Original Research Article

Potential ~~role~~ of potassium humate, garlic and lemongrass ~~natural~~ extracts ~~in~~ for improving ~~the~~ growth ~~performance~~ and productivity of faba bean ~~plants~~

ABSTRACT

Improving agricultural practices is a very important matter and remains a focal point for individuals engaged in the realm of plant nutrition. So, a field trial during two consecutive seasons of 21/2022 and 22/2023 was carried out under a randomized completed block design to assess the impact of potassium humate (KH) as soil addition as well as garlic extract (GE) and lemongrass extract (LE) as foliar application on the growth performance and productivity of faba bean plants either as individual or combined applications (KH+GE and KH+LE). Plant height (cm), No. of branches plant^{-1}, fresh and dry weights (g plant^{-1}), chlorophyll a and b as well as carotenoids (mg g^{-1}FW), green pod yield of faba bean (ton fed^{-1}), No. of pods plant^{-1}, 100 seed weight (g), seed and straw yield (ton fed^{-1}), seed chemical composition (N,P,K%), seed nutrient uptake (N,P,K, kg fed^{-1}), and seed quality (protein and carbohydrate, %) were measured and determined. The results show that the most effective treatment in achieving the highest values was the combined application of potassium humate and garlic extract followed by the combined treatment of potassium humate and lemongrass extract. The treatment involving only potassium humate addition ranked third, followed by garlic extract treatment alone, lemongrass extract treatment alone, and finally, the control treatment (without any additions). The observed synergistic effects suggest the potential for these treatments to be a valuable strategy in faba bean cultivation. Generally, these results provide valuable insights for improving agricultural practices.

Keywords: Potassium humate, Garlic extract, Lemongrass extract

INTRODUCTION

Faba bean (*Vicia faba* L.) holds significant agricultural importance in Egypt, playing a pivotal role in the Nation's agrarian landscape. It serves as a staple food crop, contributing substantially to Egypt's food security. Rich in proteins, fibers, and essential

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minerals, faba beans are integral to the Egyptian diet, providing a valuable source of nutrition (**Elsherpiny and Kany 2023)**.

Potassium humate, derived from humic substances, has gained prominence in the agricultural sector due to its multifaceted benefits **(Elshaboury and Sakara, 2021).** It serves as a source of potassium, a vital nutrient for plant growth and development. Furthermore, potassium humate has been associated with improved nutrient uptake, enhanced soil structure, and increased resistance to environmental stressors. Understanding its contents and effects on crop performance is crucial for optimizing its application in the cultivation of faba beans (**Awaad *et al.* 2020)**.

Garlic extract, known for its antimicrobial and growth-promoting properties, has been explored for its potential in enhancing crop yield and quality. Rich in bioactive compounds, such as allicin, garlic extract has been linked to improved plant defense mechanisms and nutrient utilization (**Mohamed e*t al.* 2020)**. Investigating its contents and assessing its impact on faba bean plants can provide valuable insights into harnessing its benefits for agricultural sustainability (**El-Sherpiny *et al.* 2022)**.

Lemongrass extract, derived from *Cymbopogon citratus*, has shown promise in agriculture due to its antioxidant properties and potential as a natural growth enhancer. Compounds present in lemongrass, such as polyphenols, contribute to stress tolerance and overall plant health. Examining the contents and effects of lemongrass extract on faba bean cultivation can shed light on its role in sustainable agricultural practices (**Al-Azee *et al.* 2023)**.

So, this study aims to assess the impact of potassium humate, garlic extract, and lemongrass extract on the growth performance and productivity of faba bean plants either as individual or combined applications, providing insights into their potential contributions to plant growth, yield, and quality traits. Generally, the current research aims to contribute valuable information for optimizing faba bean cultivation practices with a focus on enhancing productivity and quality.

MATERIALS AND METHODS

A field trial during two consecutive seasons of 21/2022 and 22/2023 was carried out under a randomized completed block design to assess the impact of potassium humate (KH) as soil addition as well as garlic extract (GE) and lemongrass extract (LE) as foliar application

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on the growth performance and productivity of faba bean plants either as individual or combined applications (KH+GE and KH+LE).

1. Location

The study took place on a private farm located in the village of Barq Al-Ezz, situated 5 km northeast of Mansoura City in the Dakahlia Governorate, Egypt.

2. Faba bean seeds

Faba bean seeds of the Giza 716 variety were sourced from the Leguminous Crops Research Department, Agricultural Research Center, Giza, Egypt.

3. Soil sampling

Before commencing the experiment, representative soil samples from the topsoil (0 - 30 cm) were collected, and their physical and chemical parameters were analyzed using established techniques as outlined by **Tandon (2005).** The soil exhibited a clay loam texture, with the following confirmed values for key parameters: available nitrogen (49.2 mg kg^{-1}), available phosphorus (5.24 $mg.kg^{-1}$), available potassium (185.3 $mg.kg^{-1}$), pH (7.98), electrical conductivity (EC) (1.42 dS_m^{-1}), organic matter (OM) content (1.75%), porosity (46.2%), and calcium carbonate ($CaCO_3$) content (2.85%), zinc (0.72 mg kg^{-1}), iron (3.21 mg kg^{-1}), and manganese (1.49 mg kg^{-1}).

4. Substances studied

Potassium humate (KH): It was purchased from the Egyptian commercial market and was added as soil addition according to the studied treatments at a rate of 4 kg fed^{-1}.

Garlic extract (GE): To prepare garlic extract, the first step was peeling finely chopping and crushing fresh garlic cloves. The second step was to place the crushed garlic in a container and cover it with water then macerating for a specific period. It was placed in a freezer for a duration of one day to undergo the freezing process, following which it was removed from the freezer and allowed to thaw. This sequence of freezing and thawing was iterated three times. After soaking, the following step was to filter the mixture to separate the liquid extract from the solid residues. The studied rate was (5%).

Lemongrass extract (LE): it was crushed fresh lemongrass leaves and stems. Similar to garlic extract, it was macerated ~~the~~ as crushed lemongrass in water, for a designated period. After soaking, the following step ~~was~~ to filter the mixture to obtain the liquid extract. The studied rate was (2%).

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The composition of potassium humate (KH), garlic extract (GE) and lemongrass extract (LE) used are shown in Table 1.

Table 1. The composition of potassium humate (KH), garlic extract (GE) and lemongrass extract (LE) used

KH				
Humic acid,%	**Moisture,%**	**Water solubility,%**	**pH**	**Appearance**
70	14.9	97	9	Black
GE (g kg^{-1})				
N	**P**	**K**	**Ca**	**Fe**
33	32	60	4	0.8
LE (g kg^{-1})				
N	**P**	**K**	**Ca**	**Fe**
15	22	55	2.7	0.9

5. Experimental set up

In the initial and subsequent seasons, seeds were manually sown on October 17 and 19, respectively, at a rate of 40 kg per feddan, directly by hand in hills with three seeds per hill on the shoulder bed and in the top 1/3 of the row ridge under a flooding irrigation system. Following a 20 day period from sowing, the plants were thinned to two plants per hill. Prior to sowing, all plots received calcium superphosphate (15% P_2O_5) at a rate of 100 kg per feddan and potassium sulfate (48% K_2O) at a rate of 50 kg K_2O per feddan. The effective nitrogen dose, supplied as ammonium sulfate (20.5% N), was applied in a single dose 20 days after sowing and preceding the first irrigation. Foliar application of garlic and lemongrass extracts was conducted 30 days after sowing and repeated three times at 14-day intervals using a hand sprayer with a volume of 400L per feddan for each extract treatment. Potassium humate was introduced after the thinning process. Additionally, other recommended agricultural practices for faba beans were adhered to following the guidelines outlined by the Egyptian Ministry of Agriculture.

6. Measurement traits

Measurements and determinations were implemented on a sample of five randomly selected faba bean plants (Table 2).

Table 2. Methods, formula, and references of measurements

Measurements	Methods and formula	References
At 75 days from sowing		
Plant height (cm), No. of branches plant^{-1}, fresh and dry weights (g plant^{-1})	Manually and visually	----------
Chlorophyll a, b and carotenoids (mg g^{-1}FW)	Spectrophotometrically	**Rajput and Patil, (2017)**
At 90 days from sowing		
green pod yield of faba bean (ton fed^{-1}) and No. of pods plant^{-1}	Manually and visually	----------
At harvest stage		

100 seed weight (g) seed and straw yield (ton fed^{-1})	Manually and visually	----------
Seed N, P, K content (%)	Micro-kjeldahl, spectrophotometrically and flame photometer, respectively	**Walinga *et al.* (2013)**
Seed nutrient uptake (N,P,K, kg fed^{-1})	Nutrient concentration (N, P, K) % in grain **X** grain yield (ton fed^{-1}) **X** 10	
Protein and carbohydrates (%)		**A.O.A.C (2000)**

Notes: Digesting the seed samples was done as described by **Peterburgski (1968) using** Mixed of $HClO_4$ + H_2SO_4

7. Statistical analysis

The collected data underwent analysis of variance using the methodology outlined in **Gomez and Gomez (1984).** For the comparison of means across different treatments, Duncan's Multiple Range test **(Duncan, 1955)** was employed.

RESULTS AND DISCUSSION

1. Growth criteria and photosynthetic pigments (75 days from sowing)

Figs 1 to 5 present data illustrating the impact of potassium humate, garlic extract, and lemongrass extract on the growth performance and photosynthetic pigment content in the leaves of faba bean plants. The observations were made at the 75-day mark from sowing, encompassing the seasons of 21/2022 and 22/2023 (aggregated data across both seasons). According to the figures, the most effective treatment in achieving the highest values for plant height (cm) **(Fig1),** No. of branches plant^{-1} **(Fig 2),** fresh and dry weights (g plant^{-1}) **(Figs 3 &4)**, chlorophyll a and b as well as carotenoids (mg g^{-1}FW) **(Fig5),** was the combined application of potassium humate and garlic extract followed by the combined treatment of potassium humate and lemongrass extract. The treatment involving only potassium humate addition ranked third, followed by garlic extract treatment alone, lemongrass extract treatment alone, and finally, the control treatment (without any additions).

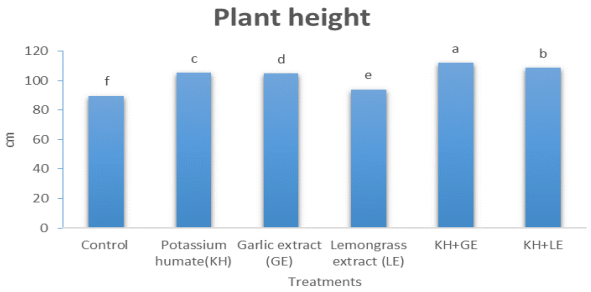

Fig 1. Effect of potassium humate, garlic extract and lemongrass extract on plant height (cm) of faba bean plants at period of 75 days from sowing (combined data over both seasons)

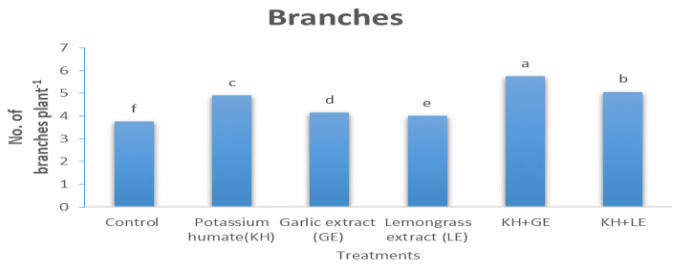

Fig 2. Effect of potassium humate, garlic extract and lemongrass extract on No. of branches plant^{-1} of faba bean plants at period of 75 days from sowing (combined data over both seasons)

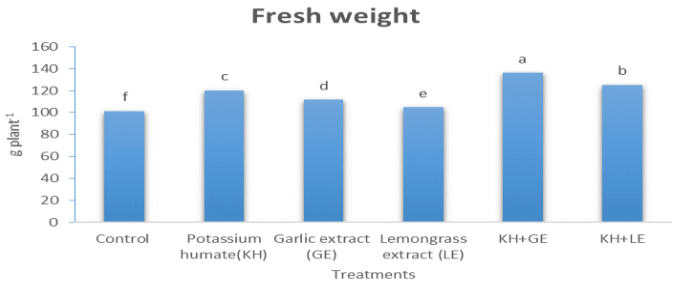

Fig 3. Effect of potassium humate, garlic extract and lemongrass extract on fresh weight (g plant^{-1}) of faba bean plants at period of 75 days from sowing (combined data over both seasons)

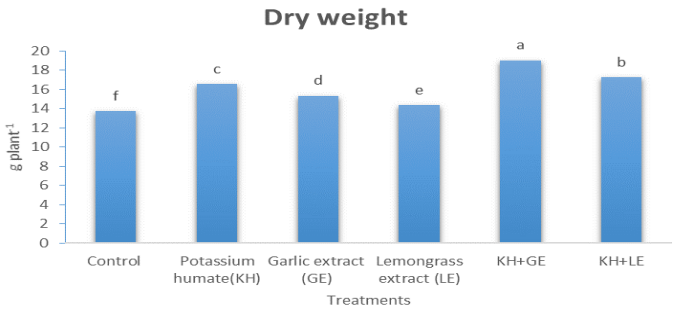

Fig 4. Effect of potassium humate, garlic extract and lemongrass extract on dry weight (g plant^{-1}) of faba bean plants at period of 75 days from sowing (combined data over both seasons)

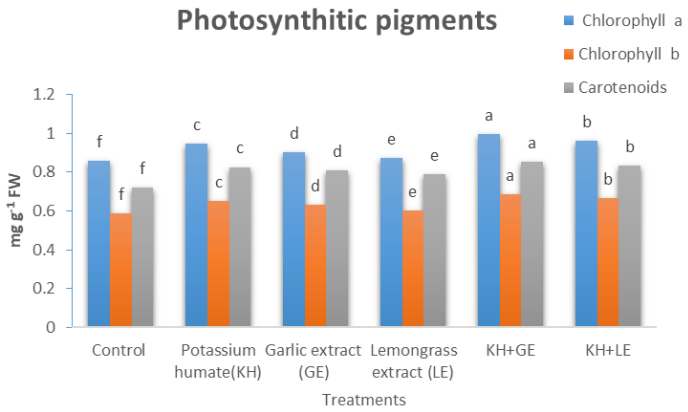

Fig 5. Effect of potassium humate, garlic extract and lemongrass extract on the content of photosynthetic pigments in leaves of faba bean plants at period of 75 days from sowing (combined data over both seasons)

The scientific reasons for the obtained results in the study could be attributed to the specific properties and functions of the substances used (potassium humate, garlic extract, and lemongrass extract) and their known effects on plant physiology. Potassium is an essential nutrient for plant growth, contributing to processes like enzyme activation, photosynthesis, and water regulation. Humic substances, such as humic acid in potassium humate, can enhance nutrient availability and uptake by plants. Humic substances are known to improve a plant's resistance to various environmental stresses, including salinity and drought. Potassium humate plays a pivotal role in enhancing the physical, chemical, and biological properties of soil, thereby significantly influencing the availability of essential elements for plant growth. Physically, it improves soil structure by promoting the formation of stable aggregates, enhancing water retention, and preventing soil erosion. Chemically, potassium humate acts as a natural chelator, binding with essential nutrients and making them more available to plants. It also contributes to cation exchange capacity (CEC), enhancing the soil's ability to retain and exchange nutrients. Biologically, it fosters the growth of beneficial microorganisms, promoting soil health and nutrient cycling. Importantly, potassium humate helps reduce soil acidity, creating a more favorable pH environment for plant growth. By mitigating soil acidity, it improves the availability of nutrients, especially micronutrients, and facilitates their uptake by plants. This multifaceted action of potassium humate underscores its crucial role in creating optimal soil conditions for robust plant development. This could contribute to better growth performance under challenging

conditions (**Ismail *et al.* 2018; Awaad *et al.* 2020).** Garlic is known for its antimicrobial and antifungal properties. The garlic extract may have helped in protecting the plants from certain pathogens, leading to healthier growth. Garlic contains bioactive compounds like allicin, which may act as plant growth regulators or antioxidants, influencing various physiological processes. The findings align with **Mohamed *et al.* (2020),** who observed that applying garlic extract to the foliage exhibited superior effects on various growth and yield parameters, leading to a significant increase in all yield criteria for faba bean plants.

Lemongrass is rich in antioxidants, such as polyphenols. These compounds can scavenge free radicals and protect plant cells from oxidative damage, contributing to improved plant health. Lemongrass extracts may contain phytochemicals with growth-promoting properties or may influence metabolic pathways in plants, leading to enhanced growth **(Fokom *et al.* 2019; Zulfikar and Sitepu, 2019).** The observed superior performance of the combined treatment of potassium humate with garlic or lemongrass extracts may be due to synergistic effects. The combination of these substances might have complementary actions, providing a more favorable environment for plant growth. The combined treatments may have resulted in a more balanced nutrient uptake by the plants, optimizing their growth and physiological processes. The control treatment, without any addition, serves as a baseline. The inferior results in this group could be attributed to the absence of the beneficial substances present in the other treatments.

2. Pod yield and its components (90 days from sowing)

Data shown in Figs 6 and 7 illustrate the effect of potassium humate, garlic extract and lemongrass extract on the green pod yield of faba bean (ton fed^{-1}) and No. of pods plant^{-1} at period of 90 days from sowing during seasons of 21/2022 and 22/2023 (combined data over both seasons).The Figs show that the superior treatment for obtaining the highest values of the green pod yield of faba bean (ton fed^{-1}) and No. of pods plant^{-1}**,** was the combined treatment of potassium humate+ garlic extract followed by the combined treatment of potassium humate+ lemongrass extract. The treatment of potassium humate addition alone came in the third order followed by garlic extract treatment alone then lemongrass extract treatment alone and lately the control treatment (without any addition).

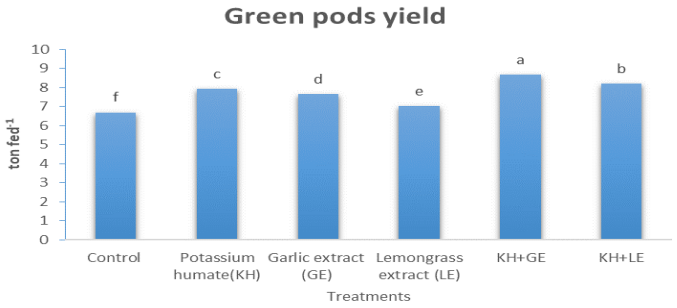

Fig 6. Effect of potassium humate, garlic extract and lemongrass extract on the green pod yield of faba bean (ton fed^{-1}) of faba bean plants at period of 90 days from sowing (combined data over both seasons)

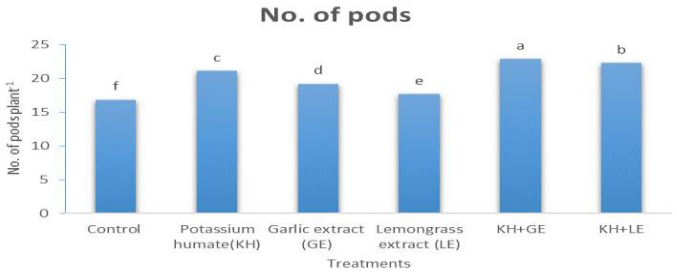

Fig 7. Effect of potassium humate, garlic extract and lemongrass extract on the No. of pods plant^{-1} of faba bean plants at period of 90 days from sowing (combined data over both seasons)

As shown in Fig 6, the most effective treatment in achieving the highest values for green pod yield in faba beans was the combined application of potassium humate and garlic extract, followed closely by the combination of potassium humate and lemongrass extract. This indicates a positive synergistic effect when these substances are used together. Similar to the green pod yield, the combined treatment of potassium humate and garlic extract proved to be the most favorable for obtaining the highest number of pods plant^{-1} (Fig7), with the combination of potassium humate and lemongrass extract also showing positive effects. Potassium humate, being a source of potassium, may have positively influenced nutrient uptake and availability, essential for pod development. Garlic extract and lemongrass extract could contribute essential nutrients and growth-promoting compounds, enhancing overall plant health and productivity. Garlic and lemongrass extracts may contain phytochemicals acting as plant growth regulators, influencing flowering and pod development. Antioxidant properties in garlic and lemongrass extracts may protect plants from oxidative stress, promoting healthier

pod development. The superior performance of combined treatments suggests potential synergistic effects, where the combined action of potassium humate with garlic or lemongrass extracts produces a more pronounced positive impact on pod yield and pod number. The lower performance in the control treatment reinforces the idea that the observed positive effects in other treatments are attributed to the specific substances added and not inherent in the natural conditions. The obtained results align consistently with those of **Kasim *et al.* (2017); Mahdi *et al.* (2021); El-Sherpiny *et al.* (2022); Ammar *et al*. (2022).**

3. Seed yield and quality (at harvest stage)

Figs 8 to 12 present data illustrating the impact of potassium humate, garlic extract, and lemongrass extract on seed yield and quality traits of faba bean plants at harvest stage, encompassing the seasons of 21/2022 and 22/2023 (aggregated data across both seasons). According to the figures, the most effective treatment in achieving the highest values for 100 seed weight (g) **(Fig8),** seed and straw yield (ton fed^{-1}) **(Fig 9),** seed chemical composition (N,P,K%) **(Fig 10)**, seed nutrient uptake (N,P,K, kg fed^{-1}) **(Fig11)** and seed quality (protein and carbohydrate, %) **(Fig12),** was the combined application of potassium humate and garlic extract. This was closely followed by the combined treatment of potassium humate and lemongrass extract. The treatment involving only potassium humate addition ranked third, followed by garlic extract treatment alone, lemongrass extract treatment alone, and finally, the control treatment (without any additions).

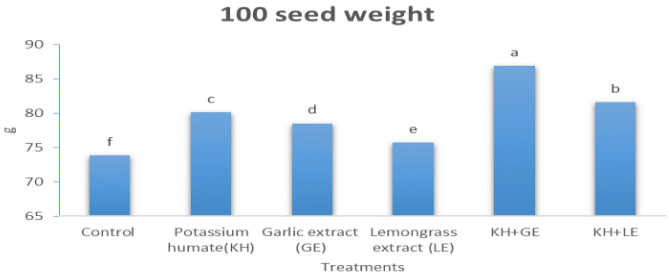

Fig 8. Effect of potassium humate, garlic extract and lemongrass extract on the 100 seed weight (g) of faba bean plants at harvest stage (combined data over both seasons)

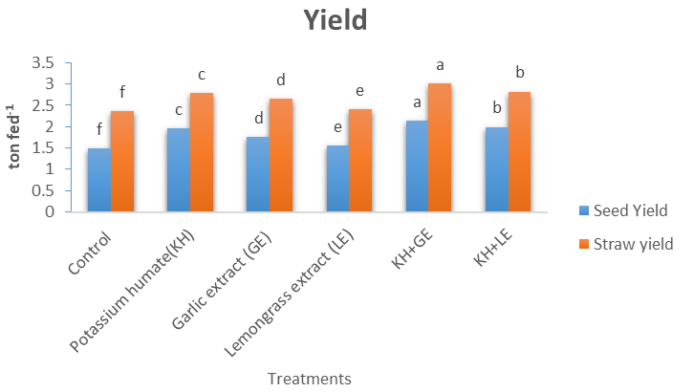

Fig 9. Effect of potassium humate, garlic extract and lemongrass extract on the seed and straw yield (ton fed^{-1}) of faba bean plants at harvest stage (combined data over both seasons)

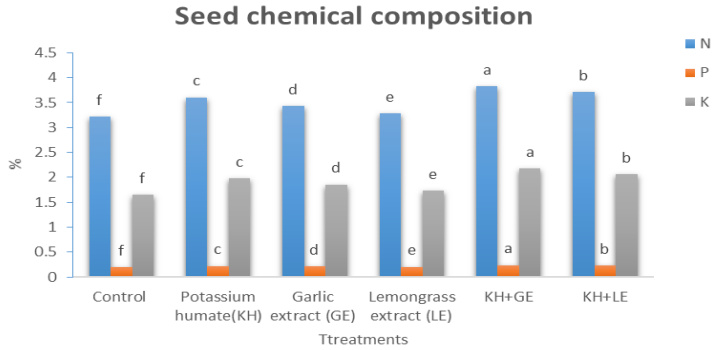

Fig 10. Effect of potassium humate, garlic extract and lemongrass extract on the seed chemical composition (%) of faba bean plants at harvest stage (combined data over both seasons)

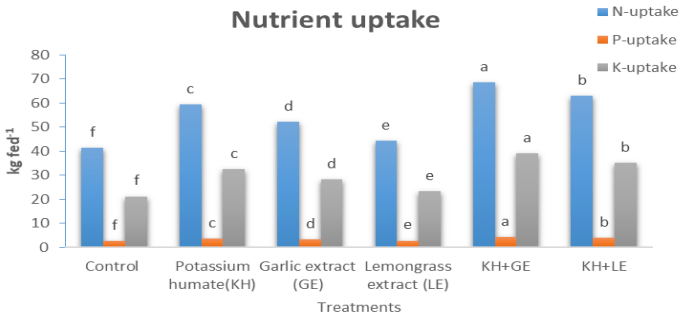

Fig 11. Effect of potassium humate, garlic extract and lemongrass extract on the seed nutrient uptake (kg fed^{-1}) of faba bean plants at harvest stage (combined data over both seasons)

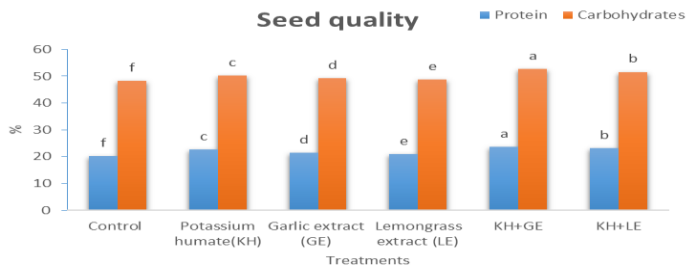

Fig 12. Effect of potassium humate, garlic extract and lemongrass extract on the seed quality (protein and carbohydrate, %) of faba bean plants at harvest stage (combined data over both seasons)

The combined treatment of potassium humate and garlic extract may have optimized nutrient availability, increasing seed weight, yield, and nutrient uptake. This combination likely enhanced the plant's ability to absorb essential nutrients such as nitrogen (N), phosphorus (P), and potassium (K). Lemongrass extract, when combined with potassium humate, could have synergistically contributed to improved nutrient utilization and uptake. Garlic and lemongrass extracts may contain bioactive compounds that act as plant growth regulators, influencing metabolic pathways and positively affecting seed development and quality. The observed improvement in seed yield and quality traits may be linked to enhanced photosynthetic activity, influenced by the combination of potassium humate and the bioactive compounds in garlic and lemongrass extracts. The combined treatment of potassium humate and garlic extract may have promoted higher protein and carbohydrate synthesis in the seeds, contributing to improved seed quality. The obtained results are in harmony with those of **Zulfikar and Sitepu, (2019); Mohamed *et al.* (2020); Al-Azee *et al.* (2023).** Generally, according to the results obtained and the results of others, it can be said that garlic extract, with its antimicrobial properties and nutrient-rich composition, can positively impact faba bean plants in various ways. It serves as a natural defense mechanism, enhancing disease resistance and acting as a deterrent to pests. The presence of essential nutrients supports overall plant growth, including root development and leaf expansion. Additionally, garlic extract may contribute to stress tolerance, helping plants withstand adverse environmental conditions. As a bio-stimulant, it stimulates physiological processes, leading to increased flowering, fruiting, and overall productivity. Furthermore, garlic's allelopathic effects can inhibit the growth of competing plants, offering an additional advantage in certain agricultural contexts. Ultimately, the application of garlic extract emerges as a holistic approach to fostering the health and

performance of plants. Combining garlic extract with potassium humate can further enhance the overall well-being of plants. Potassium humate, derived from humic acid, provides a rich source of organic matter that benefits soil structure, nutrient availability, and water retention. When used in conjunction with garlic extract, which offers antimicrobial properties and growth-stimulating effects, the synergistic action can lead to improved plant resilience. Potassium humate contributes to better nutrient absorption, promoting the efficient utilization of essential elements. Together with garlic extract, it forms a comprehensive approach to plant health by bolstering disease resistance, nutrient uptake, and stress tolerance. This combined treatment can result in robust growth, increased productivity, and a more sustainable and resilient plant ecosystem **.**

CONCLUSION

According to the obtained results, the combined application of potassium humate and garlic extract led to the best growth, yield, and quality traits of faba bean plants under the study conditions. The observed synergistic effects suggest the potential for these treatments to be a valuable strategy in faba bean cultivation. Further research is recommended to fine-tune application ratios and timings, especially for lemongrass extract, and field trials are essential to validate these findings in diverse conditions. Generally, these results provide valuable insights for improving agricultural practices.

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