Biofortification of Productivity and Quality of Faba Bean Using Sowing Dates and Calcium Boron Foliar Application

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ABSTRACT: Field experiment was conduct in the experimental farm of Etay Al-Baroud Agricultural Research Station, Agricultural Research Center, El-Beheira Governorate, Egypt., during the two growing seasons of 2021-2022 and 2022-2023 on faba bean variety Giza 716. The current field study aimed to investigate the effect of different sowing dates (1st October, 20th October and 10th November) and their combination with the foliar spraying applications of calcium-boron (once, twice and three times compared with control). For this purpose, an experiment layout in a split-plot design in three replicates was used. Sowing dates were placed in the main plots and the times of calcium-boron foliar application were randomly distributed in the sub-plots. The results indicated that sowing date 10th November increased plant heights, pods number/plant, 100-seeds weight, seed yield/fed, seeds content of total protein and seed content of boron in both seasons. Faba bean plants that sprayed three times with calcium-boron recorded the highest plant height, pods number/plant, 100-seeds weight, seed yield/fed, seeds content of total protein, calcium and boron in both seasons. The interaction effect between the sowing date and spraying applications of calcium-boron significantly affected vegetating growth character seed yield and seed quality in both seasons. It could be recommended to sowing faba beans during November with spraying with calcium-boron three times to obtain the highest yield and seed quality in the Delta region.

Keywords: *faba bean, sowing dates, spraying of calcium-boron*

INTRODUCTION

Faba bean *(Vicia faba L.)* is the most common legume food consumed worldwide. It is commonly used in for humans and animals feeding in many parts of the world due to its high nutritional value where the dry seeds contain 26-35% protein, 55-61% total carbohydrates and 6.4-8.4% fiber **(Alghamdi 2009)**. It is one of the most important food legumes in Egypt. It is considered one of the promising crops that can play an important role in increasing the production of legumes in Egypt **(Megawer *et al.*, 2017)**. In 2021 season the world total harvested area of faba bean was 2.49 million hectares with total production reached 4.85 million tons of dry seeds while the total harvested area in Egypt in the same year was 40.31 thousand hectares with total production reached 139.52 thousand tons of dry seeds **(FAOSTAT 2021)**.

The cultivated area of faba bean around the world was affected by many biotic stress factors such as pests, diseases, and intrusive weeds such as broomrape and abiotic stresses, such as climate variability such as high temperature, low amount of rain and high wind speed. Climate variability often has a bad effect on the growth and production of most field crops **(Arshad *et al.*, 2018).** Moreover, climate change may lead to a double spread of pests and diseases, soil degradation, a change in conditions that are suitable for seed germination, a change in solar radiation rates and the amount of thermal units that a plant needs to complete its life cycle, which leads to more negative effects on agricultural production **(Rosenzweig *et al.*, 2001)**. Despite the technological development in the agricultural process, agricultural production is completely dependent on the basic climatic determinants, such as the rate of rainfall, temperature and light, which are basic materials in the building process in the plant **(Wheeler and Von Braun 2013)**. In the short term, the negative effects of climate change can be avoided by simple methods as adjusting the planting date or paying attention to plant nutrition, whether with macro or micro elements **(Calzadilla *et al.*, 2013)**. However, in the long term, climate change is expected to reduce crop production by seventeen percent of the amount of yields in various regions across the world **(Nelson *et al.*, 2013)**.

There is a noticeable difference in previous studies about the optimal date for planting faba beans in Egypt. For example, **EL–Galaly *et al.* (2008)** and **Attia *et al.* (2009)** indicated that sowing faba bean around November produced the highest values for seed yield and its attributes compared to earlier (around midi Oct.) or late of Nov. and early Dec. sowing date. On the other side, **Megawer *et al.*, (2017)** and **Mahdy and Ahmed (2018)** investigated the effect of three sowing date of faba bean i.e., 22nd October, 7th and 22nd November. and indicated that the early sowing date (22nd Oct.) produced the highest values of all yield attributes and carbohydrate percentage except for harvest index and protein percentage.

As the planting date has a clear effect on the growth and yield of faba beans, the interest with plants feeding, whether with macro or micro elements has affects growth and yield, where these elements played critical roles in metabolism process and transportation, as well as some of them have a protective role against biotic and abiotic stresses.

Calcium is an essential plant nutrient. It is required for various structural roles in the cell wall and membranes, it is a counter-cation for inorganic and organic anions in the vacuole and the cytosolic Ca2+ concentration is an obligate intracellular messenger coordinating responses to numerous developmental cues and environmental challenges (**White and Broadley 2003)**. In the previous studies as conducted by **Munns and Tester (2008)** calcium foliar application of 2 gm/L significant increase seed yield/plant of faba bean compared to the control and this increase was associated with the increase in number of pods/plant. Also, **Hellal *et al.*, (2014)** indicated that calcium plays an important role in faba bean growth and nutrition, as well as in cell wall deposition. In the same way, **Khalil *et al.*, (2015)** showed that calcium application as foliar spray was significantly increased number of branches and pods/plant, weight of seeds/plant, seed index, seed yield and harvest index of faba bean. Also, **Abo-Hegazy *et al.*, (2022)** found significant increase in all faba bean growth, yield and seed quality under the application of calcium.

Boron (B) is considered as an essential element for plant growth and development. Sexual reproduction in plant is more sensitive to low B content, than vegetative growth **(Dell and Huang 1997)**. The main functions of boron are that it is related to cell wall strength and development, cell division, fruit and seed development, sugar transport and hormone development **(Osman *et al.*,2012)**. Several impairments during many processes such as sugar transport, cell wall synthesis, cell wall structure, carbohydrate metabolism, RNA metabolism and respiration caused under boron deficiency **(Kabay *et al.*,2015)**. In faba bean **Assi *et al.*, (2019)** showed that the boron spraying led to early flowering, maturity and significant increase in plant height, number of branches, number of leaves, leaf area, chlorophyll content percentage of dry matter, total number of pods per plant, the number of seeds per pod, weight of 100 seeds and the yield of plant compared to the treatment without spraying.

Therefore, the main objectives of this study were to:

1- Determine the optimal sowing date that is used to maximize growth, seed yield and seed quality of faba bean.
2- Determine the role of calcium boron foliar spraying to improve growth, seed yield and seed quality of faba bean sowed on different sowing dates.

MATERIALS AND METHODS

Two field experiments were conducted at the experimental farm of Etay Al-Baroud Agricultural Research Station, Agricultural Research Center, El-Beheira Governorate, Egypt, during the two growing seasons of 2021/2022 and 2022/2023 to evaluate the effect of sowing dates (1st Oct. 20th Oct. and 10th Nov.) and number of spraying with the recommended dose of calcium-boron (once, twice and three times) on growth, seed yield and seed quality of faba bean cultivar Giza 716. For this purpose, an experiment layout in a split-plot design in three replicates was used where sowing dates were placed in the main plots and the times of calcium-boron foliar application were randomly distributed in the sub-plots. Meteorology of the experiment area during 2021/2022 and 2022/2023 growing seasons were presented in Table 1. Also, the exprimental soil physical and chemical properties are presented in Table 2.

Table 1: Meteorology of the experiment area during 2021/2022 and 2022/2023 seasons.

Month	HC Air temperature [°C]			Solar radiation	HC Relative humidity [%]			Wind speed [m/s]	
	min	Max	Avg	Dgt [W/m2]	min	max	Avg	avg	max
Season 2020/2021									
Oct.	14.71	28.08	21.39	102.40	35.65	93.64	64.65	0.96	3.36
Nov.	11.06	24.29	17.67	75.27	45.89	98.37	72.13	0.52	2.68
Dec.	10.40	21.60	16.00	70.67	60.63	99.82	80.23	0.58	2.02
Jan.	8.36	17.62	12.99	97.33	61.21	100.00	80.61	1.63	4.10
Feb.	10.17	22.12	16.15	94.06	68.39	98.79	83.59	1.52	3.91
Mar.	13.70	26.15	19.93	96.28	60.55	99.37	79.96	1.37	3.78
Season 2021/2022									
Oct.	15.23	30.45	22.84	105.16	40.19	92.61	66.40	0.89	3.92
Nov.	11.53	23.88	17.71	77.13	42.66	96.46	69.56	0.62	2.86
Dec.	10.26	22.07	16.17	74.28	68.34	95.32	81.83	0.55	1.95
Jan.	9.74	16.85	13.30	93.11	59.43	94.63	77.03	1.73	4.18
Feb.	11.82	23.02	17.42	96.42	70.22	94.15	82.19	1.58	4.02
Mar.	12.71	25.63	19.17	100.05	65.14	96.94	81.04	1.44	3.84

The experimental plot included four ridges each ridge was four meters long and 60 cm apart. Seeds were sowing on 1st Oct, 20th Oct and 10thNov. in both seasons on the two sides of the ridge with 20 cm hill space and once seed per hill. The dry planting method called (Affier) was used and all the other cultural practices were followed as recommended. Calcium-boron material obtained from Agro- Seed Company was used as a foliar application at the rate of 3g/L water and spraying three times during the growing season after 45, 60 and 75 day from seed sowing.

Table (2): Mechanical and chemical analysis of experimental soil conducted before planting in 2021/2022 and 2022/2023seasons.

Mechanical and chemical	2020/2021	2021/2022
Sand %	7.09	8.59
Silt%	32.50	31.80
Clay%	61.41	59.61
Texture type	Clay	
PH	7.71	7.79
OM	1.99	2.07
EC (m mohs/cm)	1.93	1.61
Sp	83.8	84.3
HCO3-	0.76	0.84
CL-	10.11	8.42
SO4-	8.43	7.02
Ca++	6.12	5.00
Mg+	3.54	2.61
K+	1.56	1.64
Na+	8.17	6.89
SAR	3.73	3.53
N%	1.50	1.52
P%	0.39	0.38
K (ppm)	278.86	286.79

Data recorded:

A- Growth characteristics of faba bean:

1. **Plant height (cm):** is the average length from soil surface to the terminal bud in the main stem of five guarded plants chosen randomly from each plot.
2. **Number of branches/plant;** is the average branch number of five guarded plants chosen randomly from each plot.

B- Seed yield and its components characteristics:

1. **Number of pods/plant:** is the average pods number of 5 guarded plants chosen randomly from each sub-plots at harvest.
2. **100-seed weight (g):** is the weight of 100 seeds chosen randomly from each sub-plots at harvest.
3. **Seed yield/fed. (kg):** was estimated by convert seed yield/plot to feddan after harvest

C- Seed quality traits.

1. Total protein content: Protein content in dry seeds was determined by protein analyzer apparatus model (LC 3000 Eppendorf, Central Lab. of Desert Research Center). Hydrolysis was described according to the method of **Pellet and Young (1980)**.

2. Seed content of calcium and boron Chemical analysis of seeds Ca and B mineral contents were determined at harvest in dry seeds was determined photometrically, using flame photometer according to **Jackson (1965).**

Statistical analysis:

All data were subjected to the analyses of variance (ANOVA) for split-plot design followed by compared means with LSD at level probability 5% according to **Gomez and Gomez (1984)**.

RESULT AND DISCUSSIONS

A- Growth characteristics of faba bean

The presented results in **Table 3** confirmed that faba bean growth i.e. plant height, and branches number/plant significantly affected by sowing dates, number of calcium-boron sprays and their interactions in both seasons.

With respect to sowing dates the results showed that plant heights gradually increased while, branches number/plant decreased with delayed sowing dates in both seasons. Faba bean plants that were plant edon 10th Nov. recorded the highest plant heights (156.83 and 158.85 cm) as well as the lowest branches number/plant, on the other side, faba bean that plant edon 1st Oct. showed the shortest plants in addition to the highest branches number/plant (2.58 and 3.36) in the first and second seasons, respectively.

All growth traits in this study were significantly affected by sowing dates. Also, previous studies showed similar effect of sowing dates in all faba bean growth traits. For branches/plant **Turk and Al Tawaha (2002)** and **Kiyanbakht *et al.*, (2015)** who found that the sowing date early in October achieved highest number of branches of faba bean. In contrast of this, **Bakheit *et al.*, (2001)** revealed that sowing date exerted a significant influence on all traits except number of branches/plant.

For the effect of calcium-boron foliar spraying numbers the results showed that plant height, a significant increase while number of branches/plant decreased with the increase of calcium-boron spraying number compared with the control in both seasons. Faba bean plants that sprayed three times with calcium-boron recorded the tallest plants (141.56 and 141.61 cm) followed by plants that sprayed with twice then faba bean plants that sprayed once with calcium-boron in the two seasons, respectively. In this, faba bean plants under the control treatment recorded the lowest plant height in both seasons. The un-treated faba bean plants and had the highest branches numbers/plant (3.09 and 4.06) in both seasons, respectively. In a previous study foliar application of calcium significantly increased faba bean growth traits **(Khalil *et al.*, 2015).**

As for boron effect in branches number, **Shekhawat and Shivay (2012)** concluded that the application of boron at 1.50 kg ha-1 significantly increased number of branches plant-1 in mung bean. In the same way, **Parry *et al.*, (2016)** obtained higher number of branches values in garden pea with application of 2 kg B/ha. While **Hamouda *et al.*, (2018)** showed that B sprays had positive significant effects on plant growth traits such as number of branches per plant of common bean. **Assi *et al.*, (2019)** showed that boron spraying led to a high number of branches of faba bean plants. Finally, **Fadhil and Jader (2020)** found that boron treatment 50 mg/liters resulting in the highest number of branches per plant of broad bean.

Regarding the effect of the interactions between sowing dates and calcium-boron spraying numbers on faba bean plant height, branches number/plant, the data cleared differ response of faba bean plants to calcium-boron spraying number under the different sowing dates in both seasons. Spraying three times with calcium-boron in the late sowing date (10th Nov.) showed the highest plant heights (172.00 and 173.76 cm) followed by plants that sprayed twice with calcium-boron which planted on 10th Nov. then plants that sprayed once with calcium-boron in the late sowing date in both seasons. On the other hand, the un-sprayed faba bean plants in the early sowing date (1st Oct.) had the lowest plant heights in the first and second seasons. In all cases faba bean plants sowed on 1st Oct. were the shortest across all calcium-boron spraying numbers when compared with intermitted and late sowing dates. The un-treated faba bean plants sowed on the early sowing date (20th Oct.) had the highest branches number/plant (3.87 and 5.10) in both seasons, respectively. On the other hand, faba bean plants that sprayed with calcium-boron twice or three times in the late sowing date (10th Nov.) had the lowest branches number/plant in the first and second seasons.

Table 3: Effect of sowing dates, calcium-boron foliar application and their interaction on faba bean growth characteristics during 2021/2022 and 2022/2023 seasons.

	1st season					2nd season				
	Once	**Twice**	**Three times**	**control**	**Mean (A)**	**Once**	**Twice**	**Three times**	**control**	**Mean (A)**
					Plant height (cm)					
1st Oct.	106.33	117.0	120.33	94.67	**109.5**	103.6	113.2	115.93	93.42 i	**106.5**
20th Oct.	117.00	129.0	132.33	104.00	**120.5**	120.2	132.0	135.14	108.95	**124.1**
10th Nov.	152.33	167.6	172.00	135.33	**156.8**	154.4	169.4	173.76	137.75	**158.8**
Mean	**125.22**	**137.8**	**141.56**	**111.33**		**126.1**	**138.2**	**141.61**	**113.37**	
					Number of branches/plant					
1st Oct.	2.77 c	2.20 d	1.70 e	3.67 b	**2.58 a**	3.60 c	2.83 d	2.20 ef	4.80 b	**3.36 a**
20th Oct.	2.07 d	1.77 e	1.47 ef	3.87 a	**2.29 b**	2.73 d	2.30 e	1.90 f	5.10 a	**3.01 b**
10th Nov.	1.37 f	0.90 g	0.90 g	1.73 e	**1.23 c**	1.77 g	1.17 g	1.17 g	2.27 ef	**1.59 c**
Mean	**2.07 b**	**1.62 c**	**1.36 d**	**3.09 a**		**2.70 b**	**2.10 c**	**1.76 d**	**4.06 a**	

B- Seed yield and its components of faba bean:

The obtained data in **Table 4** indicated that faba bean yield i.e., pods number/plant, 100-seed weight, and seed yield/fed significantly affected by sowing dates, number of calcium-boron sprays and their interactions in both seasons.

Respect to sowing dates effect the results showed that pods number/plant, 100-seed weight and seed yield/fed gradually increased with delayed sowing dates in both seasons. Faba bean plants sown on 10th Nov. recorded the highest pods number/plant (19.59 and 21.06), 100-seeds weight (88.87 and 89.37 g) and seed yield/fed (2727.88 and 2775.89 kg) followed by plants sown on 20th Oct. in both seasons, respectively. On the other side, the lowest pods number/plant, 100-seeds weight and seed yield/fed were recorded in faba bean that sowed on 1st Oct.in the first and second seasons. All yield and yield components traits in the present study significantly differ under the different sowing dates. For pods number/plant, **Bakheit *et al.*, (2001)** revealed that the sowing date exerted a major influence No of pods / plant. In contrast of our findings, **Abbas *et al.*, (2010)**, **Khalil *et al.*, (2011)**, found that progressive delay in sowing beyond 20th November reduce number of pods /plant. In contrast, **Abdou *et al.*, (2013), Kiyanbakht *et al.*, (2015)** and **Marwa *et al.*, (2018)** found that the early sowing date gave the highest number of pods/plant. Respect to 100-seed weight **Wakweya *et al.*, (2016)**, **Sallam *et al.*, (2017)** who found significant reduction in 100–seeds weight with delaying faba bean sowing date after 15th November. In previously studied sowing date exerted a considerable influence on seed yield of faba bean **(Bakheit *et al.*, 2001)**. Our results are the same way of **Hussien *et al.*, (2006)** who indicated that the highest values of yield and its attributes were taken when faba bean sown in the mid-November. On the other side, **Badr *et al.*, (2013)**, **Hegab and Abdrabbo (2014)**, **Ibrahim (2016), Wakweya *et al.*, (2016), Manning (2017)**, **Megawer*et al.*, (2017)** and **Tawfik *et al.*, (2018)** found that early sowing (late Oct.to early Nov.) significantly increased vegetative growth and seed yield of faba bean.

For the effect of calcium-boron foliar spraying numbers on pods number/plant the results showed significant increase on pods number/plant, 100-seed weight and seed yield/fed with the increase of calcium-boron spraying numbers compared with the control in both seasons. Faba bean plants that sprayed three times with calcium-boron recorded the highest pods number/plant (17.68 and 19.84), 100-seeds weight (83.23 and 82.28 g) and seed yield/fed (2460.82 and 2505.81 kg) in the two seasons of the study, respectively followed by plants that sprayed with calcium-boron twice then once with calcium-boron. In contrast of this, faba bean plants under the control treatment recorded the lowest pods number/plant, 100-seeds weight, and seed yield/fed in both seasons. In faba bean calcium application as foliar spray was significantly increased number of pods/plant **(Munns and Tester (2008)** and **Khalil *et al.*, (2015))**. As for the effect of boron **Shaaban *et al.*, (2006)**, **Al-Hasany *et al.*,(2020)** and **Alabade*et al.*, (2022)** showed that boron foliar fertilization had significantly increased in number of pods of faba bean. For 100-seed weight, **Assi, *et al.*, (2019)** showed that boron spraying led to significant increase in weight of 100 seeds of faba bean compared to the control. While, **Alabade *et al.*, (2022)** showed that weight of 100 seeds was higher under boron application than the control. In previous study, the highest seed yield/plant was obtained by calcium foliar application of 2 gm/L. and this increase was associated with the increase in number of pods/plant**(Munns and Tester 2008).** Respect to the effect of calcium foliar spray in faba bean yield, **Mona *et al.*, (2011), Khalil *et al.*, (2015)**, **Mesbah (2016)** and **Abo-Hegazy *et al.*, (2022)** showed that calcium application as foliar spray was significantly

increased seed yield. With regard to the effect of boron foliar application on faba bean yield, **Obaid (2013), Khattab *et al.*, (2016)**,**Al-Hasany *et al.*, (2020)** showed that boron foliar fertilization in a in the spray solution has significantly increased seed yield compared with the control.

Regarding the effect of the interactions between sowing dates and calcium-boron spraying numbers on pods number/plant, 100-seed weight and seed yield/fed the data cleared differ response of faba bean plants to calcium-boron spraying number under the different sowing dates in both seasons. Spraying three times with calcium-boron in the late sowing date (10th Nov.) showed the highest pods number/plant (21.47 and 23.08), 100-seeds weight (97.43 and 97.67 g) and seed yield/fed (2990.63 and 3043.27 kg) in both seasons, respectively, followed by plants that sprayed twice with calcium-boron in 10th Nov. then plants that sprayed once with calcium-boron in the late sowing date. On the other hand, the un-sprayed faba bean plants in the early sowing date (1st Oct.) had the lowest pods number/plant, 100-seeds weight and seed yield/fed in the first and second seasons.

Table 4: Effect of sowing dates, calcium-boron foliar application and their interactions on faba bean yield and yield components traits during 2021/2022 and 2022/2023 seasons

Planting dates	Once	Twice	Three times	control	Mean (A)	Once	Twice	Three times	control	Mean (A)
	1st season					2nd season				
	Number of pods/plant									
1st Oct.	13.30 ef	14.67 e	15.03 de	11.80 f	**13.70 c**	14.98 gh	16.53 fg	16.91 fg	13.29 h	**15.43 c**
20th Oct.	14.67 e	16.17 d	16.53 d	12.97 ef	**15.08 b**	17.30 efg	19.09 cde	19.53 cd	15.35 g	**17.82 c**
10th Nov.	19.00 bc	21.00 ab	21.47 a	16.90 c	**19.59 a**	20.45 b	22.56 ab	23.08 a	18.14 de	**21.06 a**
Mean (B)	**15.66 b**	**17.28 a**	**17.68 a**	**13.89 c**		**17.58 b**	**19.39 a**	**19.84 a**	**15.59 c**	
	100-seed weight									
1st Oct.	65.19 f	71.92 e	73.60 de	57.83 g	**67.14 c**	62.91 e	69.41 d	71.03 d	55.81 f	**64.79 c**
20th Oct.	71.71 e	77.59 c	78.65 c	63.61 f	**72.89 b**	69.20 d	76.35 c	78.13 c	61.39 e	**71.27 b**
10th Nov.	86.30 b	95.21 a	97.43 a	76.55 cd	**88.87 a**	87.62 b	95.43 a	97.67 a	76.74 c	**89.37 a**
Mean (B)	**74.40 b**	**81.57 a**	**83.23 a**	**66.00 c**		**73.25 b**	**80.40 a**	**82.28 a**	**64.65 c**	
	Seed yield/fed (kg)									
1st Oct.	1852.34 h	2043.55 g	2091.35 f	1643.20 j	**1907.61 c**	1889.39 i	2084.42 h	2133.18 g	1676.07 k	**1945.76 c**
20th Oct.	2037.57 g	2247.90 e	2300.49 d	1807.52 i	**2098.37 b**	2073.43 h	2287.47 f	2340.97 e	1839.34 j	**2135.30 b**
10th Nov.	2648.84 b	2922.27 a	2990.63 a	2349.78 c	**2727.88 a**	2695.46 c	2973.71 b	3043.27 a	2391.14 d	**2775.89 a**
Mean (B)	**2179.59 b**	**2404.58 a**	**2460.82 a**	**1933.50 c**		**2219.43 b**	**2448.53 a**	**2505.81 a**	**968.85**	

C-Seed content of protein, calcium (Ca), and boron (Br):

The obtained data in **Table 5** revealed that faba bean seeds content of total protein, calcium and boron significantly differ under all sowing dates, calcium-boron spraying numbers and their interactions in both seasons.

Faba bean plants that sowed on 10th Nov. recorded the highest seeds content of total protein (23.28 and 24.32 g/100g dw) and seed content of boron (5.09 and 5.12 mg/100g dw) followed by plants sowed on 20th Oct. in both seasons, respectively. On the other side, the lowest seeds content of total protein and boron (2.95 and 2.92 mg/100g dw) were observed in faba bean sowed on 1st Oct. in the first and second seasons, respectively. Plants sowed on 1st Oct. had the highest seeds content of Ca (203.44 and 204.77 mg/100g dw), followed by plants sowed on 20th Oct. (142.02 and 133.37 mg/100g dw) in both seasons, respectively. On the other hand, the lowest seeds content of calcium was recorded in faba bean sowed on 10th Nov. in both seasons. In previous studies, **Hussien *et al.*, (2002)** who found that early sowing (late Oct.to early Nov.) significantly increased seed content of protein. Also, **Megawer *et al.*, (2017)** indicated that the early sowing date (22nd Oct.) produced the highest carbohydrate and protein percentage. In the same line, **Tawfik *et al.*, (2018)** detected that the highest values for micronutrients content were taken at 1st Nov. sowing date

For the effect of calcium-boron foliar spraying numbers the results showed significant increase on seeds content of total protein and Br with the increase of calcium-boron spraying numbers compared with the control in both seasons. Faba bean plants that sprayed three times with calcium-boron recorded the highest seeds content of total protein (21.80 and 22.77 g/100g dw) and seed content of Br (4.39 and 4.30 mg/100g dw) followed by plants that sprayed with calcium-boron twice then faba bean plants that sprayed once with calcium-boron in the two seasons of the study, respectively. In the contrast of this, faba bean plants under the control treatment recorded the lowest seeds content of total protein and boron in both seasons. Seed content of calcium gradually decreased with the increase of calcium-boron spraying numbers in

both seasons. Faba bean plants that sprayed three times with calcium-boron had the highest seeds content of calcium (175.63 and 172.08 mg/100g dw) followed by faba bean plants that sprayed twice with calcium-boron (166.68 and 164.55 mg/100g dw) followed by plants that sprayed with calcium-boron once (148.00 and 141.27 mg/100g dw) in the first and second seasons, respectively. In contrary of this, faba bean plants under the control treatment recorded the lowest seeds content of calcium in both seasons. In similar trend, **Abou El- Yazied and Mady (2012)** reported that foliar spray of broad bean with boron at 50 mg/l increased the content of photosynthetic pigments, total free amino acids and protein in the leaves. **Pandey and Gupta (2012)** observed that the foliar application of borax improves the seed quality in terms and storage, seed protein and carbohydrate in black gram. Finally, **Salih (2013)** showed that the effect of different treatments on nutrient concentration and seed protein were significant.

For seed content of calcium, **Hassanein *et al.*, (1999)** reported that application of boron increased the contents of P, K, Na, Ca, Fe, Mn, Zn, Cu and B in cowpea seeds. **Shaaban *et al.*, (2006)** showed that boron effect additively increased nutrient content within faba bean plant tissue. While, **Ganie *et al.*, (2014)** suggested that soil application of S and Br increased the availability of primary nutrients in addition to sulfur and boron causing their absorption by French bean plant.

Regarding seed content of boron **Ankush (2015)** found that the low dose of boron help to release micro nutrient from the soil **Hamouda *et al.*, (2018)** showed that foliar application of Zn or B led to positive increases of macronutrients (N, K and Ca) and micronutrients (Zn, B and Cu) concentration in bean leaves and seeds.

Regarding the effect of the interactions between sowing dates and calcium-boron spraying numbers, the data cleared different responses of faba bean plants to calcium-boron spraying number under the different sowing dates in both seasons. Faba bean plants that sprayed three times with calcium-boron in the late sowing date (10th Nov.) showed the highest seeds content of total protein (25.52 and 26.66 g/100g dw), seeds content of calcium (228.51 and 231.19 mg/100g dw) and boron (5.71 and 5.78 mg/100g dw) followed by plants that sprayed twice with calcium-boron in 10th Nov. then plants that sprayed once with calcium-boron in the late sowing date in both seasons. On the other hand, the un-sprayed faba bean plants in the early sowing date (1st Oct.) had the lowest seeds content of total protein, seeds content of calcium and boron in the first and second seasons.

Table 5: Effect of sowing dates, calcium-boron foliar application and their interactions on faba bean seeds contents of total protein, calcium and boron during 2021/2022 and 2022/2023 seasons.

Planting dates	Once	Twice	Three times	control	Mean (A)	Once	Twice	Three times	control	Mean (A)
	1st season					2nd season				
	Total protein (g/100 g dw)									
1st Oct.	17.07 ef	18.84 cde	19.28 cd	15.15 f	**17.58 b**	17.84 de	19.68 cd	20.14 c	15.82 f	**18.37 b**
20th Oct.	18.78 de	20.32 c	20.60 c	16.66 f	**19.09 b**	19.62 c	21.23 c	21.52 c	17.40 ef	**19.94 b**
10th Nov.	22.60 b	24.93 a	25.52 a	20.05 c	**23.28 a**	23.61 b	26.05 a	26.66 a	20.94 c	**24.32 a**
Mean	**19.49 b**	**21.36 a**	**21.80 a**	**17.29 c**		**20.36 b**	**22.32 a**	**22.77 a**	**18.06 c**	
	Seeds content of calcium (mg/100g dw)									
1st Oct.	110.09	124.06 f	133.63 e	104.34 h	**118.03 c**	106.23 h	122.06 fg	129.46 f	108.78 gh	**116.63 c**
20th Oct.	136.85 e	150.68 d	164.74 c	115.80 g	**142.02 b**	117.90 g	146.31 e	155.59 d	113.69 gh	**133.37 b**
10th Nov.	197.06 b	225.30 a	228.51 a	162.90 c	**203.44 a**	199.68 b	225.30 a	231.19 a	162.90 c	**204.77 a**
Mean	**148.00 c**	**166.68 b**	**175.63 a**	**127.68 d**		**141.27 c**	**164.55 b**	**172.08 a**	**128.46 d**	
	Seeds content of boron (mg/100g dw)									
1st Oct.	2.75 f	3.10 e	3.34 de	2.61 f	**2.95 c**	2.66 f	3.05 de	3.24 cd	2.72 ef	**2.92 c**
20th Oct.	3.42 de	3.77 d	4.12 cd	2.89 f	**3.55 b**	2.95 de	3.66 bc	3.89 b	2.84 ef	**3.33 b**
10th Nov.	4.93 b	5.63 ab	5.71 a	4.07 c	**5.09 a**	4.99 b	5.63 a	5.78 a	4.07 b	**5.12 a**
Mean	**3.70 b**	**4.17 a**	**4.39 a**	**3.19 c**		**3.53 b**	**4.11 a**	**4.30 a**	**3.21 c**	

CONCLUSION:

It could be recommended to sow faba beans during November by spraying with calcium-boron three times to obtain the highest yield and seed quality in the Delta region.

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الملخص العربي

التقوية الحيوية لإنتاجية وجودة الفول البلدي باستخدام مواعيد الزراعة والرش الورقي للكالسيوم بورون

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أجريت تجربة حقلية في المزرعة البحثية لمحطة البحوث الزراعية بإيتاى البارود، مركز البحوث الزراعية، محافظة البحيرة ، مصر خلال موسمي الزراعة 2021–2022 و 2022–2023 على صنف الفول البلدي جيزة 716. كان الهدف من الدراسة اختبار تأثير مواعيد الزراعة المختلفة (1 أكتوبر، 20 أكتوبر ، 10 نوفمبر) مقترنة مع تطبيقات الرش الورقي بالكالسيوم بورون (مرة ، مرتين وثلاث مرات مقارنة مع الكنترول). لهذا الغرض تم تصميم تجربة حقلية في نظام القطعة المنشقة في ثلاث مكررات حيث تم وضع مواعيد الزراعة في قطع الأرض الرئيسية ووزعت تطبيقات الرش الورقي بالكالسيوم– بورون بشكل عشوائي في القطع الفرعية. أوضحت النتائج أن زراعة الفول البلدي في العاشر من نوفمبر أدت إلى زيادة في نمو ومحصول النبات حيث تم الحصول على أعلى طول للنبات وكذلك أعلى عدد قرون / نبات ، وزن 100 بذرة ، محصول البذور / فدان ، محتوى البذور من البروتين الكلي ومحتوى بذور البورون في كلا الموسمين. سجلت نباتات الفول البلدي التي تم رشها ثلاث مرات بالكالسيوم والبورون أعلى ارتفاع للنبات وعدد القرون / نبات ووزن 100 بذرة ومحصول البذور/ فدان ومحتوى البذور من البروتين الكلي والكالسيوم والبورون في كلا الموسمين. أعطى تأثير التفاعل بين تاريخ الزراعة وتطبيقات الرش لبورون الكالسيوم أعلى قيم النمو الخضري ومحصول البذور وجودة البذور في كلا الموسمين.

التوصية:

يوصي البحث بزراعة الفول البلدي خلال شهر نوفمبر مع الرش ثلاث مرات بالكالسيوم–بورون للحصول على أعلى محصول وجودة بذور في منطقة الدلتا.