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Original Research

The Promoting Effect of Potassium Fertilization, Yeast Extract, Algae Extract and Molasses as Foliar Applications on Shedding Percentage and Yield Characters of Faba Bean Cultivars

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Abstract

Two field experiments were carried out to evaluate shedding (%), yield, and its components of three faba bean cultivars (Nubaria 4, Nubaria 5, and Giza 716) under growth-promoting treatments (potassium as a foliar and soil application, yeast extract, algae extract, and molasses) in the 2022/23 and 2023/24 seasons. The results showed that shedding %, number of flowers, total chlorophyll content, yield, and yield components were meaningfully augmented by applying molasses and potassium (K) as foliar treatment compared to the control in both seasons, except for straw yield (kg fed^{-1}) and shedding %. The cultivars were meaningfully varied for all studied characters, where Giza 716 was the best cultivar for all vegetative characters and yield components as compared to the other cultivars under study, while Nubaria 4 recorded the highest shedding %. Furthermore, the interaction between K treatments, natural extracts, and faba bean cultivars led to significant increases in yield

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components in both seasons. In general, applying molasses and foliar treatment with potassium was the best treatment for the maximum yield of faba bean plants (Giza 716 cultivar).

Keywords: faba bean, potassium, yeast, algae extract, molasses.

Introduction

The faba bean is a significant economic crop from the *Fabaceae* family. Many experiments were performed to increase the yield of Fabaceae plants like faba bean [1-3], soybean [4, 5], and common bean [6]. Yield production is affected by several factors, such as the fertility of soil and varieties, and environmental factors, such as drought [7-9] and salinity [10-12]. Many researchers have reported high variability among genotypes for growth characters and yield [13]. Faba bean seeds have some important organic components, such as proteins and carbohydrates; most proteins comprise globulins and albumins [14].

Potassium is a vital plant element and plays a pivotal role under drought conditions [15]. It is involved in many important physiological processes, such as oxidative stress, photosynthesis, and activation of enzymes [16-19]. Potassium plays an important role in many plants, such as rice [19], sweet potato [20], and sugar beet [21], through its important role in cell osmotic pressure and balancing the cations and anions in the cytoplasm. Also, potassium can regulate stomatal movement, cell elongation, yield, and fruit quality [22].

Potassium deficiency in the initial growth stage significantly disturbs the assimilation between above-ground organs and roots and also leads to an increase in the concentration of anti-nutritional factors in pulse seeds [23, 24]. Furthermore, K is an essential element involved in several physiological pathways, particularly maintaining active transport, enzyme activity, cell development, storage of assimilates, and other functions [23, 25]. Additionally, K is a very important element under water stress due to its role in turgor pressure and metabolic activity [16]. Many physiological and biochemical reactions require adequate potassium for successful legume growth and production [14, 26].

Broad bean plants face many problems during growth stages; one of the most complicated problems, which results in consequent loss in yield production, is the high rate of flower abscission [27-29]. This study aimed to examine the yield, yield components, and chemical constituents of three faba bean varieties under foliar application of potassium and natural extracts: yeasts, algae, and molasses.

Materials and Methods

This investigation was conducted under delta soil conditions in Kafr Elsheikh (latitude 31° 6’ 22.75”N and longitude 30° 56’ 31.11”E), Egypt, in the 2022/23 and 2023/24 seasons to study the effect of potassium fertilization and natural extracts as foliar applications at different growth stages on yield and yield components as well as the shading percentage of three *Vicia faba* L. cultivars. The factors under study were as follows:

Potassium Fertilization Treatments

Six treatments were included (control (distilled water) – K (foliar) – K (soil) – yeast extract – algae extract – molasses).

The foliar potassium application was added at 12.5 ml/liter as extra potassium (36% K_2O) in three equal doses at 40, 60, and 80 days after sowing (the amount of spray water in each spray was 20 liters/plot). Meanwhile, the soil potassium application was added at 50 kg/fed as potassium sulfate (48% K_2O) for two equal doses at 40 and 80 days after sowing, before the first and second irrigation. On the other hand, the yeast extract was added at the rate of 50 g/liter, the algae extract foliar application was added at the rate of 5 ml/liter, and the molasses foliar application was added at the rate of 25 ml/liter as a natural extract for three equal doses at 40, 60, and 80 days after sowing.

Cultivars

Nubaria 4, Nubaria 5, and Giza 716. The cultivars were obtained from the Field Crop Research Institute, ARC. Before planting faba bean genotypes, samples were taken from plots for soil analysis (0-30 cm), air-dried, ground, and sieved through a 2 mm mesh sieve. Mechanical and chemical analyses were performed, and the results are presented in Table 1.

Experimental Design

The experimental design was a split plot with four replications; the potassium and natural extracts foliar application treatments were allocated to the main plots, and the three faba bean varieties were randomly arranged in the subplots (10.5 m^2).

Cultural Practices

Calcium superphosphate (15.5%) was applied during land preparation at a rate of 31 kg P_2O_5 fed^{-1}. Planting was carried out on 16th Nov. in the 2022/23 season and on 6th Nov. in the 2023/24 season. Nitrogen at a rate of 20 kg N fed^{-1} as urea (46.5% N) was divided into two doses and applied at the planting date and before the first irrigation in both seasons.

Table 1. Mechanical and chemical properties of the investigated soil samples.

Soil characteristics	2022/23 season	2023/24 season
Mechanical analysis:		
Coarse sand %	5.15	5.23
Fine sand %	24.18	24.36
Silt %	20.31	20.41
Clay %	50.36	50.00
Textural class	Clay	Clay
Chemical analysis:		
pH (1:2.5)	7.76	7.22
Ca Co_3 %	3.20	3.50
Organic matter%	1.70	1.79
EC (dSm^{-1})*	1.75	1.85
Total N%	0.13	0.14
Total P%	1.37	1.42
Total K%	0.49	0.53

*Soil paste extract

Data Recorded

Physical and Chemical Analyses of Soil

Physical and chemical analyses of the soil were determined (Table 1).

Chemical Properties of Algae, Yeast, and Molasses

Ten plants were taken at harvest from the central ridge of each experimental plot to estimate the following characteristics:

Vegetative Growth Characteristics

Shedding (%): calculated as follows:

$$\text{Shedding (\%)} = \frac{\text{number of total flowers - number of total maturity pods} \times 100}{\text{number of total flowers}}$$

Total number of flowers: calculated by counting all flowers on the main faba bean stem.

Total chlorophyll content: chlorophyll content was estimated by chlorophyll meter (SPDS) [30].

Yield Components

Number of pods per $plant^{-1}$ - pod weight per $plant^{-1}$ (g) - seed weight per $plant^{-1}$ (g) - number of branches per $plant^{-1}$.

Yield

Biological yield (kg fed^{-1}): estimated on the whole subplot basis.

Straw yield (kg fed^{-1}): determined by the difference between biological and seed yields.

Statistical Analysis

The analysis of variance was conducted after ensuring the validity of the Partlet test according to Snedecor and Cochran [31]. The LSD test at the 5% level was used in the mean comparison.

Results and Discussions

Vegetative Growth Characteristics

Results in Tables (2, 3, and 4) show the effects of potassium fertilization and natural extracts (yeasts, algae, and molasses), varieties, and their interaction on vegetative growth characteristics of faba bean plants in the 2022/23 and 2023/24 seasons.

Effect on Shedding (%)

The impact of potassium fertilization and natural extracts on the shedding % of the grown faba bean cultivars during both seasons is presented in Table 2. Shedding % could be ranked in the following descending order: C1 (Nubaria 4), C2 (Nubaria 5), followed by C3 (Giza 716). The respective shedding % were 70.2, 62.4, and 57.2% in the first season and 63.2, 58.2, and 54.6% in the second season, respectively. These results agree with Mohamed et al. [32] and Zewail [29]. It could be generally noted that C1 (Nubaria 4) gave the highest shedding % over the applied fertilization treatments, while C3 (Giza 716) gave the lowest. C2 (Nubaria 5) came halfway in the shedding % (Table 2). These results align with Mohamed et al. [32] and Zewail [29]. The differences in shedding % in cultivars were due to their specific genetic makeup, which interacted differently with the prevailing environmental conditions. Results in Table 2 indicated that potassium fertilization and natural extracts caused a significant decrease in shedding % compared to the control. The application of molasses produced a shedding % of 51.4% compared to the control in the first season; the shedding % of the second season was 50.9%. Such a result was noticed in both growing seasons (Table 2). In descending rank order in shedding % was: Control (74.5) > Yeasts (66.6) > K soil (66.5) > Algae (64.2) > K foliar (56.3) > Molasses (51.4%) in the first season, and Control (69.8) > Algae (62.9) > Yeasts (60.7) > K soil (57.2) > Molasses (50.9) > K foliar (50.7%) in the second season, respectively (Table 2). Similar results were also reported by Pyke et al. [33] and Badawy et al. [34].

The interaction impact on shedding % was significant, as presented in Table 2. The highest shedding % was noticed for Nubaria 4 (C1) compared to the control (without). The obtained shedding % was 80.9 and 73.2% in the first and second growing seasons, respectively. The lowest shedding % was for Giza 716 (C3), producing 41.6% in the first season and 43.8% in the second season when receiving molasses (Table 2). This result may be due to the role of molasses in improving growth characteristics and, consequently, decreasing the shedding %. The obtained results agreed with Mohamed et al. [35] and Abdel-Aziz et al. [36].

Impact on the Number of Flowers per Plant^{-1}

Table 3 shows the effects of potassium fertilization and natural extracts (yeasts, algae, and molasses), cultivars, and their interaction on the total number of flowers in the 2022/23 and 2023/24 seasons. In this respect, Table 3 indicated significant differences between the studied cultivars in the total number of flowers in both seasons. Nubaria 5 cultivar recorded the highest total number of flowers (1300.3 per plant^{-1}), followed by Giza 716 cultivar (1252.6 flowers per plant^{-1}), then Nubaria 4 cultivar (1067.5 flowers per plant^{-1}) in the first season. Corresponding to the Giza 716 cultivar (1139.1 flowers per plant^{-1}), then the Nubaria 5 cultivar (1115.5 flowers per plant^{-1}) followed by the Nubaria 4 cultivar (866.6 flowers per plant^{-1}) in the second season, respectively. This result reflects the specific genetic structure of each cultivar under study as affected by the environmental conditions. These results align with the findings of Mohamed et al. [32] and Zewail [29].

Regarding faba bean cultivars, the values of potassium fertilization and natural extract treatments showed significant differences in both seasons (Table 3). Application of potassium gave the highest number of flowers (1402.9 and 1255.0 flowers per plant^{-1}) in the 1st and 2nd seasons, with significant differences in magnitudes compared to the control. Meanwhile, the lowest total number of flowers was produced from the addition of algae extract treatment, which was (913.2 and 940.4 flowers per plant^{-1}) in both seasons, respectively, compared to the control. Other treatments were in between during both growing seasons (Table 3). Similar results were also reported by Pyke et al. [33] and Badawy et al. [34]. The effect of the interaction between

Table 2. Effect of potassium fertilization and natural extracts on shedding (%) of faba bean plants during the 2022/23 and 2023/24 seasons.

Fertilization (F)	2022 / 2023 season			
	Cultivars (C)			
	Nubaria 4	Nubaria 5	Giza 716	Means
Control	80.9	73.5	69.2	74.5
K (Soil)	74.4	61.2	64.0	66.5
K (Foliar)	63.7	55.3	50.1	56.3
Yeast extract	71.5	67.3	61.1	66.6
Algae extract	70.8	64.6	57.2	64.2
Molasses	60.2	52.5	41.6	51.4
Means	70.2	62.4	57.2	
L.S.D at 5% for:	F = 2.71, C = 3.42 and FC = 6.47			
Fertilization (F)	2023 / 2024 season			
	Cultivars (C)			
	Nubaria 4	Nubaria 5	Giza 716	Means
Control	73.2	68.2	68.2	69.8
K (Soil)	63.2	58.4	50.1	57.2
K (Foliar)	54.9	48.9	48.4	50.7
Yeast extract	64.1	60.6	57.4	60.7
Algae extract	65.5	63.1	60.2	62.9
Molasses	58.7	50.2	43.8	50.9
Means	63.2	58.2	54.6	
L.S.D at 5%	F = 2.18, C = 2.85 and FC = 5.53			

potassium fertilization, natural extract application, and cultivars was significant on the total number of flowers of faba bean in both seasons (Table 3). The highest total number of flowers of faba bean plants (1862.1 and 1379.8 flowers per plant^{-1}) was obtained with the Giza 716 cultivar when fertilized with algae extract and K (foliar) in both seasons, respectively. The lowest total number of flowers per plant^{-1} of faba bean plants (804.3 and 809.7 flowers per plant^{-1}) was obtained with the Nubaria 4 cultivar when fertilized with algae extract and K (soil) application in the first and second seasons, respectively. The obtained results agreed with the recorded results of Mohamed et al. [35] and Abdel-Aziz et al. [36].

Effect on Total Chlorophyll Content

Data in Table 4 show potassium fertilization and natural extracts (yeasts, algae, and molasses), faba bean cultivars, and their interaction with the total chlorophyll content in the 2022/23 and 2023/24 seasons. In this respect, the results recorded in Table 4 indicated significant differences between the studied cultivars in total chlorophyll in both seasons. Giza 716 cultivar recorded the highest total chlorophyll content (46.0 and 45.2), followed by Nubaria 5 (42.0 and 42.9) in the first and second seasons, respectively. The lowest contents were recorded with Nubaria 4 (40.1 and 41.3) in both seasons, respectively, as shown in Table 4. These results are in agreement with those obtained by Zewail [29]. Regarding natural extracts, molasses application treatment produced the highest total chlorophyll content (44.9 and 45.9) in both seasons, with significant differences in magnitudes compared to the control. Meanwhile, the lowest total chlorophyll content was produced from adding algae extract treatment (41.2 and 41.7) during both growing seasons, respectively, as compared to the control. Similar results were also reported by Pyke et al. [33] and Badawy et al. [34].

Concerning the impact of the interaction between potassium fertilization and natural extracts (yeasts, algae, and molasses), the varieties significantly affected the total chlorophyll content in both seasons (Table 4). The maximum total chlorophyll content (48.5 and 48.7) was obtained with the Giza 716 cultivar when fertilized with K (foliar) and molasses in both seasons, respectively. The lowest total chlorophyll content

Table 3. Effect of potassium fertilization and natural extracts on the number of flowers per faba bean plant during the 2022/23 and 2023/24 seasons.

Fertilization (F)	2022 / 2023 season			
	Cultivars (C)			
	Nubaria 4	Nubaria 5	Giza 716	Means
Control	764.3	1128.3	1071.4	988.0
K (Soil)	1194.4	1369.3	1627.7	1397.1
K (Foliar)	1373.5	1444.5	1390.7	1402.9
Yeast extracts	1112.2	1382.2	1167.0	1220.4
Algae extracts	804.3	1073.4	1862.1	913.2
Molasses	1156.5	1404.2	1397.2	1319.3
Means	1067.5	1300.3	1252.6	
L.S.D at 5% for:	F = 77.4 , C = 117.9 and FC = 188.73			
Fertilization (F)	2023 / 2024 season			
	Cultivars (C)			
	Nubaria 4	Nubaria 5	Giza 716	Means
Control	563.4	915.0	988.3	822.2
K (Soil)	809.7	1047.7	1110.2	989.2
K (Foliar)	1144.1	1241.2	1379.8	1255.0
Yeast extracts	922.0	1136.3	1000.0	1019.4
Algae extracts	738.2	1098.3	984.9	940.4
Molasses	1022.5	1255.0	1371.8	1216.4
Means	866.6	1115.5	1139.1	
L.S.D at 5%	F = 64.12, C = 96.82 and FC = 164.44			

Table 4. Effect of potassium fertilization and natural extracts on total chlorophyll content in faba bean plants during the 2022/23 and 2023/24 seasons.

Fertilization (F)	2022 / 2023 season			
	Cultivars (C)			
	Nubaria 4	Nubaria 5	Giza 716	Means
Control	36.8	40.5	42.1	39.8
K (Soil)	43.8	44.1	47.9	45.3
K (Foliar)	39.7	42.2	48.5	43.5
Yeast extract	39.4	41.4	44.4	41.7
Algae extract	38.9	40.9	43.9	41.2
Molasses	42.1	43.3	49.5	44.9
Means	40.1	42.0	46.0	
L.S.D at 5% for:	F = 0.66, C = 1.24 and FC = 1.52			
Fertilization (F)	2023 / 2024 season			
	Cultivars (C)			
	Nubaria 4	Nubaria 5	Giza 716	Means
Control	37.9	41.6	42.9	40.8
K (Soil)	42.5	42.9	45.8	43.7
K (Foliar)	41.2	43.4	47.1	43.9
Yeast extract	42.5	42.5	42.4	42.5
Algae extract	39.2	41.8	44.1	41.7
Molasses	44.2	44.9	48.7	45.9
Means	41.3	42.9	45.2	
L.S.D at 5% for:	F = 1.03, C = 1.12 and FC = 1.47			

in faba bean plants (39.7 and 39.2) was obtained from the Nubaria 4 cultivar with K (foliar) and algae extract application in both seasons, respectively. These results may be due to the positive role of K (foliar) and algae extract in improving chlorophyll content. The same results were recorded with those of Mohamed et al. [35] and Abdel-Aziz et al. [36].

Effect on Yield Components

Number of Pods Per Plant^{-1}

Table 5 shows the effects of potassium fertilization and natural extracts (yeasts, algae, and molasses), cultivars, and their interaction on the number of pods per plant^{-1} in the 2022/23 and 2023/24 seasons. The tested faba bean cultivars exerted significant differences in number of pods per plant^{-1} in both seasons (Table 5). In this respect, the results clearly indicate that the Giza 716 cultivar recorded was superior in the number of pods per plant^{-1} (54.61 and 52.83 pods per plant^{-1}) in both seasons, respectively. The lowest levels were those of the Nubaria 4 cultivar (32.79 and 32.89 pods per plant^{-1}) in both seasons, respectively. Nubaria 5 produced values in between (Table 5). The same results were observed by Mohamed et al. [32] and Zewail [29].

Regarding the natural extracts, the values of potassium fertilization and natural extract treatments that showed significant differences in both seasons are presented in Table 5. Molasses application treatment produced the highest number of pods per plant^{-1} (64.79 and 60.61 pods per plant^{-1}) in both seasons, with significant differences in magnitudes compared to the control. Meanwhile, the lowest number of pods per plant^{-1} was produced from spraying of algae extract treatment, which was (32.95 and 35.07 pods per plant^{-1}) in both seasons, respectively, compared to the control. Other treatments produced means in between, as presented in Table 5. Similar results were recorded by Mohamed et al. [35], Abdel-Aziz et al. [36], and Abou-Husssien et al. [37].

In this respect, the impact of the interaction between potassium fertilization, natural extract application, and the studied cultivars was significant on the number of pods per plant^{-1} in both seasons (Table 5). However, the highest number of pods per plant^{-1} of faba bean plants

Table 5. Effect of potassium fertilization and natural extracts on the number of pods per plant^{-1} during the 2022/23 and 2023/24 seasons.

Fertilization (F)	2022 / 2023 season			
	Cultivars (C)			
	Nubaria 4	Nubaria 5	Giza 716	Means
Control	14.66	29.90	33.00	25.86
K (Soil)	30.50	53.13	58.60	47.41
K (Foliar)	49.86	64.57	69.37	61.28
Yeast extract	31.70	45.20	45.40	40.77
Algae extract	23.96	37.93	36.93	32.95
Molasses	46.04	66.70	81.63	64.79
Means	32.79	49.57	54.61	
L.S.D at 5% for:	F = 3.61, C = 4.16 and FC = 7.31			
Fertilization (F)	2023 / 2024 season			
	Cultivars (C)			
	Nubaria 4	Nubaria 5	Giza 716	Means
Control	15.10	29.10	31.43	37.34
K (Soil)	29.83	44.73	55.40	43.32
K (Foliar)	51.63	68.43	71.23	63.77
Yeast extract	33.10	45.00	42.60	40.23
Algae extract	25.47	40.53	39.20	35.07
Molasses	42.23	62.50	77.10	60.61
Means	32.89	48.38	52.83	
L.S.D at 5% for:	F = 3.72, C = 3.62 and FC = 6.65			

(81.63 and 77.10 pods per plant^{-1}) was obtained from the Giza 716 cultivar when fertilized with molasses in both seasons, respectively. The lowest number of pods per plant^{-1} of faba bean plants (23.96 and 25.47 pods per plant^{-1}) was obtained from the Nubaria 4 cultivar when spraying algae extract in both seasons, respectively. This result may be due to the helpful role of molasses in improving growth features and, consequently, increasing the number of pods per plant^{-1}. The results agreed with those recorded by Mohamed et al. [35] and Abdel-Aziz et al. [36].

Pods Weight Plant^{-1}

Data in Table 6 present that (over potassium fertilization and natural extracts), the tested faba bean cultivars exerted significant differences in pod weight per plant^{-1} in both seasons (Table 6). In this respect, the results show clearly that the Giza 716 cultivar recorded superiority in the weight of the pods per plant^{-1} (209.63 and 186.91 g) in both seasons, respectively. The lowest values were those of the Nubaria 4 cultivar (130.24 and 125.97 g) in both seasons, respectively. Nubaria 5 produced values in between, as presented in Table 6. These results are in agreement with the recorded results of El-Emary and Amer [38], Anish et al. [39], and Al-Zubaidy [40]. Regarding the natural extracts, the values of potassium fertilization and the natural extract treatments showed significant differences in both seasons and are presented in Table 6.

Molasses spraying treatment gave the heaviest weight of pods per plant^{-1} (232.12 and 217.65 g) in both seasons, with significant differences in magnitudes compared to the control. Meanwhile, the minimum weight of pods per plant^{-1} was produced from spraying of algae extract treatment, which was (125.73 and 115.60 g) in both seasons, respectively, compared to the control. Other treatments produced means in between, as presented in Table 6. The interaction effect between potassium fertilization, natural extracts spraying, and cultivars was significant in the weight of pods per plant^{-1} in both seasons (Table 6). The heaviest weight of pods per plant^{-1} of faba bean plants (301.05 and 268.52 g) was obtained from the Giza 716 cultivar when fertilized with molasses in both seasons, respectively. The lowest weight of pods per plant^{-1} of faba bean plants (88.08 and 82.49 g) was obtained from the Nubaria 4 cultivar when spraying algae extract in both seasons, respectively.

Table 6. Effect of potassium fertilization and natural extracts on the weight of pods per plant^{-1} of faba bean plants during the 2022/23 and 2023/24 seasons.

Fertilization (F)	2022 / 2023 season			
	Cultivars (C)			
	Nubaria 4	Nubaria 5	Giza 716	Means
Control	73.05	95.10	134.45	100.86
K (Soil)	149.01	173.00	221.00	181.00
K (Foliar)	186.00	201.14	266.14	217.76
Yeast extract	113.32	143.15	181.05	145.84
Algae extract	88.08	135.00	154.13	125.73
Molasses	172.02	223.30	301.05	232.12
Means	130.24	161.78	209.63	
L.S.D at 5% for:	F = 20.116, C = 14.658 and FC = 26.632			
Fertilization (F)	2023 / 2024 season			
	Cultivars (C)			
	Nubaria 4	Nubaria 5	Giza 716	Means
Control	68.40	98.84	122.54	96.59
K (Soil)	132.57	169.02	194.65	165.41
K (Foliar)	200.74	230.41	231.54	220.89
Yeast extract	102.12	121.16	162.57	128.61
Algae extract	82.49	122.64	141.69	115.60
Molasses	169.53	214.92	268.52	217.65
Means	125.97	159.49	186.91	
L.S.D at 5% for:	F = 18.953, C = 21.58 and FC = 31.82			

These findings could be attributed to the supportive role of molasses in improving number of pods per plant^{-1} and consequently increasing the weight of pods per plant^{-1}. Similar findings were reported by Pyke et al. [33] and Hassan et al. [41].

Seed Weight Per Plant^{-1}

The presented results in Table 7 showed the effects of potassium fertilization and natural extracts (yeasts, algae, and molasses), varieties, and their interaction on the weight of seeds per plant^{-1} (g) of faba bean plants in the 2022/23 and 2023/24 seasons. The studied faba bean cultivars showed significant differences in the weight of seeds per plant^{-1} in both seasons (Table 7). The Giza 716 cultivar was superior in seed weight per plant^{-1} (85.02 and 79.09 g) in both seasons, respectively. The minimum values were recorded with the Nubaria 4 cultivar (53.59 and 52.53 g) in both seasons, respectively. Nubaria (5) produced values in between, as presented in Table 7. Similar results were recorded with Zewail [29] and El-Katony et al. [42]. Concerning potassium fertilization, natural extract treatments showed significant differences in the first and second seasons, as presented in Table 7.

Molasses spraying treatment produced the heaviest weight of seeds per plant^{-1} (99.78 and 90.72 g) in the first and second seasons, with significant differences in magnitudes compared to the control. Meanwhile, the lowest weight of seeds per plant^{-1} was produced from spraying of algae extract treatment, which was (48.32 and 47.95 g) in both seasons, respectively, compared to the control. Other treatments produced means in between, as presented in Table 7. Similar results were also observed by Mohamed et al. [35], Abdel-Aziz et al. [39], Pyke et al. [33], and Badawy et al. [34]. The interaction effect between potassium and amino acid application and the studied faba bean cultivars significantly affected the weight of seeds per plant^{-1} of faba bean in both seasons (Table 7). However, the heaviest seed weight per plant^{-1} (123.28 and 115.76 g) was obtained with the Giza 716 cultivar when fertilized with molasses in both seasons, respectively. The lowest weight of seeds per plant^{-1} of faba bean plants (36.66 and 34.41 g) was obtained with the Nubaria 4 cultivar when fertilized with algae extract application in both seasons,

respectively. These results are in agreement with the results of Mohamed et al. [35], Abdel-Aziz et al. [36], and El-Gamal et al. [43].

Number of Branches Per Plant^{-1}

The tested faba bean cultivars exerted significant differences in the number of branches per plant^{-1} in both seasons (Table 8). In this respect, the results indicate clearly that the Giza 716 cultivar recorded the maximum number of branches per plant^{-1} (6.18 and 6.14 branches per plant^{-1}) in both seasons, respectively. The minimum number was recorded with the Nubaria 4 cultivar (3.71 and 3.83 branches per plant^{-1}) in both seasons, respectively. These results are in agreement with those obtained by Mohamed et al. [32], Zewail [29], and Sary et al. [44]. The mean values of potassium fertilization and natural extract treatments showed significant differences between both seasons and are presented in Table 8.

Molasses application treatment gave the maximum number of branches per plant^{-1} (7.33 and 7.05 branches per plant^{-1}) in both seasons with significant differences in magnitudes compared to the control. Meanwhile, the lowest number of branches per plant^{-1} was produced from spraying algae extract treatment (3.83 and 4.08 branches per plant^{-1}) in both seasons, respectively, compared to the control. This result was in accordance with Mohamed et al. [35], Abdel-Aziz et al. [36], and Anish et al. [39].

The effect of the interaction between potassium fertilization, natural extract application, and cultivars was significant on the number of branches per plant^{-1} in both seasons (Table 8). The maximum number of branches per plant^{-1} of faba bean plants (9.23 and 8.97 branches per plant^{-1}) was obtained with the Giza 716 cultivar when fertilized with molasses in both seasons, respectively. The lowest number of branches per plant^{-1} of faba bean plants (2.71 and 2.96 branches per plant^{-1}) were recorded in the Nubaria 4 cultivar with the algae extract application in both seasons, respectively. This positive effect of algae extract may be because algae extract contains some important components, such as amino acids, that play an important role in improving the number of branches per plant$^{-1.}$ The results agreed with those obtained by Mohamed et al. [35] and Abdel-Aziz et al. [36].

Table 7. Effect of potassium fertilization and natural extracts on seed weight per plant^{-1} (g) during the 2022/23 and 2023/24 seasons.

Fertilization (F)	2022 / 2023 season			
	Cultivars (C)			
	Nubaria 4	Nubaria 5	Giza 716	Means
Control	29.26	38.02	50.78	39.35
K (Soil)	61.21	70.96	93.52	75.23
K (Foliar)	76.02	81.02	115.78	90.94
Yeast extract	47.11	63.08	69.37	59.85
Algae extract	36.66	50.92	57.38	48.32
Molasses	71.28	104.79	123.28	99.78
Means	53.59	68.13	85.02	
L.S.D at 5% for:	F = 6.16, C = 4.18 and FC = 9.14			
Fertilization (F)	2023 / 2024 season			
	Cultivars (C)			
	Nubaria 4	Nubaria 5	Giza 716	Means
Control	26.59	37.28	47.62	37.15
K (Soil)	54.29	65.56	77.21	65.69
K (Foliar)	84.71	89.63	102.86	92.39
Yeast extract	45.62	57.77	70.41	57.93
Algae extract	34.41	48.71	60.74	47.95
Molasses	69.57	86.84	115.76	90.72
Means	52.53	64.29	79.09	
L.S.D at 5% for:	F = 7.71, C = 3.63 and FC = 10.87			

Table 8. Effect of potassium fertilization and natural extracts on the number of branches per faba bean plant during the 2022/23 and 2023/24 seasons.

Fertilization (F)	2022 / 2023 season			
	Cultivars (C)			
	Nubaria 4	Nubaria 5	Giza 716	Means
Control	1.65	3.38	3.73	2.92
K (Soil)	3.45	6.01	6.63	5.36
K (Foliar)	5.64	7.30	7.85	6.93
Yeast extract	3.59	5.10	5.14	4.61
Algae extract	2.71	4.29	4.48	3.83
Molasses	5.20	7.55	9.23	7.33
Means	3.71	5.61	6.18	
L.S.D at 5% for:	F = 0.46, C = 0.51 and FC = 1.22			
Fertilization (F)	2023 / 2024 season			
	Cultivars (C)			
	Nubaria 4	Nubaria 5	Giza 716	Means
Control	1.76	3.38	3.66	2.93
K (Soil)	3.47	5.20	6.44	5.04
K (Foliar)	6.00	7.96	8.28	7.41
Yeast extract	3.85	5.23	4.95	4.68
Algae extract	2.96	4.71	4.56	4.08
Molasses	4.91	7.27	8.97	7.05
Means	3.83	5.63	6.14	
L.S.D at 5%	F = 0.54, C = 0.54 and FC = 1.36			

Yield

Tables (9 and 10) presented the results of the yield (biological and straw) of faba bean as affected by potassium fertilization and natural extracts (yeasts, algae, and molasses), application, cultivars, and their interactions in the 2022/23 and 2023/24 seasons.

Biological Yield (Kg Fed^{-1})

Table 9 clarified significant differences among the three cultivars in the biological yield fed^{-1} in both seasons. The Giza 716 cultivar had the highest biological yield fed^{-1}, followed by the Nubaria 5 cultivar. Meanwhile, the lowest yield productivity was the Nubaria 4 cultivar, with significant differences among them in both seasons. This could be ranked in descending order as follows: Giza 716 (4107.08) > Nubaria 5 (3383.41) > Nubaria 4 (2720.02 kg fed^{-1}), respectively, with significant differences of various magnitudes during the first season. Like the first season, the second season produced the same trend of biological yield but with different magnitudes, with significant differences (Table 9). Generally, it can be concluded that the Giza 716 cultivar was superior in biological yield compared to the other two faba bean cultivars; this result is clear evidence of the good performance of faba bean cultivars [33, 34, 45].

Data in Table 9 present the effect of potassium fertilization and natural extracts (yeasts, algae, and molasses). Application treatments were significantly different in both seasons. Molasses and potassium foliar application produced the highest biological yield (kg fed^{-1}) in both seasons. They produced 4297.7 and 4216.8 kg fed^{-1} in the first season and 3988.9 and 4104.08 kg fed^{-1} in the second season, respectively, without significant differences between them and significant differences in magnitudes, compared to the other treatments (Table 9).

Along the same line, biological yield productivity was ranked as follows: Molasses followed by K (foliar), then K (soil), followed by yeast extract, then algae extract in the 1st season, with significant differences in magnitudes. The respective biological yield was K (foliar), then molasses, followed by K (soil), then yeast extract, followed by algae extract in the second season

Table 9. Effect of potassium fertilization and natural extracts on the biological yield (kg fed^{-1}) of faba bean during the 2022/23 and 2023/24 seasons.

Fertilization (F)	2022 / 2023 season			
	Cultivars (C)			
	Nubaria 4	Nubaria 5	Giza 716	Means
Control	1762.9	2194.5	2884.4	2280.6
K (Soil)	3176.3	3724.4	4525.5	3808.7
K (Foliar)	3515.4	3967.9	5167.1	4216.8
Yeast extract	2491.7	3167.9	3729.6	3129.6
Algae extract	2032.8	3031.4	2998.8	2687.6
Molasses	3341.1	4214.7	5337.2	4297.7
Means	2720.02	3383.41	4107.08	
L.S.D at 5% for:	F = 277.66, C = 228.20 and FC = 461.40			
Fertilization (F)	2023 / 2024 season			
	Cultivars (C)			
	Nubaria 4	Nubaria 5	Giza 716	Means
Control	1594.9	2039.1	2662.8	2098.9
K (Soil)	3271.8	3482.9	4151.7	3635.4
K (Foliar)	3599.4	3804.2	4908.8	4104.0
Yeast extract	2305.8	2979.9	3430.4	2905.4
Algae extract	1861.7	2655.5	2582.8	2364.9
Molasses	2987.3	3912.3	5067.3	3988.9
Means	2603.5	3145.6	3799.7	
L.S.D at 5%	F = 305.68, C = 221.63 and FC = 534.56			

(Table 9). These results ensure that the role of potassium in important physiological and biological activities, which all reflect growth and productivity, is very well known. The effect of potassium on the movement and translocation of carbohydrates and other essential materials responsible for stimulating the metabolism and anabolism activities is very functional in plant growth and productivity. Similar results were also reported by Pyke et al. [33] and Badawy et al. [34].

Along the same line, it is well known that the important role of natural extracts (yeasts, algae, and molasses) in enhancing the photosynthetic and metabolic activities resulted in improved growth of faba bean plants as well as increased accumulated carbohydrate materials, which is very important for yield and its components [46, 47].

The interaction between potassium fertilization, natural extracts foliar application, and the tested faba bean cultivars was significant in the faba bean's biological yield in both seasons (Table 9). Meanwhile, the maximum biological yield (kg fed^{-1}) of faba bean plants (5337.2 and 5067.3 kg fed^{-1}) was obtained with the Giza 716 cultivar when fertilized with molasses in both seasons. Meanwhile, the minimum biological yield of faba bean (2032.8 and 1861.7 kg fed^{-1}) was obtained from applying algae extract in both seasons, respectively. Similar results were recorded by Abdel-Aziz et al. [36] and El-Kamar [48].

Straw Yield (Kg Fed^{-1})

Potassium fertilization and natural extracts (yeasts, algae, and molasses) application treatments differed significantly in both seasons, as reported in Table 10. Over potassium fertilization and natural extracts, results in Table 10 showed that there were significant differences among 3 cultivars in straw yield fed^{-1} in both seasons. The Giza 716 cultivar was superior in straw yield fed^{-1} (2446.8 and 2139.6 kg fed^{-1}), followed by the Nubaria 5 cultivar (1953.2 and 1795.5 kg fed^{-1}), then the Nubaria 4 cultivar (1594.7 and 1296.2 kg fed^{-1}) during both seasons with significant differences of various magnitudes (Table 10). Generally, it can be concluded that the Giza 716 cultivar was superior in straw yield compared to the other cultivars [49]. Over faba bean cultivars, the superior treatment of potassium application was K (soil),

Table 10. Effect of potassium fertilization and natural extracts on straw yield (kg fed^{-1}) during the 2022/23 and 2023/24 seasons.

Fertilization (F)	2022 / 2023 season			
	Cultivars (C)			
	Nubaria 4	Nubaria 5	Giza 716	Means
Control	1148.5	1396.2	1818.1	1454.3
K (Soil)	1890.9	2234.3	3311.6	2478.9
K (Foliar)	1919.1	2266.5	2735.8	2307.1
Yeast extract	1502.4	1845.6	2272.9	1873.6
Algae extract	1263.0	1962.2	1793.9	1673.0
Molasses	1844.3	2014.2	2748.3	2202.3
Means	1594.7	1953.2	2446.8	
L.S.D at 5% for:	F = 277.53, C = 228.11 and FC = 461.21			
Fertilization (F)	2023 / 2024 season			
	Cultivars (C)			
	Nubaria 4	Nubaria 5	Giza 716	Means
Control	1036.6	1256.6	1662.9	1318.7
K (Soil)	1906.6	2106.1	2530.3	2181.0
K (Foliar)	1820.5	1922.1	2748.9	2163.8
Yeast extract	1347.8	1766.7	1951.8	1688.8
Algae extract	1139.1	1632.7	1307.4	1359.7
Molasses	1526.4	2088.8	2636.4	2083.9
Means	1296.2	1795.5	2139.6	
L.S.D at 5%	F =305.52, C = 221.56 and FC = 534.34			

which produced the highest straw yield (kg fed^{-1}) in both seasons, with values of 2478.9 and 2181.0 kg fed.$^{-1}$ in both seasons, respectively, with significant differences in magnitudes as compared to the other treatments (Table 10).

Straw yield productivity was ranked in the following order: K (soil) (2478.9) > K (foliar) (2307.1) > molasses (2202.3) > yeast (1873.6) > algae (1673.0) > control (1454.3 kg fed^{-1}) in the first season with significant differences in magnitudes, being K (soil) (2181) > K (foliar) (2163.8) > molasses (2083.9) > yeast (1688.8) > algae (1359.7) > control (1318.7 kg fed^{-1}) in the second season with significant differences in magnitudes (Table 10). The obtained results ensure that the role of potassium in some of the important physiological and biological activities, which all reflect growth and productivity, is very well known. The effect of potassium on the movement and translocation of carbohydrates and other essential materials responsible for stimulating metabolism and anabolism is very functional in plant growth and productivity. Similar results were also reported by El-Emary and Amer [35], El-Hawary and Nashed [50], and Nadeeka and Seran [51]. The interaction effect between potassium fertilization, natural extract application, and cultivars was significant in both seasons on straw yield kg fed^{-1} (Table 10). The highest straw yield of faba bean plants (3311.6 and 2748.9 kg fed^{-1}) was obtained with the Giza 716 cultivar when fertilized with K (soil) in the first season and K (foliar) in the second season, respectively. The results agreed with those obtained by Khalil [52].

Conclusion

This experiment was performed to study three faba bean cultivars (Nubaria 4, Nubaria 5, and Giza 716) under six growth-promoting treatments (control (distilled water), K (as a foliar), K (soil application), yeast extract, algae extract, and molasses). From the obtained data, it can be concluded that applying molasses and K (foliar) treatment could be suggested for the maximum number of flowers, total Chl. content, and maximum yield of Giza 716 under delta conditions.

Abbreviations

Chl	Chlorophyll
K	Potassium
C1	Nubaria 4
C2	Nubaria 5
C3	Giza 716

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Data Availability Statement

All data that support this study's findings are included in the article.

Conflicts of Interest

The authors declare no conflict of interest.

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