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Maximizing Productivity of some Faba Bean Varieties by Foliar of Wood Vinegar and Algae under Sandy Soil Conditions

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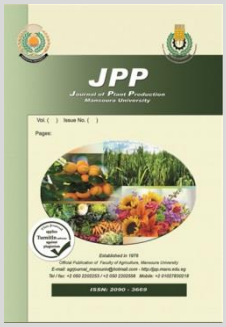

ABSTRACT

Increasing food productivity is one of the most important requirements to meet the growing demand for it. So, this study aimed to study the effect of foliar spraying with algae and wood vinegar on the yield and quality of some faba bean varieties grown in sandy soil during the winter seasons (2021–22 and 2022–23). The results showed that the foliar spraying with wood vinegar and algae had a substantial impact on yield, its components, and the quality indices of faba bean varieties. Also, the results showed that foliar spraying with high rates of wood vinegar and algae enhanced the seed yield and quality of faba bean varieties. The results also showed that the Nubaria-2 variety was superior to the Giza-716 variety in most of the studied traits. Foliar spraying at a rate of 4 ml/l was superior to all other rates in yield, yield components, P%, K %, protein and total carbohydrates for both faba bean cultivars in the two seasons. The results of the study had important effects on the cultivation of faba bean in modern sandy soil. Foliar spray treatments with wood vinegar and algae can be a successful technique for increasing crop productivity and nutritional content, contributing to food security. The results obtained revealed the superiority of the Nubaria-2 variety over the Giza-716 in terms of yield and its components, and foliar spraying at a rate 4 ml/l of wood vinegar gave better results than other rates.

Keywords: Faba bean, Nubaria-2, Giza-716, Wood vinegar, Algae, Sandy soil.

INTRODUCTION

In the Egyptian diet, faba bean (*Vicia faba* L) is an essential source of protein. Now, all efforts are aimed at increasing agricultural productivity to fulfill the growing demand for food. As a result, a large amount of fertilizer has been used to improve agricultural productivity, which is both costly and detrimental to the environment (Foda *et al*., 2021). As a result, several researchers enhanced their efforts to produce a high quantity and quality of output by discovering alternative mineral fertilizers, such as algae extract and wood vinegar.

Foliar feeding is one of the most important fertilizer delivery tactics because it promotes nutrient absorption by breaking the leaf cuticle and entering the cells, resulting in increased crop yield (Mady 2009; Grewal and Abbey 2018). As a result, foliar application of bio-fertilizers is one of the most significant and effective sources of plant nutrients, emerging as a viable alternative to chemical fertilizers, offering improved nutrient absorption to boost crop output. As a result, foliar spraying is regarded as one of the most environmentally benign farming practices, as well as being more effective than chemical fertilizers applied to the soil (Youssef, 2016).

Wood vinegar (WV) is a fluid collected from pyrolysis flue gas produced during the high-temperature production of biochar from agricultural waste. It includes between 10% and 20% organic compounds and around 200 distinct types of chemical molecules. Organic acids, benzene, ketones, aldehydes, alcohols and their derivatives, heterocyclic compounds, phenols, and their derivatives, alkyl phenyl ether derivatives, carbohydrates, and nitrogen compounds are among these organic compounds (Ma *et al*., 2013).

Wood vinegar is the gaseous byproducts, water vapor, tar, and volatiles formed by the slow pyrolysis of biomass into charcoal, also known as pyroligneous acid (Lashari *et al*., 2013). Its composition is complicated, consisting mostly of water (80–90%) and more than 200 chemical molecules, including acid, alcohol, phenol, aldehyde, and ester (10–20%), with acetic acid serving as the primary organic acid component (Feng et al., 2020).

Wood vinegar is becoming more popular as a natural plant material since it is non-polluting and environmentally benign. It may be utilized in agricultural production as a plant growth booster (Luo *et al*., 2019), an antibacterial agent, and a soil amendment (Lashari *et al*., 2015). Furthermore, because of its acidic nature, wood vinegar has been proposed to be utilized to increase nutrient availability and minimize N_2O and CH_4 emissions (Zhang et al., 2020). In principle, wood vinegar treatment is expected to improve phytoextraction by improving soil metal bioavailability and, as a result, plant absorption and accumulation. Furthermore, wood vinegar may provide a variety of essential components for plant development.

However, as an environmentally beneficial product, extensive studies on the effects of wood vinegar on the efficiency of phytoextraction have never been done. Pyroligneous acid (PA) or Wood vinegar is an acidic reddish-brown aqueous liquid. It is obtained by clarifying the liquid output of the combustion process of woods or wood remnants from the wood processing industry, tree branches, bamboo, agricultural straw, fruit shell, and other biomaterials. (Yang *et al*., 2016).

Wood vinegar is frequently utilized in the manufacturing of NR sheets as an insect repellent, odor

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eliminator, wood preserving, plant growth booster and soil and/or foliar fertilizer, animal feed additive, and coagulant. Until recently, many of the goods have been used in a wide range of markets. Wood vinegar has lately been shown to be good to crops. Wood vinegar, on the other hand, contains a variety of functional substances in appropriate proportions that not only benefit crop growth, but also yield good interactions, that can promote stress and disease resistance, crop growth, and thus such an effect can eventually boost crop yield and quality (Gu *et al*., 2020).

According to previous studies, diluting wood vinegar 300 times can boost, yield as well as protein content, enhance rice quality, and significantly increase panicle number, photosynthesis, and efficient tillers number. (Jeong *et al*., 2015). In low soil quality or dry conditions, adding wood vinegar to beans can increase their nutritional content while reducing infection with dangerous bacteria (Mao *et al*., 2019).

Algae, whether linked in a small zone or not, enhance soil structure and increase production. The use of algae in plants has resulted in an increase in root, shoot length, and the number of leaves, and hence the plant's overall improvement. (Vyomendra and Kumar 2016).

Moreover, Clear types of blue-green algae can carry out both photosynthesis and nitrogen fixation, which provides them with biological and agrarian inclinations for a different type of bio-fertilizer that may enhance the structure of mainly saline-alkaline soil, and boost crop yielding and quality. To some extent, they are useful in water refining. (Gupta, *et al*., 2015; Nabti *et al*., 2017).

Meanwhile, the applied study of foliar wood vinegar and algae on field crops is still in the exploratory stage, some concentrations of wood vinegar and algae were selected to study the effect of foliar spraying addition on yield and quality of faba bean for two years under sandy soil conditions.

MATERIALS AND METHODS

Experimental Site

The sets were tested at a private farm in the El-Wadi El-Gaded Governorate for two seasons (2021/22 and 2022/23). The soil type is sandy and had previously been grown at the test site. Soil samples were gathered from the 30 cm soil layer depth for lab analysis before the trail was started, as shown in Table 1.

The irrigation water was collected for analysis, as shown in Table 2, as described by Carter and Gregorich (2008), while the analysis of the wood vinegar and algae used is shown in Tables 3 and 4.

Table 1. Physical and chemical properties of the experimental site before sowing.

Soil Layer (cm)	Sand	Silt	Clay	Textural	EC ($dS\ m^{-1}$)	pH	O.M	$CaCO_3$	P	K	S
		(%)							(%)		
0-30	85.80	6.55	7.65	Sandy	0.55	7.90	0.35	3.12	0.13	1.65	1.70

Table 2. Chemical analysis of irrigation water.

pH	EC dSm^{-1}	Soluble cations (mg/l)				Soluble anions (mg/l)			
		K^+	Na^+	Mg^{++}	Ca^{++}	$CO_3^=$	HCO_3^-	Cl^-	$SO_4^=$
7.70	0.80	3.18	3.12	6.22	7.02	0.00	3.87	0.57	15.10

Table 3. Chemical analysis of compound wood vinegar

Organic acids	Ketones	Esters	Furan derivatives	Alkanes	Aldehydes	phenols
			(%)			
25.92	9.77	4.10	1.59	3.52	1.80	40.15

Table 4. Physico-chemical analysis of the algae.

pH	C/N	O.M	O.C	N	P	K	Fe	Zn	Mn	Cu
						(%)				
7.50	18.30	57.30	25.00	3.30	2.50	0.63	0.15	0.05	0.02	0.005

Experimental design

The experimental design of the study was a split plot design with three replicates in a randomized complete block configuration. The main plots were allocated faba bean cultivars, whereas the subplots received foliar spraying rates. Field trials in both seasons were conducted utilizing a drip irrigation system with drippers positioned 30 cm apart. (2 L/hour). The seeds were planted in hills 25 cm apart on plots 15 m^2 (1/280 fed) in area with five ridges (500 cm long and 60 cm width). The irrigation system was irrigated every 5-7 days, and it was added once before sowing at 10 days.

Agricultural practices

In both seasons, faba bean varieties, i.e., Giza-716 and Nubaira-2, were planted on November 10th at a rate of 30 kg/fed (fed =4200 m^2). The Beans Research Institute, Agricultural Research Centre provided the Faba bean seeds. Phosphorus and potassium were applied at rates of 75 kg P_2O_5/fed and 50 kg K_2O/fed, respectively. Before planting, a mono-calcium super-phosphate treatment of phosphorus (15.5% P_2O_5) was applied. Potassium sulphate (48% K_2O) was applied after 45 days of sowing. Nitrogen was applied twice (after 20 and 30 days after sowing) at a rate of 30 kg N/fed in the form of ammonium nitrate (33.5% N). During both growth seasons, weeds were treated twice, 25 and 50 days after planting, as well as insects and other agricultural practices, as directed by Egypt's Ministry of Agriculture.

Treatments

Algae and wood vinegar were sprayed for faba bean varieties after 30 days, 45 days, and 60 days from sowing with an average of 300 liters of water per feddan at the following rates:

1.Control foliar spaying with water (F_1)
2.Foliar spaying with algae (1 ml/l)(F_2)
3.Foliar spaying with algae (2 ml/l)(F_3)
4.Foliar spaying with algae (4 ml/l)(F_4)
5.Foliar spaying with wood vinegar (1 ml/l)(F_5)
6.Foliar spaying with wood vinegar (2 ml/l)(F_6)
7.Foliar spaying with wood vinegar (4 ml/l)(F_7)

Yield and its components

At harvest time, a random sample of 10 randomly selected plants was placed between the middle ridges of each plot to determine plant height (cm), number of seeds per plant (g), seed weight per plant (g), and 100-seed weight (g). All plants in each plot were harvested to estimate, seed yield

(ton/fed), straw yield (ton/fed), biological yield (ton/fed) = (seed yield + straw yield), and harvest index % = (seed yield/biological yield).

Chemical analysis

A.O.A.C. (2002) evaluated the levels of total nitrogen and soluble carbohydrates in seeds. The crude protein content was determined by multiplying the N% by 6.25 (A.A.C.C. 2000). According to Carter and Gregorich (2008) method for estimating phosphorus levels using a spectrophotometer, according to Motsara and Roy (2008), the K^+ concentrations were measured using an emission flame photometer.

Statistical analyses

The data were statistically evaluated using analysis of variance (ANOVA), mean comparisons with COSTAT, and the least significant differences (LSD) at a level of 5% to determine differences between means. Statistical software for Windows version 6.1 was used for the calculations (Statsoft Inc., 2004).

RESULTS AND DISCUSSION

1. Yield and yield components

Variety differ

The findings in Table 5 show a significant difference in yield and yield components between the two varieties, such as plant height, number of seeds per plant, weight of seeds per plant, weight of 100 seeds, seed and straw yield per feddan, as well as biological yield, which were all higher in the Nubaria-2 variety than in the Giza-716 variety in two seasons. In both seasons, the Giza-716 variety outperformed the Nubaria-2 variety in terms of harvest index. Genetic variations may explain the variation in yield characteristics across faba bean varieties.

Many studies have documented the favorable impact of algae on plant yield, such as Reda *et al.* (2020) on soybean, Ali (2021) on wheat, and Kunmiao *et al.*, (2021), who have also found a good influence of wood vinegar on plant production. In this regard, Travero and Mihara (2016) discovered that wood vinegar treatment of soybean plants had no statistically significant influence on plant growth but had a significant effect on yield. However, the Nubaria-2 variety had the greatest yield features when treated with wood vinegar. These findings were corroborated by Foda *et al.*, (2021).

These results have also been supported by Abd El Gawad *et al.*, (2015), who claimed that algae may be used to boost the productivity of faba beans. In this regard, Vyomendra and Kumar (2016) and Cao *et al.*, (2017) are noteworthy. Furthermore, the use of algae in plants has increased root, shoot, and leaf length, resulting in an overall improvement in peanut plants. In this regard, Ahmed and El-Abagy (2007) linked differences in growth characteristics among faba bean cultivars to differences in the number of nodules formed on the roots of the tested cultivars, implying that each cultivar's growth may be primarily dependent on nitrogen fixation, as well as differences in photosynthetic partitioning and migration between cultivars and the endogenous.

Table 5. Effect of foliar spraying with wood vinegar and algae on yield and yield components of faba bean varieties under sandy soil

Varieties	Plant height(cm)	No. of seeds/plant	Seed weight /plant (g)	Weight of 100 seed(g)	Seed yield (ton/fed)	Straw yield (ton/fed)	Biol. Yield (ton/fed)	Harvest index (%)
				2021/2022				
Giza-716	86.47	30.65	48.42	99.66	1.90	2.05	3.96	48.13
Nubarua-2	102.95	33.80	50.14	105.83	1.92	2.42	4.35	44.52
$LSD_{0.05}$	0.54	0.82	0.61	7.52	0.01	0.03	0.03	1.42
				2022/2023				
Giza-716	91.19	33.38	51.50	105.40	2.04	2.19	4.23	48.29
Nubarua-2	108.23	36.52	53.31	111.93	2.06	2.58	4.65	44.68
$LSD_{0.05}$	0.82	0.58	0.89	3.59	0.01	0.18	0.18	1.95

Foliar spraying treatments

Faba bean cultivars respond to wood vinegar and algae, depending on the rate of treatments. Some kinds may perform better at higher rates, while others may perform better at lower rates. Finding the appropriate balance is critical to increasing yield and yield components, biological yield, and harvest index%. It is possible that synergistic effects will occur, resulting in greater nutrient availability and improved overall plant performance. On the other hand, they may have neutral or even negative effects on certain kinds or at specified rates, as seen in Table 6.

In data Table 6 shown that all foliar spraying rates improved for all yield and yield components, and the higher spraying rate was better than the lower spraying rate in the two seasons. Spraying at a rate of 4 ml/l algae and wood vinegar is an effective strategy for improving faba bean productivity and efficiency, and the highest values were obtained from spraying at a rate of 4 ml/l (F_7) from wood vinegar treatment, indicating that the algae and wood vinegar foliar spraying application leads to an increase in plant efficiency to produce a higher yield.

According to Chalermsan and Peerapan (2009), an optimal concentration of wood vinegar contains various functional substances in an appropriate proportion that are not only beneficial to crop growth but also produce good interactions that can promote robust crop growth, and this effect can ultimately increase crop yield and quality. Ali (2021) observed that spraying with bio-fertilizer (3 ml/l) and adding algae fertilizer (5 ml/l) separately resulted in a significant increase in all vegetative growth and yield components of wheat seed.

The results presented in the table show that spraying faba bean varieties with algae or wood vinegar significantly increased yield components and thus seed and straw yield, while untreated faba plants had the lowest values, as seen in Table 6. In this regard, Ahmed and El-Abagy (2007) linked differences in growth characteristics among faba bean cultivars to differences in the number of nodules formed on the roots of the tested cultivars, implying that each cultivar's growth may be primarily dependent on nitrogen fixation as well as differences in photosynthetic partitioning and migration between cultivars and the endogenous.

Table 6. Effect of foliar spraying with wood vinegar and algae treatments on yield and yield components of faba bean varieties under sandy soil

Foliar fertilizers		Plant height (cm)	No. of seeds / plant	Seed weight /plant (g)	Weight of 100 seed (g)	Seed yield (ton/fed)	Straw yield (ton/fed)	Biol. Yield (ton/fed)	Harvest index (%)
2021/2022									
Control	F_1	78.50	25.33	38.66	85.56	1.67	1.66	3.33	50.15
	F_2	85.33	28.33	43.16	95.50	1.90	2.19	4.09	46.54
Algae	F_3	90.83	30.00	45.33	101.92	1.92	2.26	4.18	45.50
	F_4	95.50	32.33	47.83	105.74	1.95	2.31	4.26	45.42
	F_5	100.33	35.00	53.00	108.03	1.96	2.35	4.31	46.70
Wood vinegar	F_6	104.16	36.83	56.00	111.09	1.99	2.42	4.41	45.15
	F_7	108.33	38.50	61.00	111.38	2.02	2.49	4.51	44.83
$LSD_{0.05}$		1.29	0.76	0.89	5.19	0.01	0.06	0.05	0.78
2022/2023									
Control	F_1	83.00	27.33	41.11	90.49	1.78	1.77	3.55	50.23
	F_2	89.83	30.33	45.89	101.01	2.03	2.33	4.36	46.72
Algae	F_3	95.66	32.50	48.19	107.80	2.06	2.41	4.47	45.68
	F_4	101.00	35.16	50.85	111.83	2.09	2.46	4.55	45.57
	F_5	105.83	38.00	56.35	114.25	2.11	2.50	4.61	46.81
Wood vinegar	F_6	109.16	39.83	59.54	117.50	2.13	2.58	4.72	45.34
	F_7	113.50	41.50	64.85	117.81	2.17	2.66	4.83	45.03
$LSD_{0.05}$		0.82	0.83	1.34	5.41	0.01	0.05	0.06	0.75

Foliar spaying interaction

Data presented in Table 7 demonstrate that varieties Giza-716 and Nubaria-2 responded substantially differently to algae and vinegar treatments on most yield parameters as well as straw and seed yield. The same data also shows that both cultivars reacted favorably to the algae and vinegar treatments. So, the combination of faba bean varieties with different rates can lead to unique interactions. Some varieties may show increased yield, yield components, biological yield, and harvest index% when treated with specific wood vinegar and algae formulations at optimal rates, and these variations may be explained by the genetic foundation of cultivars.

Regarding the interaction between faba bean varieties and fertilizer rate; faba bean varieties responses to wood vinegar and algae, depending on the varying rates, might result in interesting interactions. When treated at suitable rates with certain wood vinegar and algae compositions, some types may display improved seed and straw output. Certain varieties, on the other hand, may not respond as well, resulting in varied outcomes, where the seed and straw yield, biological yield, and harvest index% are significant in both seasons, while pant height, number of seeds per plant, seed weight per plant, and weight of 100 seeds are no significant in two seasons, as seen in table 7.

Table 7. Effect of interaction between faba bean varieties and rates on yield and yield components of faba bean varieties under sandy soil.

Variety	Foliar Fertilizers		Plant Height (cm)	No. of seeds /plant	Seed weight /plant (g)	Weight of 100 seed (g)	Seed yield (ton/fed)	Straw yield (ton/fed)	Biological yield (ton/fed)	Harvest index (%)
2021/2022										
Giza-716	Control	F_1	78.50	25.33	38.66	85.56	1.67	1.60	3.27	51.07
	Algae	F_2	80.67	27.33	42.00	93.00	1.80	1.95	3.75	49.04
		F_3	83.00	28.67	44.33	99.30	1.91	2.14	4.05	47.13
		F_4	87.67	30.67	47.33	103.20	1.94	2.18	4.11	47.09
	Wood vinegar	F_5	92.00	33.33	52.00	105.60	1.96	1.96	3.92	50.00
		F_6	95.33	35.33	55.00	108.30	1.98	2.22	4.21	47.04
		F_7	99.67	36.67	61.00	115.00	2.04	2.27	4.31	46.71
Nubaria-2	Control	F_1	86.00	26.67	40.00	88.16	1.68	1.66	3.34	50.32
	Algae	F_2	94.00	29.33	44.30	98.01	1.91	2.43	4.34	44.05
		F_3	98.67	31.33	46.33	104.55	1.93	2.48	4.40	43.88
		F_4	103.33	34.00	48.33	108.28	1.95	2.52	4.47	43.76
	Wood vinegar	F_5	108.67	36.67	54.00	110.46	1.97	2.57	4.55	43.40
		F_6	113.00	38.33	57.00	113.88	2.00	2.62	4.62	43.26
		F_7	117.00	40.33	61.00	120.00	2.07	2.70	4.77	42.97
$LSD_{0.05}$			ns	ns	ns	ns	0.01	0.08	0.08	0.01
2022/2023										
Giza-716	Control	F_1	83.00	27.33	41.11	90.49	1.78	1.71	3.49	50.91
	Algae	F_2	85.67	29.33	44.65	98.36	1.98	2.08	4.06	49.23
		F_3	87.67	30.67	47.13	105.02	2.05	2.28	4.33	47.31
		F_4	92.67	33.33	50.32	109.15	2.08	2.32	4.40	47.25
	Wood vinegar	F_5	97.00	36.33	55.29	111.69	2.10	2.09	4.19	50.12
		F_6	100.33	38.33	58.48	114.55	2.13	2.38	4.51	47.19
		F_7	105.00	39.67	64.86	119.31	2.16	2.44	4.60	46.92
Nubaria-2	Control	F_1	91.00	28.67	42.53	93.24	1.80	1.71	3.51	50.39
	Algae	F_2	99.00	31.33	47.13	103.66	2.05	2.59	4.64	44.22
		F_3	103.67	34.33	49.26	110.57	2.08	2.64	4.71	44.06
		F_4	109.33	37.00	51.39	114.52	2.10	2.69	4.79	43.91
	Wood vinegar	F_5	114.67	39.67	57.41	116.83	2.11	2.74	4.86	43.51
		F_6	118.00	41.33	60.60	120.45	2.15	2.79	4.94	43.49
		F_7	122.00	43.33	64.86	125.37	2.19	2.88	5.07	43.16
	$LSD_{0.05}$		ns	ns	ns	ns	0.01	0.09	0.09	0.01

So, it is critical to undertake field trials and research experiments under specific local conditions to understand how faba bean types respond to wood vinegar, algae, and rates. Based on more current studies in your area, local agricultural specialists, research organizations, and extension agencies can give helpful recommendations and insights. For the best solutions adapted to your unique needs, always speak with agronomists or professionals with knowledge of faba beans and sustainable farming techniques.

Also, the pace at which fertilizer is applied affects faba bean growth. Finding the right fertilizer rate for a particular type of sandy soil is critical for minimizing waste and maximizing nutrient consumption by the plants. Nevertheless, the combination of different faba bean varieties, and treatment rates might provide unexpected results. For example, a certain variety may respond positively to a specific fertilizer type at a low application rate but negatively as the rate is increased. So, foliar application of algae or wood vinegar at all rates promotes most yield characteristics, including plant length, number of seeds per plant, and seed weight per plant, as well as straw and seed yield.

The findings also suggest that the higher the rate of application of algae or vinegar treatment, the greater the reaction to most biological yield and harvest index characteristics. Dalal *et al*., (2020) observed this impact of algae application rate and recommended that foliar spraying application of algae extracts at 4 ml/l under water stress is an effective approach for enhancing soybean yield. Where, many substances in wood vinegar promote crop growth, such as acids and phenol, the effect of hormones and all the substances that have a promoting effect in the wood vinegar or algae can generate a condition of balanced plant interaction that increases crop development from all angles and has a beneficial effect that exceeds the administration of a single plant hormone regulator (Cao *et al*., 2017). The interactions between faba bean varietals, algae, and wood vinegar treatments, as well as their rates, can be complicated and vary depending on the experimental settings.

The current study clearly showed that foliar spraying with wood vinegar and algae boosted faba bean plant growth, nutrient absorption, quality, and yield. where wood vinegar is a natural extension of cytokinins, proteins, nucleic acids, and chlorophyll (Kunmiao *et al*., 2021). The findings revealed that yield and yield components reacted to all interventions. When compared to the other treatments, the wood vinegar treatment produced the highest yield component values, such as average plant height, seed number, and weight of 100 seeds. Furthermore, wood vinegar suppressed the Nubaria-2 variety better than the Giza-716 variety. Thus, Pangnakorn *et al*., (2009) observed that foliar wood vinegar improved soybean yield in comparison to either the positive control or the negative control.

2. Quality characteristics

Variety defer

Data in Table 8 show that the application of algae and wood vinegar treatments enhanced phosphorus, potassium, protein, and total carbohydrates in the seeds of faba bean varieties. However, the extent of the effect may differ among varieties. The findings demonstrate that the Nubaria-2 cultivar outperformed the other cultivar in all quality characteristics in two seasons. The disparities in performance for growth qualities between the two cultivars may be linked to their genetic background, which had a significant effect in this respect. Some Faba bean varieties differ in their growth features, such as phosphorus, potassium, as well as protein percentages and total carbohydrates.

Table 8. Effect of foliar spraying with wood vinegar and algae on quality of faba bean varieties under sandy soil

Varieties	2021/2022				2022/2023			
	P	K	Protein	T. Carb	P	K	Protein	T. Carb
	(%)							
Giza-716	٠,١٤	٢,١٨	13.25	29.00	0..17	2.25	13.68	30.59
Nubarua-2	٠,١٦	2.51	14.16	33.09	0.19	2.58	14.58	34.90
$LSD_{0.05}$	0.01	0.0١	0.07	3.55	0.01	0.12	0.28	2.04

Simma *et al*., (2017) and Pangnakorn *et al*., (2009) had comparable results. The same data shows that there were significant changes in macro-element (N, P, and K) content, total carbohydrate percentage, and crude protein content amongst cultivars. Furthermore, the Nobaria-2 cultivar had the highest values for these chemical contents of the seeds. Hassanein *et al*., (2020) also observed differences in the chemical composition of different faba bean seed types.

Foliar spaying treatments

The data presented in Table 9 show the effect of foliar spraying at different rates on the quality characteristics of faba bean seeds. The application of algae and wood vinegar treatments, especially at optimal rates, may enhance protein synthesis and total carbohydrates in the seeds. However, the extent of the effect may differ among varieties, and application rates, but it is significant with the increase in fertilizer rates in both seasons. The findings revealed that foliar spraying rates had a considerable impact on the quality of faba bean seed. Where, the greatest rate provided P%, K%, protein%, and total carbohydrates% with a 4 ml/l (F_7) from the same rate of algae and wood vinegar. This impact might be attributed to the high density of the features investigated, which increases element absorption in two seasons, as seen in Table 9

While, Phosphorus (P) and Potassium (K) Content: Algae-based products and wood vinegar treatments can influence nutrient availability and uptake in faba bean plants. While, wood vinegar may enhance nutrient absorption from the soil. Proper treatment rates can promote better nutrient content in faba bean seeds, positively impacting yield quality. For that reason, the interaction between fertilizer rate and the K and P content is significant in both seasons. For the total carbohydrate content, factors like variety, climatic circumstances, and nutrient availability can all have an impact on the total carbohydrate content of faba bean seeds. While nitrogen-rich algae treatments may promote carbohydrate synthesis, wood vinegar may boost nutrient absorption, which may increase carbohydrate content.

The same data demonstrates that vinegar treatment greatly increased faba bean production more than algae treatment, as seen by a considerable rise in most of the yield quality characteristics. Many researchers (Mao *et al*., 2019) have found that vinegar treatment increases the concentration of macro elements (NPK), protein, and carbohydrates in seeds. The good effect of wood vinegar may be explained by the fact that it contains various beneficial components in suitable quantities that can boost crop development (Gu *et al*., 2020).

Table 9. Effect of foliar spraying with algae and wood vinegar treatments on quality of faba bean crop under sandy soil.

Foliar fertilizers		2021/2022				2022/2023			
		P	K	Protein	T. Carb	P	K	Protein	T. Carb
		(%)							
Control	F_1	0.12	1.95	11.73	25.16	0.15	2.01	12.10	26.55
Algae	F_2	0.14	2.30	12.90	27.00	0.17	2.38	13.32	28.48
	F_3	0.15	2.34	13.36	28.50	0.18	2.40	13.80	30.06
	F_4	0.16	2.35	13.83	30.50	0.19	2.41	14.29	32.17
Wood vinegar	F_5	0.16	2.40	14.27	33.66	0.19	2.47	14.73	35.51
	F_6	0.17	2.53	14.65	35,16	0.20	2.60	15.12	37.09
	F_7	0.19	2.58	15.20	37.33	0.22	2.65	15.83	39.38
$LSD_{0.05}$		0.01	0.03	0.15	0.94	0.01	0.02	0.21	1.56

Foliar spaying interaction

The data in Table 10 reveal that the interaction between varieties and rates of foliar spraying has a positive effect on the quality characteristics when the rate of application is gradually increased. The data in the same table reveal that the maximum chemical contents of the seeds were obtained by the Nubaria-2 variety under high levels of foliar spraying.

Regarding the interaction between varieties and rate of application, it is clear from the data presented in Table 10 that most quality characteristics are positively affected by either algae or wood vinegar treatment as the rate of application is gradually increased. It is interesting to see the advantage of vinegar treatment over algae treatment at all concentrations. where the highest value of seed quality were obtained in Nubaria-2 variety from foliar spraying at a rate of 4 ml/l (F_7) with wood vinegar treatment in both seasons

In this regard, Nurhayati *et al*., (2005) showed that a 3-5% concentration of wood vinegar considerably enhanced quality characteristics. Kunmiao *et al*., (2021) recently stated that wood vinegar may be viewed as a compound plant growth regulator analog and that wood vinegar has a good effect on crops when used at the recommended dosage. The encouraging impact of algae rate was reported by Reda *et al*., (2020), who showed that foliar spraying with algae at 8 g/l generated good yields and high NPK, crude protein, and total carbohydrate content in seed.

Table 10. Effect of interaction between faba bean varieties and rates on quality of faba bean crop under sandy soil.

Variety	Foliar Fertilizers		20212022				2022/2023			
			P	K	Protein	T. Carb	P	K	Protein	T. Carb
			(%)							
Giza-716	Control	F_1	0.12	1.95	11.73	25.16	0.14	1.94	11.96	25.32
	Algae	F_2	0.14	2.13	12.48	26.33	0.17	2.18	12.88	27.78
		F_3	0.15	2.16	12.94	27.33	0.18	2.21	13.38	28.83
		F_4	0.15	2.21	13.25	28.33	0.18	2.27	13.69	29.88
	Wood vinegar	F_5	0.16	2.26	13.75	30.67	0.19	2.32	14.19	32.34
		F_6	0.15	2.31	14.13	32.00	0.18	2.37	14.56	33.75
		F_7	0.17	2.37	14.67	34.33	0.21	2.43	15.17	36.22
Nubaria-2	Control	F_1	0.13	2.01	11.88	26.33	0.15	2.06	12.25	27.78
	Algae	F_2	0.14	2.51	13.33	27.67	0.17	2.57	13.77	29.18
		F_3	0.17	2.54	13.79	29.67	0.20	2.60	14.23	31.29
		F_4	0.16	2.60	14.42	32.67	0.19	2.66	14.90	34.46
	Wood vinegar	F_5	0.18	2.43	14.79	36.67	0.21	2.49	15.29	38.68
		F_6	0.17	2.75	15.19	38.33	0.20	2.82	15.69	40.43
		F_7	0.20	2.79	15.73	40.33	0.23	2.86	16.00	42.55
$LSD_{0.05}$			ns	0.06	0.23	1.37	ns	0.04	0.75	1.45

Economic Feasibility

The effects of foliar spraying wood vinegar and algae on the net return, gross income, and total cost of two faba bean varieties are shown in Table 11. The faba bean cultivars with the highest net return values were found to be those treated with a 4 ml/L spray of wood vinegar and algae. Plants in the control group that were not treated with wood vinegar or algae yielded the least significant outcomes.

Foliar spraying faba bean plants at a rate of 4 ml/l with algae or wood vinegar enhanced net yield by 16%, 19%, and 20%, respectively, compared to the control without spraying algae or wood vinegar for both cultivars Giza -716 and Nubaria-2. The net return ranged between (44840, 46120 L.E.) and (47040, 48480 L.E./fed) in varieties Giza -716 and Nubaria-2, with the highest significant values recorded in the case of 4 ml/l with plants foliar sprayed with algae and wood vinegar and the lowest in the case of control without foliar spraying wood vinegar.

Table 11. Economic feasibility of foliar spraying with algae and wood vinegar fertilizers on seed and straw yield of faba bean varieties under sandy soil average of two years.

Varieties	Fertilizers Type	Feddan costs(L.E)	Foliar Fert. Price(L.E)	Seed yield	Price (L.E)	Straw yield	Price (L.E)	Total income	Net return
Giza -716	No fertilizers	2500	0.0	1.72	34400	1.72	6880	41280	38780
	Algae	2500	900	1.98	39600	2.16	8640	48240	44840
	Wood vinegar	2500	1500	2.06	41200	2.23	8920	50120	46120
Nubaria-2	No fertilizers	2500	0.0	1.74	34800	1.72	6880	41680	39180
	Algae	2500	900	2.01	40200	2.56	10240	50440	47040
	Wood vinegar	2500	1500	2.08	41600	2.72	10880	52480	48480

Algae= 300 L.E/liter Wood vinegar= 500L.E/liter Seed yield = 20 L.E/Kg Straw yield = ٤.00 L.E/Kg

CONCLUSION

Based on the findings, it can be concluded that foliar spraying treatment of either algae or wood vinegar has a mimicking impact on faba bean production, with the effect being more obvious at higher levels of application. Finally, the use of algae or wood vinegar not only increases faba bean output, but also quality, as seen by high macro element, protein, and carbohydrate content. As a result, it can aid in the attainment of sustainability goals in newly sandy soils.

Overall, these studies suggest that the dose of algae or wood vinegar applied beneath sandy soil is crucial for obtaining the advantages. These data indicate that foliar spraying with a rate 4 ml/l wood vinegar produced the highest yield, yield components and seeds quality.

List of abbreviations

N	Nitrogen	pH	hydrogen ion buffer
P	Phosphorus	Na	Sodium
K	Potassium	Mg	Magnesium
Ca	Calcium	CO_3	Carbon trioxide or Carbonate
T. Cab.	Total carbohydrates	HCO_3	Bicarbonate Calcium
O.M	Organic matter	Cl	Chloride
Fed	feddan	SO_4	Sulphate
L.E.	Egyptian pound	O.C	Organic Carbon
E.C	Electrical conductivity	WV	Wood Vinegar

Consent for publication

The authors declare that the work has consent for publication.

Competing interests

The authors have no competing interests to declare relevant to this article's content.

Author contributions

Authors R.E and A.A: Data analysis, results interpretation, final editing and proofreading of the paper, checking for consistency, and citation guidelines. Authors A.T and S.E: literature review, and methodology, initial data analysis. All authors read and approved the final manuscript.

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تعظيم إنتاجية بعض أصناف الفول البلدي بالرش بخل الخشب والطحالب تحت ظروف الأراضي الرملية

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الملخص

زيادة إنتاجية الغذاء احد أهم المتطلبات لتلبية الطلب المتزايد عليه. لذلك، كان الهدف من هذه الدراسة هو دراسة تأثير الرش الورقي بالطحالب وخل الخشب على المحصول وجودته لبعض أصناف الفول البلدي تحت ظروف الأراضي الرملية خلال موسمي الشتاء (٢٠٢١/٢٢، ٢٠٢٢/٢٣).أظهرت النتائج أن الرش الورقي بخل الخشب والطحالب كان لهما تأثير ايجابي على مؤشرات المحصول والجودة لأصناف الفول البلدي، وأوضحت النتائج أيضا أن صنف نوبارية-٢ تفوق علي صنف حيزة -٧١٦ في معظم الصفات المدروسة. أيضا، الرش الورقي بمعدل ٤ مل/لتر بخل الخشب والطحالب كان له تأثير ايجابي من المعدلات الأخرى في المحصول ومكوناته، الفوسفور، البوتاسيوم، والبروتين والكربوهيدرات الكلية لكلا من صنفي الفول البلدي في الموسمين. كذلك جميع معاملات الرش الورقي بخل الخشب والطحالب كان لها تأثيرات ايجابية علي محصول البذور لأصناف الفول البلدي وجودتها الغذائية. وكان لنتائج الدراسة آثار مهمة على زراعة الفول البلدي في الأراضي الرملية الحديثة، مما يوفر رؤى جديدة حول التقنيات الحديثة للزراعة المستدامة والصديقة للبيئة. مما يساهم في الأمن الغذائي.كشفت النتائج التي تم الحصول عليها تفوق صنف نوبارية-٢ علي صنف حيزة- ٧١٦ في المحصول ومكوناته، الرش الورقي بمعدل ٤ مل/لتر بخل الخشب أعطي أفضل النتائج من المعدلات الأخرى.