J. of Plant Production, Mansoura Univ., Vol. 16 (9):567 -574, 2025

Journal of Plant Production

Journal homepage & Available online at: www.jpp.journals.ekb.eg

Response of Peanut Plants to Foliar Nutrition Treatments and Plant Densities Under the Condition of Newly Reclaimed Sandy Soils

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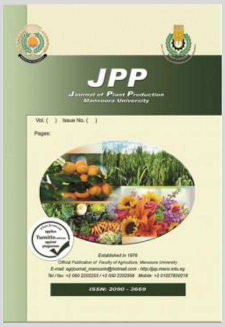

Article Information
Received 16/ 8/2025
Accepted 22/ 9/2025

ABSTRACT

The effects of four foliar applications [tap water (control), 1700 ppm chelated calcium (10% Ca-EDTA), 1700 ppm chelated calcium plus 1500 ppm chelated zinc (13% Zn-EDTA), and 1700 ppm chelated calcium plus 1200 ppm chelated iron (13% Fe-EDTA)] as well as three plant densities (56000, 42000, and 33600 plants/fad) were investigated in two field experiments during the 2023 and 2024 seasons in the El-Qasasin district of the Ismailia Governorate on peanut Ismailia 2 cultivar in sandy soils. A split plot design with four replications was used. Foliar nutrition treatments allocated in the main plots, while the plant density treatments were arranged in sub plots.Regarding yield characters (pod, seed, straw, oil, and protein yields/fad) and plant traits, number of branches, pods, and seeds/plant as well as weight of hundred pods, pods and seeds/plant; it found that peanut plants sprayed with 1700 ppm chelated calcium plus 1200 ppm iron or 1500 ppm zinc significantly outperform those treated with calcium alone and the unsprayed control in the two seasons.The yields of pods, seed, straw, oil, and protein per fad in the two seasons were significantly increased by reducing the hill spacing from 25 cm to 20 and 15 cm. Peanuts planted in hills 15 cm apart, with 56000 plants/fad and sprayed with 1700 ppm chelated calcium and 1200 ppm iron yielded the highest pod, seed, oil, and protein/fad, in the two seasons.

Keywords: Peanut; Nutrients foliar Spraying; Plant density

INTRODUCTION

Peanuts (*Arachis hypogaea* L.) are among the world's most significant edible oil crops. In Egypt, it is an important field crop for export with a total area reached about 159.95 thousand fad during the average period (2020-2022). Egyptian average peanut productivity is about 1.4 ton/fad, and the average total production is about 198.78 thousand ardabs. By studying the indicators of foreign trade for the crop during the period from (2015-2020), it shows the fluctuation in the quantity of exports and the increase in the value of Egyptian exports of peanut during the study period, where the minimum amounted to about 39.80 million dollars in 2015 and a maximum of about 70.87 million dollars in the year 2020, as for the geographical distribution of Egypt's exports of the crop to the countries of the world (El-Sareef., 2022). Peanut cultivation in recently reclaimed sandy soils faces numerous challenges, including low fertility, particularly in micronutrients and calcium, as well as deficiencies and significant nutrient loss due to leakage.

Calcium promotes root and leaf development and is important for formation and functioning of root nodules bacteria in legumes. It is a constituent of the cell walls and necessary for cell elongation, protein synthesis and normal cell division. Also calcium regulates the translocation of carbohydrates, cell acidity and permeability. It improves general plant vigor and increases stiffness of straw and encourages seed production (Follett *et. al.* 1981).

Several investigators announced that application of calcium had favorable effect on peanut yield, its attributes and quality (Kamara *et al.* (2011); Kabir *et al.* (2013); Xue-hua *et al.* (2015); Nobahar *et al.* (2019); Hamza *et al.* (2023); Wang *et al.* (2023) and Norani (2024)).

Concerning micronutrients, Zinc plays essential roles in metabolism of carbohydrates and proteins in addition to it is required for auxin and ribosome formation. Also, zinc is a component of many enzymes such as dehydrogenase and phosphohydrolase beside it stimulates various enzymatic systems (Marschner, 1986). In sandy soils, foliar spraying of micronutrients ensures that they are easily absorbed by the leaves and do not loss through fixation, degradation, or leaching.

Numerous researchers have documented the advantages of zinc foliar spraying on peanut yield, its components, and quality (Abd EL-Kader, 2013; Irmaka *et al.*, 2016; Rajiv and Vanathi, 2018; Nobahar *et al.*, 2019; Noaman *et al.*, 2022; Shokri *et al.*, 2022 and Norani *et al.*, 2024).

Iron is a crucial mineral for the healthy growth of plants. It is an essential component of numerous enzymes, including cytochrome oxidase, peroxidase, and catalase. Iron also contributes to the synthesis of proteins, chlorophyll and chloroplastides. Iron increases the rate of photosynthesis and the rate at which bacteria in root nodules fix nitrogen. It controls breathing (Marschner, 1986). However, iron concentration in sandy soils is insufficient for plants to meet their needs, and in addition, iron fertilizers are highly lost through fixation or leaching in sandy soils. In turn, iron application, in form of foliar spraying, is so important.

Gohari and Niyaki (2010), Poonia *et al.* (2018), Akhtar *et al.* (2019), Kaya and Ünay (2022), Keskin and Kayişoğlu (2022), Noaman *et al.* (2022) and Poonia *et al.* (2022) documented the positive effects of foliar iron spray on peanut yield, its attributes and quality.

Increasing peanut productivity from sandy soils can be achieved by growing new high yielding cultivars with

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DOI: 10.21608/jpp.2025.406544.1493

optimum plant population density. Ismailia 2 is new peanut cultivar in Egypt; it is semi spread cultivar. Therefore optimum plant density for peanut could be achieved by comparison between several hill spacing and picked the best one. Many researchers have examined how plant density affects peanut yield, its characteristics and quality (Gabisa *et al*., 2017; Kurt *et al*., 2017; Zhao *et al*., 2017; Bakal *et al*., 2020; Yilmaz and Jordan, 2022; Musa *et al*., 2023).

The purpose of this study was to examine how the new peanut cultivar (Ismailia 2) responded in terms of production, characteristics and quality to foliar application of chelated calcium, zinc, and iron under varying plant densities in sandy soils at the Ismailia Governorate.

MATERIALS AND METHODS

The effects of foliar spraying with chelated calcium, zinc and iron as well as plant density on a novel peanut (*Arachis hypogaea* L.) cultivar called Ismailia 2 were investigated in two field trails carried out in 2023 and 2024 at the EI-Qasasin district in the Ismailia Governorate. The soil was sandy with 0.11% and 0.12% organic matter, 3.66 and 3.71 ppm of available N, 1.75 and 1.78 ppm of available P, 10.68 and 10.82 ppm of available K, EC 1.13 (ds/m) and a pH of 7.74 and 7.71 in the two seasons, respectively.

Each replicate contains twelve treatments (four foliar nutrition treatments: tap water (control), 1700 ppm chelated calcium (10% Ca-EDTA), 1700 ppm chelated calcium plus 1500 ppm chelated zinc (13% Zn-EDTA), and 1700 ppm chelated calcium plus 1200 ppm chelated iron (13% Fe-EDTA) and Peanuts were planted in ridges 50 cm wide with hill spacing of 15, 20, and 25 cm to provide three plant densities treatments: 56000, 42000, and 33600 plants/fad). Four replicates were used in the split plot experimental design. The main plots had four randomly placed foliar nutrition treatments, and the subplots had three randomly assigned plant density treatments. Six ridges measuring six meters in length and fifty centimeters in width made up each experimental subplot (plot size was 18 m^2). In both growing seasons, wheat was the previous crop.

The soil was prepared for sowing by applying a basal dosage of calcium superphosphate (15.5% P_2O_5) at a rate of 350 kg/fad. Three separate foliar nutrition treatments were sprayed three times at 35, 50, and 65 days after seeding.Four equal doses of nitrogen in the form of ammonium sulphate (20.5% N) to give total amount 90 kg N/fad were applied at 20, 30, 45, and 60 days after seeding. After 30, 45, and 60 days from seeding, three equal basal doses of potassium sulphate (48% K_2O) were applied at a rate of 150 kg/fad.

Ismailia 2 was the cultivar that utilized. For the first and second seasons, seeds were sown on May 4 and May 5, respectively. Before being sown, the seeds were immediately covered with Arab gum and inoculated with the particular strain of Rhizobium according to the improved package of the Ministry of Agricultural recommendations, practices for growing peanut were allowed. at Ismailia Governorate, excluding the factors under study.

In order to measure plant height (cm), number of branches/plant, number of pods/plant, number of seeds/plant, weight of pods per plant (g), weight of 100 pods (g), weight of 100 seeds (g) and shelling percentage, samples of twenty guarded plants were randomly obtained from each three inner ridges in each subplot at harvest time (135 days after sowing).

Plants of the inner ridges in each subplot were used to estimate the pod yield per fad (in Ardab), seed yield per fad (kg) and straw yield per fad (in Ton).

In accordance with A.O.A.C. (1990), the Soxhelt continuous extraction device was used to estimate seed oil percentage using petroleum ether as an organic solvent.

By multiplying the seed oil % by the seed yield per fad, the oil yield per fad (kg) was determined. The modified Micro-Kjeldahl Apparatus, as described by A.O.A.C. (1990), was used to calculate the seed crude protein percentage as total nitrogen (%) of peanut seeds. The results were then multiplied by 6.25, as used by Tripathi *et al*. (1971). Seed crude protein % and seed yield per fad were multiplied to determine protein yield per fad (kg).

The design of split plots was analyzed for variance in accordance with Snedecor and Cochran (1982). Duncan's Multiple Range Test (Duncan, 1955) was used to compare the means of the treatments. According to Duncan's Multiple Range Test, at the 5% level of significance, means that are followed by the same alphabetical letters are not statistically distinct (Duncan, 1955).

RESULTS AND DISCUSSION

A- Effect of chelated calcium and micronutrients:

In comparison to the unsprayed plants (control) table 1 show that foliar spraying peanut plants with 1700 ppm chelated calcium, either alone or in combination with 1500 ppm chelated zinc or 1200 ppm chelated iron, increased plant height and that was true in the two seasons but the differences between the three treatments were insignificant. In this regard, the current study's findings were comparable to those published by Nawaz *et al*. (2012), Kabir*et al*. (2013), Abdel-Motagally*et al*. (2016), Gowthami and Ananda (2017), Dinkar (2019), Nobahar*et al*. (2019) and Noaman*et al*. (2022).

Table (1) demonstrates that plants sprayed with chelated calcium plus iron produced the highest numbers of branches and pods per plant as well as the weight of 100 peanut pods. These plants were followed by plants sprayed with chelated calcium plus zinc, chelated calcium only and unsprayed control. The same trend of results was found in the two growing seasons. Kabir *et al*. (2013), Xue-hua *et al*. (2015), Abdel-Motagally *et al*. (2016), Hagari and Pattar (2017), Dinkar (2019), Nobahar *et al*. (2019), Noaman *et al*. (2022), Hamza *et al*. (2023) and Wang *et al*. (2023) all cited results of previous researches support the present findings.

Spraying peanut plants with chelated calcium plus iron increased the number of pods per plant by 9.72%, 20.75% and 56.07 % in the first season and 9.90%, 21.51% and 58.20% in the second season when compared to calcium plus zinc, calcium only and unsprayed control (Table 1).

Statistically, peanut plants treated with chelated iron and chelated calcium were comparable to those treated with zinc and calcium in terms of hundred seed weight. Both treatments significantly outperform plants sprayed with calcium only. However, compared to the unsprayed control, the three aforementioned treatments significantly increased the weight of 100 seeds, and that held true in the two seasons (Table 2). The findings of this study were comparable to those of Abdel-Motagally *et al*. (2016), Dinkar (2019), Nobahar *et al*. (2019) and Noaman *et al*. (2022).

Table 1. Effect of chelated calcium plus micronutrients and plant density on plant height, number of branches per plant, number of pods per plant and weight of 100 pods of peanut in 2023 and 2024 seasons.

Treatments	Plant height (cm)		Number of branches per plant		Number of pods per plant		Weight of 100 pods	
	2023	2024	2023	2024	2023	2024	2023	2024
Foliar application								
Tap water (control)	52.76 d	57.22 d	25.18 d	27.95 d	23.86 d	25.96 d	227.15 d	235.28 d
Ca	62.79 c	68.26 c	37.19 c	40.75 c	30.84 c	33.80 c	281.13 c	290.09 c
Ca + Zn	63.86 b	69.42 b	39.63 b	44.02 b	33.94 b	37.37 b	303.16 b	313.58 b
Ca + Fe	65.56 a	70.97 a	43.71 a	48.45 a	37.24 a	41.07 a	341.90 a	351.45 a
Hill spacing (Plants densities)								
15 cm (56000)	56.86 c	61.93 c	33.22 c	36.61 c	29.45 c	32.24 c	278.11 c	287.98 c
20 cm (42000)	61.15 b	66.61 b	36.46 b	40.38 b	31.69 b	34.77 b	288.68 b	297.96 b
25 cm (33600)	65.72 a	70.87 a	39.59 a	43.88 a	33.27 a	36.64 a	298.22 a	306.86 a
Interaction effect								
Foliar x D	*	*	*	*	*	*	*	*

Table 2. Effect of chelated calcium plus micronutrients and plant density on weight of pods per plant, number of seeds per plant, weight of 100 seeds and weight of seeds per plant of peanut in 2023 and 2024 seasons.

Treatments	Weight of pods per plant (g)		Number of seeds per plant		Weight of 100 seeds (g)		Weight of seeds per plant (g)	
	2023	2024	2023	2024	2023	2024	2023	2024
Foliar application								
Tap water (control)	66.20 d	71.28 d	39.58 d	42.89 d	86.18 d	88.25 d	34.74 d	37.48 d
Ca	89.20 c	96.47 c	54.26 c	59.53 c	108.42 c	111.02 c	59.94 c	65.13 c
Ca + Zn	96.26 b	104.95 b	60.51 b	66.69 b	110.42 b	113.06 b	65.68 b	71.53 b
Ca + Fe	108.18 a	117.42 a	67.17 a	74.23 a	112.74 a	115.46 a	75.53 a	82.71 a
Hill spacing (Plants densities)								
15 cm (56000)	86.41 c	94.31 c	51.21 c	56.12 c	103.44 c	105.93 c	55.59 c	60.98 c
20cm (42000)	90.20 b	97.40 b	55.68 b	61.26 b	104.14 b	106.64 b	59.05 b	64.13 b
25cm (33600)	93.24 a	100.87 a	59.25 a	65.13 a	105.74 a	108.27 a	62.28 a	67.53 a
Interaction effect								
Foliar x D	*	*	*	*	*	*	*	*

Concerning the weight of pods and weight of seeds per plant as well as the number of seeds per plant data in Table 2 illustrated that plants sprayed with iron and calcium outperformed those treated with zinc and calcium. However, both treatments significantly outperformed plants sprayed with calcium alone and the unsprayed plants (control). The same trend of results was found in 2023 and 2024 seasons.

In terms of pod weight per plant, peanut plants sprayed with iron and calcium were 12.38%, 21.28% and 63.41% exceeded those sprayed with zinc and calcium, calcium alone and unsprayed control in the first season and 11.88%, 21.72% and 64.73% respectively in the second season (Table 2). Kabir *et al.* (2013), Abdel-Motagally *et al.* (2016), Noaman *et al.* (2022) and Hamza *et al.* (2023) reported highlighted similar findings.

The increase in seed weight per plant may be as result in increasing number of seeds per plant and the weight of the hundred seeds. The findings of Abdel-Motagally *et al.* (2016), Noaman *et al.* (2022) and Hamza *et al.* (2023) are in agreement with these findings.

When chelated calcium was sprayed on peanut plants, shelling percentage and seed oil content increase significantly in comparison to the unsprayed control (Table 3). Also plants sprayed with calcium plus zinc or iron showed a significant increase in the percentage of shelling and seed oil content compared to those sprayed with calcium alone or plants unsprayed (control treatment).

Table 3. Effect of chelated calcium plus micronutrients and plant density on shelling percentage, pod yield per fad, straw yield per fad and seed oil percentage of peanut in 2023 and 2024 seasons.

Treatments	Shelling percentage		Pod yield per fad (Ardab)		Straw yield per fad (ton)		Seed yield per fad (kg)	
	2023	2024	2023	2024	2023	2024	2023	2024
Foliar application								
Tap water (control)	52.43 d	52.58 d	41.72 d	44.44 d	12.95 d	14.06 d	1641.23 d	1769.41 d
Ca	67.17 c	67.56 c	50.50 c	53.78 c	14.09 c	15.22 c	2547.04 c	2736.83 c
Ca + Zn	68.21 b	68.51 b	54.61 b	58.16 b	15.52 a	16.85 a	2799.05 b	3026.01 b
Ca + Fe	69.78 a	70.47 a	55.91 a	59.54 a	15.36 b	16.66 b	2927.65 a	3123.34 a
Hill spacing (Plants densities)								
15 cm (56000)	63.14 c	63.72 c	62.77 a	66.86 a	18.10 a	19.56 a	3015.28 a	3261.69 a
20 cm (42000)	64.38 b	64.71 b	49.15 b	52.34 b	13.90 b	14.97 b	2411.75 b	2575.74 b
25 cm (33600)	65.68 a	65.91 a	40.14 c	42.74 c	11.44 c	12.56 c	2009.19 c	2154.27 c
Interaction effect								
Foliar x D	*	*	*	*	*	*	*	*

The increase in seed oil content by spraying chelated calcium alone either zinc or iron plus calcium was expected since calcium regulates the translocation of carbohydrates, while, zinc plays essential role in metabolism of carbohydrates and stimulates various enzymes. Moreover iron is a component of many enzymes and enhances several metabolic processes. Gashti *et al.* (2012), Kabir *et al.* (2013), Xue-hua *et al.* (2015), Abdel-Motagally *et al.* (2016), Hagari and Pattar (2017), Dinkar (2019), Noaman *et al.* (2022), Shokri *et al.* (2022), Hamza *et al.* (2023) and Norani *et al.* (2024) have all reported results that are consistent with these findings.

From Table (3) it's clearly evident that peanut plants sprayed with chelated calcium plus iron was statistically similar to those sprayed by chelated calcium plus zinc in pod and straw yields per fad, however both treatments significantly overcome plants sprayed with 1700 ppm chelated calcium only and unsprayed control in the two seasons. However, in comparison to the unsprayed control in both seasons, spraying peanut plants with chelated calcium only significantly increased the two aforementioned features. These findings agree with those published by Gashti *et al.* (2012), Kabir *et al.* (2013), Xue-hua *et al.* (2015), Abdel- Motagally *et al.* (2016), Dinkar (2019), Noaman *et al.* (2022), Hamza *et al.* (2023), Wang *et al.* (2023) and Norani (2024).

The increases in the number of branches per plant, number of pods per plant, the weight of the hundred pods and the weight of the pods per plant may be related to the increases in pod yield and straw yield per fad.

Table (4) shows that, in comparison to the unsprayed control, spraying peanut plants with chelated calcium significantly increased seed yield per fad and seed crude protein %. In terms of seed yield per fad and seed crude protein percentage, plants sprayed with chelated calcium plus iron were statistically equal to those treated with chelated calcium plus zinc; however, both treatments significantly outperformed plants that received chelated calcium alone and the unsprayed control in both seasons.

The increase in number of seeds per plant, seed weight per plant, and seed weight per plant can be attributed to the beneficial effects of spraying peanut plants with chelated calcium, zinc, and iron on seed yield per fad. Gashti *et al.* (2012), Xue-hua *et al.* (2015), Abdel-Motagally *et al.* (2016), Dinkar (2019), Nobahar *et al.* (2019), Shokri *et al.* (2022), Hamza *et al.* (2023) and Norani (2024) have all published findings that are similar to the results presented here.

In comparison to plants treated with chelated zinc plus calcium, peanut plants sprayed with chelated iron plus calcium showed a significant increase in oil and protein yields per fad (Table 4). Nevertheless, both treatments significantly outperformed plants sprayed with calcium only and unsprayed control in both seasons. However, during both seasons, peanut plants sprayed with chelated calcium significantly outperformed the unsprayed plants (control).

Peanut plants sprayed with chelated iron plus calcium outyielded those received chelated zinc plus calcium, calcium only and unsprayed plants (control) in oil yield per fad by 6.10 %, 20.36 % and 97.49 %, respectively in the first season and 5.28 %, 20.03 and 95.06%, respectively in the second season (Table 4).

Table 4. Effect of chelated calcium plus micronutrients and plant density on seed yield per fad, seed crude protein percentage, oil yield per fad and protein yield per fad of peanut in 2023 and 2024 seasons.

Treatments	Seed oil percentage		Seed crude protein percentage		Oil yield per fad (Kg)		Protein yield per fad (Kg)	
	2023	2024	2023	2024	2023	2024	2023	2024
				Foliar application				
Tap water (control)	47.41 d	48.38 d	28.27 d	28.55 d	780.14 c	856.88 d	463.01 d	503.38 d
Ca	50.20 c	50.92 c	30.84 c	31.26 c	1280.05 b	1392.52 c	785.61 c	853.93 c
Ca + Zn	51.74 b	52.45 b	32.32 b	32.78 b	1452.08 a	1587.61 b	906.36 b	992.26 b
Ca + Fe	52.49 a	53.47 a	33.53 a	34.07 a	1540.69 a	1671.47 a	983.46 a	1064.15 a
				Hill spacing (Plants densities)				
15 cm (56000)	50.08 c	50.79 c	30.62 c	31.00 c	1525.69 a	1670.27 a	938.76 a	1026.96 a
20 cm (42000)	50.44 b	51.40 b	31.22 b	31.74 b	1230.49 b	1336.41 b	765.81 b	829.86 b
25 cm (33600)	50.87 a	51.72 a	31.87 a	32.25 a	1033.53 c	1124.67 c	649.26 c	703.47 c
				Interaction effect				
Foliar x D	*	*	*	*	*	*	*	*

The increase in oil yield per fad may be due to the increases in seed oil content and seed yield per fad. These findings match those of Dinkar (2019), Nobahar *et al.* (2019), Hamza *et al.* (2023) and Norani (2024).

The rise in seed crude protein % and seed yield per fad may be the cause of the beneficial effect of applying chelated calcium, zinc and iron on protein yield per fad. Xue-hua *et al.* (2015), Dinkar (2019), Nobahar *et al.* (2019) and Norani (2024) came to similar results.

B-Plant density's impact:

Table (1) illustrates that during the growing seasons of 2023 and 2024, there was a significantly increased in plant height, the number of branches per plant, the number of pods per plant and weight of 100 pods as the planting distance between hills was increased from 15 cm to 20 cm and subsequently to 25 cm, concurrently decreasing the plant population density from 56,000 to 42,000 and 33,600 plants per fad. These results can be attributed to the diminished competition for growth resources, including light, spatial availability, moisture, and nutrients, among plants that are spaced further apart. These observations are consistent with the research findings published by Shaban *et al.* (2009), Kurt *et al.* (2017), Zhao *et al.* (2017), Chakraborty *et al.* (2019), Bakal *et al.* (2020), Minh *et al.* (2021), Sudhalakshmi *et al.* (2021), Yilmaz and Jordan (2022) and Musa *et al.* (2023).

Table (2) elucidates that peanut plants cultivated with a spacing of 25 cm exhibited the maximum seed weight per individual plant as well as the highest seed number per plant compared with those planted at 20 cm and 15 cm intervals following in productivity. There were significant variations among the three hill spaces, a trend that persisted across both growing seasons. Extensive hill spacing exerts a beneficial influence on yield parameters, which can be attributed to the enhanced accessibility and sufficiency of various growth resources, including nutrients, light, and moisture. These observations have been corroborated by the findings of Islam *et al.* (2011), Awal and Aktar (2015), Hefny and Ahmed (2017), Nwokwu *et al*. (2020) and Tallarita *et al*. (2021).

Increasing the distance between plants from 15 cm to 20 cm and 25 cm led to an increase in the weight of pods per plant, with no significant differences among these spaces, except for the significant difference between the 25 cm spacing and the narrower 15 cm spacing in both growing seasons (Table 2). Comparable findings were reported by Gabisa *et al*. (2017), Bakal *et al*. (2020), Gawas *et al*. (2020) and Yilmaz and Jordan (2022).

As shown in Table 2, increasing hill spacing from 15 cm to 20 cm and 25 cm led to an insignificant increase in the weight of one hundred seeds, a trend observed across both seasons. Findings by Kurt *et al*. (2017), Onat *et al*. (2017), Zhao *et al*. (2017), Bakal *et al*. (2020), Minh *et al*. (2021) and Musa *et al*. (2023) align with these recent observations.

Results in Table (3) indicate that increasing the hill spacing from 15 cm to 20 and 25 cm consistently increased shelling percentage and seed oil content. However, during the 2023 and 2024 seasons, the same trend of results was obtained concerning the two traits. Similar outcomes were documented by Hefny and Ahmed (2017), Kurt *et al*. (2017), Zhao *et al*. (2017), Gawas *et al*. (2020), Sudhalakshmi *et al*. (2021) and Yilmaz and Jordan (2022).

As shown in Table (3), increasing the plant population density from 33,600 to 42,000 and 56,000 plants per fad by decreasing the planting distance between hills from 25 cm to 20 cm and 15 cm led to a significant increase in peanut pod and straw yields per fad. This outcome was evident in both the 2023 and 2024 seasons.

In narrow hill spacing, the reduction in yield components of individual plants, such as the number and weight of pods per plant and the number of branches per plant, might be compensated by the rise in the number of plants per unit area. This could positively impact the highest pod and straw yields per fad. Ensuring the maximum yield per fad comes from the unit land area, is return to the individual yield per plant and the number of plants per unit area.

The present study outcomes concur with the preceding research findings of several investigators, encompassing Chandrasekaran *et al*. (2007), Islam *et al*. (2011), Sokoto *et al*. (2013), Gabisa *et al*. (2017), Hefny and Ahmed (2017), Kurt *et al*. (2017), Waghmode *et al*. (2017), Chakraborty *et al*. (2019), Bakal *et al*. (2020), Sunilkumar *et al*. (2020) and Yilmaz and Jordan (2022).

Regarding pod yield per fad, plants cultivated in hills spaced 15 cm apart (56,000 plants per fad) exhibited higher yields compared to those grown in hills spaced 20 cm apart (42,000 plants per fad) and 25 cm apart (33,600 plants per fad), with increases of 27.71% and 56.38%, respectively, during the first season and 27.74% and 56.43%, respectively, in the second season (Table 3).

Furthermore, data from the 2023 and 2024 growing seasons, presented in Table 4, indicate that increasing hill spacing from 15 cm to 20 cm and 25 cm led to a slight increase in the percentage of seed crude protein. These results are consistent with the findings reported by Kurt *et al*. (2017), Onat *et al*. (2017), Bakal *et al*. (2020) and Yilmaz and Jordan (2022).

Table (4) clearly demonstrates that, across the 2023 and 2024 growing seasons, there was a consistent and significant increase in oil and protein yields per fad as plant density was elevated to 56,000 plants per fad through the reduction of hill spacing to 15 cm. These findings align with the results previously reported by Gabisa *et al*. (2017), Waghmode *et al*. (2017) and Bakal *et al*. (2020).

Compared to planting distances of 20 cm (42,000 plants per fad) and 25 cm (33,600 plants per fad), the cultivation of peanut plants at 15 cm intervals (56,000 plants per fad) resulted in relative increases in oil yield per fad of 23.99% and 47.62%, respectively, during the first growing season. Corresponding increases of 24.98% and 48.51% were observed in the second season (Table 4).

C- Interaction effect:

During the 2023 and 2024 growing seasons, a significant interaction was identified between the application of chelated calcium combined with micronutrients and plant density, affecting various growth and yield parameters. These parameters included plant height, number of branches, pods and seeds per plant, weight of 100 pods, weight of 100 seeds, total weight of pods and seeds per plant, shelling percentage, seed oil content, and seed crude protein percentage (Table 5). The highest values across all these attributes were recorded in peanut plants treated with chelated calcium and iron, cultivated at a spacing of 25 cm between hills (equivalent to 33,600 plants per fad). Conversely, the lowest values were observed in plants spaced 15 cm apart (56,000 plants per fad) without any foliar application of calcium and micronutrients over the two seasons (Table 5). These findings are consistent with previous studies conducted by Fard *et al*. (2012), Salem *et al*. (2014), Khalil *et al*. (2015), Afshoon *et al*. (2022) and Coppetti *et al.* (2024).

The data presented in Table 5 indicate that the interaction between the application of chelated calcium plus micronutrients and plant density across two growing seasons significantly influenced the yields of pods, seeds, oil and protein per fad. Specifically, plants treated with chelated calcium and iron, and spaced at 15 cm intervals within hills, achieved the highest yields in all measured parameters. Conversely, untreated plants - those not sprayed with calcium and micronutrients - and cultivated at a wider spacing of 25 cm between hills (equivalent to 33,600 plants per fad) exhibited the lowest yield values. These findings are consistent with previous studies conducted by Fard *et al*. (2012), Salem *et al*. (2014), Khalil *et al*. (2015), Afshoon *et al*. (2022) and Coppetti *et al*. (2024).

According to the findings presented in Table 5, peanut plants cultivated in hills spaced 15 cm apart and treated with foliar applications of chelated calcium and zinc exhibited the highest straw yield per fad. Conversely, plants established in hills spaced 25 cm a part (equivalent to 33,600 plants per area) without foliar application of calcium and micronutrients over two growing seasons produced the lowest straw yield. These results are consistent with those reported by Kenawey (2019).

Table 5. Yield, its attributes and quality of peanut as significantly affected by the interaction between chelated calcium plus micronutrients and plant density in 2023 and 2024 seasons.

Character	Season	Highest value	Treatment	Lowest value	Treatment
Plant height (cm)	2023	69.33 a	(Ca+ Fe) X 25 cm (33600)	46.04 k	Control (Tap water) X 15 cm (56000)
	2024	74.02 a	(Ca+ Fe) X 25 cm (33600)	50.02 i	Control (Tap water) X 15 cm (56000)
Number of branches per plant	2023	47.42 a	(Ca+ Fe) X 25 cm (33600)	22.11 j	Control (Tap water) X 15 cm (56000)
	2024	52.62 a	(Ca+ Fe) X 25 cm (33600)	24.53 j	Control (Tap water) X 15 cm (56000)
Number of pods per plant	2023	39.30 a	(Ca+ Fe) X 25 cm (33600)	21.11 j	Control (Tap water) X 15 cm (56000)
	2024	42.99 a	(Ca+ Fe) X 25 cm (33600)	23.14 j	Control (Tap water) X 15 cm (56000)
Number of seeds per plant	2023	71.58 a	(Ca+ Fe) X 25 cm (33600)	34.34 j	Control (Tap water) X 15 cm (56000)
	2024	78.54 a	(Ca+ Fe) X 25 cm (33600)	37.65 i	Control (Tap water) X 15 cm (56000)
Weight of 100 pods (g)	2023	355.29 a	(Ca+ Fe) X 25 cm (33600)	221.08 k	Control (Tap water) X 15 cm (56000)
	2024	361.78 a	(Ca+ Fe) X 25 cm (33600)	229.28 k	Control (Tap water) X 15 cm (56000)
Weight of 100 seeds (g)	2023	113.18 a	(Ca+ Fe) X 25 cm (33600)	83.88 g	Control (Tap water) X 15 cm (56000)
	2024	115.89 a	(Ca+ Fe) X 25 cm (33600)	85.89 g	Control (Tap water) X 15 cm (56000)
Weight of pods per plant (g)	2023	112.14 a	(Ca+ Fe) X 25 cm (33600)	62.13 k	Control (Tap water) X 15 cm (56000)
	2024	121.35 a	(Ca+ Fe) X 25 cm (33600)	67.41 i	Control (Tap water) X 15 cm (56000)
Weight of seeds per plant (g)	2023	79.85 a	(Ca+ Fe) X 25 cm (33600)	31.82 k	Control (Tap water) X 15 cm (56000)
	2024	86.34 a	(Ca+ Fe) X 25 cm (33600)	34.67 k	Control (Tap water) X 15 cm (56000)
Shelling percentage	2023	71.20 a	(Ca+ Fe) X 25 cm (33600)	51.21 j	Control (Tap water) X 15 cm (56000)
	2024	71.21 a	(Ca+ Fe) X 25 cm (33600)	51.48 g	Control (Tap water) X 15 cm (56000)
Seed oil percentage	2023	52.81 a	(Ca+ Fe) X 25 cm (33600)	47.23 k	Control (Tap water) X 15 cm (56000)
	2024	53.82 a	(Ca+ Fe) X 25 cm (33600)	48.17 k	Control (Tap water) X 15 cm (56000)
Seed crude protein percentage	2023	33.90 a	(Ca+ Fe) X 25 cm (33600)	27.29 l	Control (Tap water) X 15 cm (56000)
	2024	34.41 a	(Ca+ Fe) X 25 cm (33600)	27.51 j	Control (Tap water) X 15 cm (56000)
Pod yield per fad (Ardab)	2023	68.45 a	(Ca+ Fe) X 15 cm (56000)	32.70 j	Control (Tap water) X 25 cm (33600)
	2024	72.92 a	(Ca+ Fe) X 15 cm (56000)	34.82 j	Control (Tap water) X 25 cm (33600)
Seed yield per fad (kg)	2023	3523.00 a	(Ca+ Fe) X 15 cm (56000)	1321.76 i	Control (Tap water) X 25 cm (33600)
	2024	3798.36 a	(Ca+ Fe) X 15 cm (56000)	1424.52 i	Control (Tap water) X 25 cm (33600)
Straw yield per fad (ton)	2023	19.51 a	(Ca+ Zn) X 15 cm (56000)	10.14 i	Control (Tap water) X 25 cm (33600)
	2024	21.27 a	(Ca+ Zn) X 15 cm (56000)	11.39 i	Control (Tap water) X 25 cm (33600)
Oil yield per fad (kg)	2023	1846.55 a	(Ca+ Fe) X 15 cm (56000)	632.36 h	Control (Tap water) X 25 cm (33600)
	2024	2021.70 a	(Ca+ Fe) X 15 cm (56000)	694.19 j	Control (Tap water) X 25 cm (33600)
Protein yield per fad (kg)	2023	1169.88 a	(Ca+ Fe) X 15 cm (56000)	389.88 i	Control (Tap water) X 25 cm (33600)
	2024	1277.86 a	(Ca+ Fe) X 15 cm (56000)	422.88 j	Control (Tap water) X 25 cm (33600)

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استجابة نباتات الفول السوداني لمعاملات التغذية الورقية وكثافات النباتات تحت ظروف التربة الرملية المستصلحة حديثا

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الملخص

أجريت تجربتان حقليتان في موسمي ٢٠٢٣و ٢٠٢٤ بمنطقة القصاصين بمحافظة الاسماعيلية لدراسة تأثير أربع معاملات من الرش الورقي هي الرش بالماء (كنترول) والرش بالكالسيوم المخلبي بتركيز ١٧٠٠جزء في المليون والرش بالكالسيوم المخلبي مع الزنك بتركيز ١٥٠٠ جزء في المليون والرش بالكالسيوم المخلبي مع الحديد بتركيز ١٢٠٠ جزء في المليون وكذلك ثلاث معدلات من الكثافة النباتية هي ٥٦٠٠٠ و ٤٢٠٠٠ و ٣٣٦٠٠ نبات/فدان ناتجة من الزراعة علي خطوط عرضها ٥٠ سم ومسافات زراعة بين النباتات ١٥ و ٢٠ و ٢٥ سم علي محصول الفول السوداني صنف اسماعيلية ٢ في الاراضي الرملية بمحافظة الاسماعيلية.تفوقت النباتات المعاملة بالكالسيوم المخلبي بتركيز ١٧٠٠ جزء في المليون بالاضافةالي الحديد بتركيز ١٢٠٠ جزء في المليون أو الزنك بتركيز ١٥٠٠ جزء في المليون علي النباتات المعاملة بالكالسيوم فقط والكنترول في محصول القرون/فدان ومحصول البذور /فدان ومحصول القش / فدان ومحصول الزيت/ فدان ومحصول البروتين/فدان ووزن المائة قرن وعدد الأفرع/ نبات وعدد القرون/ نبات وعدد البذور / نبات ووزن القرون /نبات ووزن البذور/ نبات في كلا الموسمين.أدي تقليل مسافة الزراعة من ٢٥سم الي ٢٠ سم و ١٥ سم الي زيادة معنوية في محصول القرون / فدان ومحصول البذور / فدان ومحصول القش / فدان ومحصول الزيت / فدان ومحصول البروتين / فدان في كلا الموسمين.أمكن الحصول علي أعلي القيم لكل من محصول القرون /فدان ومحصول البذور/ فدان ومحصول الزيت / فدان ومحصول البروتين /فدان بالزراعة علي مسافة ١٥ سم (٥٦٠٠٠ نبات / فدان) ومحصول الزيت / فدان ومحصول البروتين / فدان بالزراعة علي مسافة ١٥ سم (٥٦٠٠٠ نبات/ فدان) والرش الورقي بالكالسيوم المخلبي بتركيز ١٧٠٠ جزء في المليون مع الحديد بتركيز ١٢٠٠ جزء في المليون في كلا الموسمين.

الكلمات الدالة :- الفول السوداني - الرش الورقي للعناصر الغذائيه- الكثافة النباتية