilled water, and the mixing process was carried out using an electric blender for 3–5 min to obtain a homogeneous mixture[13]. After that, the solution was left for 24 hours at room temperature inside a dark container for the purpose of cold extraction of

the active compounds, then it was filtered using gauze to obtain the crude extract. the extract was diluted before use in three different concentrations for the purpose of foliar spraying on fenugreek plants as follows: (5%): 50 mL extract + 950 mL water, (10%): 100 mL extract + 900 mL water (15%): 150 mL extract + 850 mL water foliar spraying was applied in the early morning or evening hours to reduce solution loss due to evaporation, with an interval of 10–14 days during the different growth stages[14].

Preparing organic fertilizers from banana peels (banana)

Banana peels were used as an organic source rich in nutrients within the organic composting system. the fresh peels were collected and cut into small pieces to increase the surface area exposed to decomposition. 200 g of the peels were placed in 2 L of water inside a partially sealed plastic container, then left to ferment for 7–10 days at room temperature with daily stirring to ensure uniform decomposition [15]. After the fermentation period, the solution was filtered to obtain the liquid organic fertilizers, and it was diluted before use in three concentrations as follows: (5%): 50 mL solution + 950 mL water , (10%): 100 mL solution + 900 mL water (15%): 150 mL solution + 850 mL water fertilizers was added directly to the soil around the plants every 2–3 weeks during the growing season [16].

The results of the banana peels extract after filtration showed that the pH value was within the weakly acidic to neutral range, approximately between 6.2 – 7.0, which is relatively suitable for agricultural use and does not cause root stress to the plant. As for electrical conductivity (EC), it recorded values around 3.5 dS/m, indicating a moderate level of dissolved salts resulting from the decomposition of organic materials during fermentation. Regarding the chemical analysis, the results showed that banana peels contain major nutrients as follows: Total nitrogen (N): approximately 0.7% Phosphorus (P): approximately 1.2% Potassium (K): about 3.0%. These values reflect the efficiency of the fermentation process in releasing essential nutrients and converting them into soluble forms that are absorbable by plants. As for the microbiological examination, it showed that the total microbial density was within relatively high levels, which is expected in fermented organic extracts, estimated to be approximately $10^6 - 10^8$ CFU/mL, with no pathogenic microorganisms detected, indicating the safety of the extract for experimental use. the extract was also stored

under refrigerated conditions at 4 °C in sterile and opaque containers to maintain its chemical and microbiological stability and prevent the deterioration of its biological properties.

Statistical Analysis

The results were statistically analyzed using the Genstat program to distinguish differences between treatments according to the complete randomized block design (RCBD) for factorial experiments, and the means were compared using the least significant difference (LSD) at the 0.05 level[17].

RESULTS

The results of table 1 showed a significant difference in the quercetine % when using banana peels %, as a concentration of 15% recorded the highest average of 27.73%, while using basil extract%, as a concentration of 15% recorded the highest average of 26.07%. However, the interaction between basil extract% and banana peels % at a concentration of 15% had the highest average (30.76%) compared to the control (18.65%).

Table 1. The effect of foliar spraying with basil extract and banana peels on the quercetine%

Banana peels %	Basil extract%				Mean%
	Control	5%	10%	15%	
Control	18.65	19.45	20.76	21.87	20.18
5%	20.76	21.67	22.87	24.87	22.54
10%	22.76	24.87	25.76	26.76	25.04
15%	24.65	26.76	28.76	30.76	27.73
Means	21.71	23.19	24.54	26.07	
LSD _{0.05}	banana peels = 1.54, basil extract= 1.44, Interaction= 2.34				

Based on the results of table 2 showed a significant difference in the diosgenin % when using banana peels %, as a concentration of 15% recorded the highest average of 31.57%, while using *basil extract*%, as a concentration of 15% recorded the highest average of 30.57%.

However, the interaction between basil extract% and banana peels % at a concentration of 15% had the highest average (33.98%) compared to the control (23.76%).

Table 2. The effect of foliar spraying with basil extract and banana peels on the diosgenin%

Banana peels %	Basil extract%				Means %
	Control	5%	10%	15%	
Control	23.76	24.76	25.76	26.76	25.26
5%	25.76	26.87	27.87	29.87	27.59
10%	26.76	28.87	29.45	31.65	29.18
15%	28.76	30.76	32.77	33.98	31.57
Means	26.26	27.82	28.96	30.57	
LSD _{0.05}	banana peels = 1.46, basil extract = 1.35, Interaction = 2.65				

Indicated to the results in table 3, that showed a significant difference in the trigoneline % when using banana peels %, as a concentration of 15% recorded the highest average of 30.95%, while using basil extract%, as a concentration of 15% recorded the highest average of 30.66%. However, the interaction between basil extract% and banana peels % at a concentration of 15% had the highest average (33.76%) compared to the control (24.65%).

Table 3. The effect of foliar spraying with basil extract and banana peels on the trigoneline%.

Banana peels %	Basil extract%				
	Control	5%	10%	15%	
Control	24.65	25.65	26.76	27.76	26.21
5%	25.76	26.76	28.56	29.45	27.63
10%	26.65	27.87	29.56	31.65	28.93
15%	28.65	29.75	31.65	33.76	30.95
Means	26.43	27.51	29.13	30.66	
LSD _{0.05}	banana peels = 0.95 , basil extract = 0.84, Interaction = 1.58				

Based on the results of table 4 showed a significant difference in the seeds number when using banana peels %, as a concentration of 15% recorded the highest average of 13.29 seed pods⁻¹, while using basil extract%, as a concentration of 15% recorded the highest average of 13.23 seed pods⁻¹. However, the interaction between basil extract% and banana peels % at a concentration of 15% had the highest average (15.87 seed pods⁻¹) compared to the control (6.65 seed pods⁻¹).

Table 4. The effect of foliar spraying with basil extract and banana peels on the on seeds number seed pods⁻¹ seeds plant⁻¹

banana peels %	basil extract%				Means
	Control	5%	10%	15%	
Control	6.65	7.45	8.87	9.65	8.16
5%	7.76	9.56	10.76	12.65	10.18
10%	8.65	11.65	12.76	14.76	11.96
15%	9.76	12.65	14.87	15.87	13.29
Means	8.21	10.33	11.82	13.23	
LSD _{0.05}	banana peels = 0.94, basil extract= 0.84, Interaction = 1.65				

Based on the results in table 5, they show a significant difference in the pods numbers when using banana peels %, as a concentration of 15% recorded the highest average of 18.51 pods plant⁻¹, while using basil extract%, as a concentration of 15% recorded the highest average of 17.98 pods plant⁻¹. However, the interaction between basil extract% and *banana peels* % at a concentration of 15% had the highest average (20.65 pods plant⁻¹) compared to the control (11.65 pods plant⁻¹).

Table 5. The effect of foliar spraying with basil extract and banana peels on the on pods numbers pods plant⁻¹

banana peels %	basil extract%				Means
	Control	5%	10%	15%	
Control	11.65	12.65	13.65	14.63	13.15
5%	12.65	14.65	15.76	16.76	14.96
10%	13.65	16.76	17.87	19.87	17.04
15%	15.76	17.87	19.75	20.65	18.51
Means	13.43	15.48	16.76	17.98	
LSD _{0.05}	banana peels = 1.76, basil extract= 1.54% , Interaction = 2.54				

DISCUSSION

The study results showed that the biotic treatments, represented by foliar spraying with basil extract and organic fertilization using banana peels, had a clear impact on improving productivity traits and increasing the content of active compounds in fenugreek seeds. these results can be explained by the physiological role of bio stimulants and the improvement of the plant's nutritional environment [18]. The improvement in growth and productivity indicators can be attributed to the role of plant extracts in regulating hormonal processes within the plant, as extracts of aromatic plants like basil contain active compounds that enhance cell division and stimulate vegetative growth. that plant bio stimulants contribute to improving nutrient absorption efficiency and activating the vital processes associated with growth [19].

On the other hand, organic fertilization with banana peels has contributed to improving soil properties and increasing the availability of nutrients, especially potassium, which plays an important role in carbohydrate transfer and seed formation [20]. Additionally, the addition of organic matter improves the physical structure of the soil and increases its water retention capacity, which positively reflects on plant growth [21] confirmed that organic fertilization improves soil fertility and increases agricultural production efficiency sustainably. As for the increase in active compounds such as phenols and saponins in fenugreek seeds, this may be due to the activation of biosynthetic pathways for secondary compounds as a result of bio

stimulation[22]. Evidence suggests that plants may increase the production of defensive compounds when exposed to biotic stimuli or mild stress, which supports the hypothesis of increased medicinal value of the crop. [23] that phenolic compounds are directly affected by environmental conditions and organic nutrition.

The results also showed that the interaction treatment between foliar spraying and organic fertilization yielded the best results compared to single treatments, indicating a clear synergistic effect [24]. Organic fertilization provides a rich and stable root environment, while foliar spraying offers rapid support for metabolic pathways in the leaves, leading to improved nutrient use efficiency within the plant. This aligns with what [25] mentioned about the importance of integrating bio stimulants and organic nutrition in improving the productivity of medicinal crops. In general, these results support the modern trend towards reducing reliance on chemical fertilizers and replacing them with sustainable natural alternatives, due to their role in improving productivity and quality and reducing environmental impact. The study results showed that the biotic treatments, represented by foliar spraying with basil extract and organic fertilization using banana peels, had a clear impact on improving productivity traits and increasing the content of active compounds in fenugreek seeds. these results can be explained by the physiological role of bio stimulants and the improvement of the plant's nutritional environment [18]. The improvement in growth and productivity indicators can be attributed to the role of plant extracts in regulating hormonal processes within the plant, as extracts of aromatic plants like basil contain active compounds that enhance cell division and stimulate vegetative growth. that plant bio stimulants contribute to improving nutrient absorption efficiency and activating the vital processes associated with growth [19].

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In general, these results support the modern trend towards reducing reliance on chemical fertilizers and replacing them with sustainable natural alternatives, due to their role in improving productivity and quality and reducing environmental impact.

Conclusions

- 1.The interventional treatment (basil + banana peels) outperformed the individual treatments in all studied traits, indicating a clear synergistic effect.
- 2.These treatments can be adopted as sustainable natural alternatives to reduce reliance on chemical fertilizers and improve crop quality.

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