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EFFECT OF DIFFERENT PLANTING DATES AND POTASSIUM AND PROLINE SPRAYING ON GROWTH AND YIELD OF FABA BEAN (VICIA FABA L.)

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Abstract:
The field experiment was conducted at the Agricultural Research Station affiliated with the College of Agriculture, University of Basrah, during the winter agricultural season 2022-2023 in soil with a mixed clay-silt texture. The experiment aimed to study the effect of three planting dates (October 1, mid-October and November 1), represented by the symbols D3, D2, and D1, respectively, and spraying with four levels of potassium sulfate (3000, 2000, 1000, and 0 mg L-1) and proline acid (150, 100, 50, and 0 mg L-1), represented by the symbols T3, T2, T1, and T0, respectively. A factorial experiment was conducted using the Complete Randomized Block Design (RCBD) with three replications. Some physiological properties, different growth characteristics, yield characteristics, and some qualitative characteristics were studied. The results showed that the second planting date was superior in most of the studied traits, recording the highest average for plant height, number of branches, number of leaves, number of seeds per pod, 100-seed weight, and individual plant yield, with values of 99.61 cm, 8.64 branches plant-1, 77.06 leaves plant-1, 4.84 seeds pod-1, 124.74 g, and 75.36 g, respectively. On the other hand, the first planting date recorded the highest average for the number of pods, which amounted to 14.76 pods plant-1. The results also showed that the potassium-proline combination at treatment T3 was superior in all the studied traits, giving the highest average for plant height, number of branches, number of leaves, number of pods, number of seeds per pod, 100-seed weight, and individual plant yield, with values of 107.57 cm, 9.01 branches plant-1, 76.69 leaves plant-1, 14.40 pods plant-1, 5.22 seeds pod-1, 124.39 g, and 94.04 g, respectively. The interaction between the factors affected most of the studied traits, and treatment D2T3 gave the highest average for plant height, number of branches, number of leaves, number of seeds per pod, and 100-seed weight, with values of 120.34 cm, 10.49 branches plant^{-1}, 87.60 leaves plant^{-1}, 13.83 pods plant^{-1}, and 5.69 seeds pod^{-1}, respectively.

Keywords: Bean; planting dates; potassium; proline and bean yield.

INTRODUTION

Faba bean (*Vicia faba* L.) is a member of the legume family and a staple food for many people around the world. It is grown for its green pods or tender and dry seeds, which have a moderate calcium and phosphorus content. Temperature and light are the most important climatic factors affecting crop growth. Temperature is fundamental in photosynthesis, growth rate, and crop maturity (Hafez Abdul, 2011). Every crop has thermal limits for growth that can be controlled by planting at the right time. The key to good management is planting at the ideal time, which means placing the crop in specific climatic and environmental conditions that must be ideal in order to achieve the highest organization of the relationship between the source and the sink and to give the highest economic and biological yield. High temperatures during the flowering period have been observed to lead to flower damage and pod formation (Al-Djoui, 1996).

The low yield rate in Iraq may be due to several reasons, the most important of which is the lack of readiness of some soil nutrients that affect pollination, pod formation, flower drop, and resistance to some stresses, especially salt stress. Therefore, foliar feeding is one of the important means to provide the plant with nutrients and provides what the plant requires during the sensitive and critical periods of growth that the roots cannot fulfil, in addition to reducing the loss of energy consumed to transport some important ions inside the plant.

Potassium is one of the nutrients that clearly impacts agricultural production in terms of the quantity and quality of production. Potassium affects the biological activities of the plant, growth, and development of the pollen tube. Its deficiency causes leaf, flower, and fruit to drop.

Proline acid is an amino acid that can regulate the osmotic potential inside the cell, specifically between the vacuole and the cytoplasm, under salt-stress conditions. Ions accumulate in the vacuole, which leads to an imbalance of osmotic potential inside the cell. This drives the accumulation of proline in the cytoplasm to create a state of balance. In addition to its role in maintaining cell turgor, membrane synthesis of cell organelles, and enzymatic activity by protecting enzymes from degradation, it also helps the plant to get rid of the oxidative stress state to which it has been exposed and to recover and return to the normal state as it is a scavenger of oxidized free radicals (Britto and Kronzucker, 2008).

Because of the above, the importance of this study, which aims to:

1. Determine the optimal date for planting beans within the environmental conditions of Basrah Governorate.
2. Study the effect of spraying potassium sulfate and proline acid on the growth and yield of bean plants.
3. Study the effect of the interaction between planting dates and spraying agents to determine the best combination that achieves the highest response in growth characteristics and yield to improve and increase the productivity of beans in quantity and quality.
4. Study of thermal accumulation at different stages of plant growth and the extent of its effect on yield components.

MATERIAL AND METHODS

A field experiment was conducted at the Agricultural Research Station affiliated with the College of Agriculture, University of Basrah / Karma Ali site, located on longitude 47.39275 degrees west and latitude 30.37560 degrees north during the winter season 2022-2023. The experiment aimed to study the effect of planting dates foliar application of proline and potassium on physiological growth indicators and yield of faba bean crop. Random samples were taken from different areas of the field soil before planting at a depth of (0-30) cm. Then, they were mixed, and a composite sample was taken to estimate some physical and chemical properties. The analyses were conducted at the Central Laboratory/College of Agriculture, University of Basrah, as shown in the table below.

Table (1) some physical and chemical properties of soil of the cultivated field

attribute	value	units
pH	8.50	1:1
$E.C._e$	7.32	des m^{-1}
Available elements		
N	53.3	mg kg^{-1}
P	5.2	
K	122.3	
Organic matter	11.8	g kg^{-1}
Soil texture		
sand	385	g kg^{-1}
silt	515	
clay	100	

Tillage, smoothing, and leveling operations were carried out, and then the agricultural land was divided into plots. The experiment was conducted using a factorial experiment design using a complete randomized block design (RCBD) with three replications. Each plot contained 12 experimental units, for a total of 36 experimental units. The area of the experimental unit was 6 m2 with dimensions of (3 m × 2 m). A distance of 1.5 m was left between each plot. The seeds were planted on lines with a distance of 50 cm between them and 20 cm between each hole. Chemical fertilizers were added according to the fertilizer recommendation. The nitrogen fertilizer was applied at a rate of 120 kg N ha-1 in the form of urea fertilizer (46% N) in equal quantities after 15, 30, and 45 days of planting (Kamal et al., 2021). The phosphate fertilizer was applied at 105 kg P ha-1 at planting in superphosphate (43% P) (Al-Shummary et al., 2021).

The experiment included the study of two factors.

1- The first factor was the planting date of the faba bean at three dates: October 1st (D1), mid-October (D2), and November 1st (D3).

2- The second factor was the application of foliar sprays of proline and potassium. The sprays were applied in two stages, the first after one month of germination and the second after two months of germination. The treatments were as follows:

- Control treatment without spraying (T0)
- Spraying of potassium sulfate at a concentration of 1000 mg L-1 + spraying of proline at a concentration of 50 mg L-1 (T1)
- Spraying of potassium sulfate at a concentration of 2000 mg L-1 + spraying of proline at a concentration of 100 mg L-1 (T2)

- Spraying of potassium sulfate at a concentration of 3000 mg L-1 + spraying of proline at a concentration of 150 mg L-1 (T3)

Crop management practices were carried out as needed. At maturity, ten plants were selected from each experimental unit to study the following traits:
(Plant height, number of branches, number of leaves, number of pods, number of seeds per pod, 100-seed weight, and individual plant yield).

RESULTS AND DISCUSSION

1- Plant height (cm)

The results of Table 2 showed that planting dates significantly affected the height of faba bean plants. The second planting date recorded the highest mean plant height of 99.61 cm, a significant increase of 10.86% over the first planting date, which was 89.85 cm. This increase in plant height may be due to the suitability of the planting date for the plant, which resulted in forming an ideal vegetative mass that positively reflected the plant's height. This result agrees with the results of Abido and Seadh (2014).
As for the effect of the potassium and proline spraying factors, treatment T3, which included spraying potassium sulfate at a concentration of 3000 mg L-1 and proline at a concentration of 150 mg L-1, had a significant superiority, with a mean height of 107.57 cm, which was a significant increase of 43.68% over the control treatment, which recorded the lowest mean of 74.87 cm. This increase in height may be due to the significant and direct role of potassium in the physiological functions of the plant and metabolic processes. It also has a role in stimulating cells to divide and elongate, especially the meristematic cells in the growing tips, strengthening the stem and increasing its thickness, and thus, good vegetative and root growth, which increases the efficiency of water and nutrient absorption from the soil to the plant, which positively reflects on the plant's height. The same is the case for the effect of proline acid, which encourages and increases the formation of proteins that participate in photosynthesis and the formation of chlorophyll, thus increasing the size of the vegetative mass of the plant. These results are consistent with the results of Haidar et al. (2020).
As can be seen from the table, treatment D2T3, which included planting on the second date and spraying with potassium sulfate at a concentration of 3000 mg L-1 and proline at a concentration of 150 mg L-1, had a significant superiority over the other interactions and gave the highest mean for the plant height trait of 120.34 cm, which is an increase of 56.61% over the control treatment (D1T0), which was 76.84 cm. This significant increase is due to the effect of the planting date factor and the spraying combination on the plant height trait.

Table (2) Effect of planting dates and spraying proline and potassium on plant height (cm)

Planting date D	Spray Treatments T				Average D
	T0	T1	T2	T3	
D1	76.84	83.63	96.53	102.40	89.85
D2	79.51	89.67	108.90	120.34	99.61
D3	68.27	78.59	89.77	99.98	84.15
Average T	74.87	83.96	98.40	107.57	
$LSD_{0.05}$	**T**		**D**		**D x T**
	5.16		4.47		8.93

2- Number of branches (branches plant^{-1})

The results of Table 3 showed significant differences for planting dates, with the second planting date recording the highest mean for the number of branches at 8.64 branches plant-1, an increase of 42.57% compared to the first planting date, which gave the lowest mean for the trait at 6.06 branches plant-1, which was not significantly different from the third planting date, which recorded 8.10 branches plant-1. The increase may be attributed to planting at the appropriate time, which reflected positively on forming a good vegetative mass and increasing the number of branches. These results agree with the findings of Gharee et al. (2019).
As can be seen from the table, the number of branches in a single plant increased directly with the concentration of potassium sulfate and proline spraying treatments, and all of them were significantly superior compared to the control treatment (T0). Treatment (T3) achieved the highest mean for the number of branches at 9.01 branches plant-1, followed by treatment (T2) at 7.90 branches plant-1. Treatment (T0) gave the lowest mean for the trait at 6.29 branches plant-1, a decreasing percentage of 43.24% compared to treatment (T3). These results agree with the findings of Qasim et al. (2012), who found that proline stimulates growth and increases the number of branches in faba beans. The effect of potassium in increasing the number of branches is that it enhances the water status of the

plant and increases the transfer of photosynthesis products from their places of manufacture to their places of need, which leads to improving growth indicators, especially plant height and the number of branches. This is consistent with the results of Eman and Semida (2020), who found that potassium increases the number of branches in faba beans.

As can be seen from the results of the table, the number of branches in the plant increased at the interaction treatment (D2T3), which recorded 10.49 branches plant-1, an increase of 86.32% compared to the control treatment (D1T0), which recorded the lowest number of branches at 5.63 branches plant-1. This is due to the significant joint effect of planting dates and spraying with potassium and proline.

Table (3) Effect of planting dates and spraying proline and potassium on Number of branches (branches $plant^{-1}$)

Planting date D	Spray Treatments T				Average D
	T0	T1	T2	T3	
D1	5.63	5.77	6.23	6.60	6.06
D2	6.91	8.11	9.04	10.49	8.64
D3	6.33	7.70	8.43	9.93	8.10
Average T	6.29	7.19	7.90	9.01	
$LSD_{0.05}$	**T**		**D**		**D x T**
	0.65		0.56		1.12

3- Number of leaves (leaves $plant^{-1}$)

The results of Table 4 showed that planting dates significantly affected the number of leaves per plant. The second planting date recorded the highest mean for the number of leaves at 77.06 leaves plant-1, an increase of 30.37% compared to the first planting date, which recorded the lowest mean for the trait at 59.11 leaves plant-1. The increase may be attributed to the fact that the appropriate planting date led to the formation of a large vegetative mass, which reflected the increase in the number of branches and leaves in the plant. These results agree with the findings of Tawfik et al. (2018).

The table results also showed significant differences in the number of leaves for potassium and proline spraying. Treatment T3 recorded the highest mean for the trait at 76.69 leaf plant-1, an increase of 41.60% compared to the control treatment T0, which recorded the lowest mean at 54.55 leaf plant-1. The increase may be attributed to the positive role of potassium through activating enzymes, opening and closing of stomata, regulating the osmotic potential of plant cells, increasing their permeability, contributing to the process of photosynthesis and the transfer of its products, and stimulating cells to divide and elongate leaf cells, which led to an increase in the number of leaves per plant. These results agree with Al Falahi and Abdulkafoor's (2021) findings on faba bean plants.

As for the interaction between planting dates and spraying, the factorial treatment D2T3 recorded a significant effect of 87.60 leaves plant-1. This is due to the significant increase in planting dates and the spraying factor in the number of leaves per plant.

Table (4) Effect of planting dates and spraying proline and potassium on Number of leaves (leaves $plant^{-1}$)

Planting date D	Spray Treatments T				Average D
	T0	T1	T2	T3	
D1	51.88	56.22	64.08	64.28	59.11
D2	65.61	75.31	79.70	87.60	77.06
D3	46.16	62.17	69.24	78.19	63.94
Average T	54.55	64.57	71.01	76.69	
$LSD_{0.05}$	**T**		**D**		**D x T**
	3.76		3.25		6.51

4- Number of pods (pods plant^{-1})

Table 5 showed significant differences between planting dates in the number of pods per plant. The first planting date gave the highest mean for the trait at 14.76 pods plant-1, an increase of 29.47% compared to the third planting date, which gave the lowest mean at 11.40 pods plant-1. These results agree with those found by Gharee et al. (2019).

The results of the table also showed significant effects of potassium sulfate and proline spraying. Treatment T3 gave the highest mean for the trait at 14.40 pods plant-1, followed by treatment T2 at 13.53 pods plant-1. This indicates that the number of pods per plant increased directly with the increase in the concentration of the spray. All treatments were significantly superior to the control treatment T0, which gave the lowest mean of 11.31 pods plant-1. These results agree with those found by Al-Jubouri and Shaker (2019).

Table (5) Effect of planting dates and spraying proline and potassium on Number of pods (pods plant^{-1})

Planting date D	Spray Treatments T				Average D
	T0	T1	T2	T3	
D1	13.13	13.89	15.57	16.46	14.76
D2	10.77	11.42	12.95	13.83	12.24
D3	10.04	10.60	12.07	12.91	11.40
Average T	11.31	11.97	13.53	14.40	
LSD0.05	**T**		**D**		**D x T**
	0.55		0.47		N.S

5- Number of seeds per pod (seeds pod^{-1})

Table 6 showed that the second planting date recorded the highest mean for the number of seeds per pod at 4.84 seeds pod-1, compared to the lowest number of seeds per pod recorded at the third planting date at 3.98 seeds pod-1. The increase may be attributed to the appropriate planting date, which led to the formation of a good vegetative mass and the maximum utilization of nutrients from the places of manufacture in the formation of seeds in the pods. These results agree with those found by Al-Sabahi (2013).

The differences were also significant when comparing the spraying treatments with potassium sulfate and proline. Treatment T3 gave the highest mean for the number of seeds per pod at 5.22 seeds pod-1, an increase of 37.01% compared to the control treatment T0, which recorded the lowest mean for the trait of the number of seeds per pod at 3.81 seeds pod-1. This increase may be due to the role of potassium in plant growth and productivity through its contribution to photosynthesis, the transfer of its products, the division of plant cells, the increase in their permeability, and its contribution to the formation of nucleic acids, proteins, and enzymes. It also contributes to the completion of many important biological activities in the plant, and the plant needs it to produce the energy-rich compound ATP, which is important for plant metabolism. It also contributes to the transfer of sugars from the source to the sink and plays an important role in protein formation. (Hussain et al., 2011) These results agree with those found by Al-Falahi and AbdulKafoor (2021).

As for the interaction between the treatments, it had a significant effect on the trait of the number of seeds per pod, as treatment D2T3 gave the highest mean for the trait at 5.69 seeds pod-1, which did not differ significantly from treatment D1T3, which recorded 5.58 seeds pod-1. In contrast, treatment D1T1 gave the lowest mean of 3.81 seeds pod-1

Table (6) Effect of planting dates and spraying proline and potassium on Number of seeds per pod (seeds pod^{-1})

Planting date D	Spray Treatments T				Average D
	T0	T1	T2	T3	
D1	3.81	4.15	4.49	5.58	4.50
D2	3.98	4.40	5.28	5.69	4.84
D3	3.65	4.04	3.84	4.38	3.98
Average T	3.81	4.20	4.54	5.22	
LSD0.05	**T**		**D**		**D x T**
	0.254		0.220		0.440

6- Seed weight (g)

The results of Table 7 showed significant differences between planting dates, with the second planting date giving the highest mean for the trait of seed weight at 124.74 g, which did not differ significantly with the third planting date, which was 124.58 g, an increase of 5.22% compared to the first planting date, which gave the lowest mean for the trait at 118.55 g. These results agree with those found by Fakhr et al. (2020).

As for the effect of spraying with potassium sulfate and proline, treatment T3 gave the highest mean for the trait of seed weight at 124.39 g, while treatment T0 gave the lowest mean for the trait at 120.82 g, an increase of 2.95%. This increase may be due to the role of potassium in increasing photosynthesis, regulating the opening and closing of stomata, reducing water loss, and increasing the transfer of manufactured material from the source to the sink, which positively reflects on the seed weight rate in the pods. The same is the case for the amino acid proline, which helps form proteins involved in photosynthesis and increases the transfer of manufactured products to the pods. These results agree with those found by Qasim et al. (2012).

It is noted from the table that the interaction between the factors does not have a significant effect on the trait of seed weight.

Table (7) Effect of planting dates and spraying proline and potassium on seed weight (g)

Planting date D	Spray Treatments T				Average D
	T0	T1	T2	T3	
D1	116.69	116.78	119.77	120.96	118.55
D2	122.60	124.34	125.39	126.63	124.74
D3	123.17	124.48	125.09	125.58	124.58
Average T	120.82	121.86	123.42	124.39	
$LSD_{0.05}$	**T**		**D**		**D x T**
	0.922		0.80		N.S

7- Individual plant yield (g plant^{-1})

The results in Table 8 showed that the first planting date was superior in the trait of individual plant yield, which recorded the highest mean of 80.23 g plant-1, which was not significantly different from treatment D2, which was 75.36 g plant-1, an increase of 40.90%. This increase may be due to the increase in the individual plant yield components (number of pods, number of seeds per pod, and 100-seed weight), leading to the increase in individual plant yield. These results agree with the results of Al-Silaiwi et al. (2018).

It is noted from the table the significant effect of spraying with potassium and proline acid, where treatment T3 recorded the highest mean for the trait of individual plant yield at 94.04 g plant-1, an increase of 80.36% compared to the lowest individual plant yield at treatment T0, which was 52.14 g plant-1. The increase may be attributed to the role of both potassium and proline in transferring the products of photosynthesis and nutrients from the source to the sink, which leads to an increase in the amount and quantity of yield. These results agree with the results of Al-Hassani et al. (2019). As for the interaction between the factors, the factorial treatment (T3 D1) gave the highest individual plant yield of 111.41 g plant-1, which was not significantly different from the factorial treatment (D2T3), which recorded 99.76 g plant-1.

Table (8) Effect of planting dates and spraying proline and potassium on Individual plant yield (g plant^{-1})

Planting date D	Spray Treatments T				Average D
	T0	T1	T2	T3	
D1	58.34	67.35	83.81	111.41	80.23
D2	52.72	62.52	86.42	99.76	75.36
D3	45.37	53.43	58.00	70.95	56.94
Average T	52.14	61.10	76.08	94.04	
$LSD_{0.05}$	**T**		**D**		**D x T**
	6.40		5.54		11.08

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