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Response Two Cultivars of Chickpea (*Cicer arietinum* L) to Phosphate Fertilization Level and Bacterial Inoculum

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Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

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ABSTRACT

The research was conducted during season 2020 in Al-Shallalat area, 5 km northeast of Mosul. The study included three factors, namely, the treatment of seed soaking with water and the bacterial inoculum, two local cultivars of chickpea: large seeds (Kabuli) and small seeds (Desi) and three levels of phosphate fertilization (zero, 50 kg, and 100 kg P_2O_5. h^{-1}). The study was conducted according to the factorial experiment system, in (R. C. B. D) design. In three replication, some traits of plant are obtained such as: plant height (cm), the height of the first pod above the ground (cm), pod length (cm), number of seeds/ pod, number of pods/plant (total), number of pods/plant (full) number of pods cleavage (empty), percentage of yield, the weight of 100 seeds (g), biological yield (g/plant), Seed yield (g/plant) and harvest index. The results indicate a significantly excelled of the treatment of soaking with bacteria inoculum on the treatment of soaking with water for all the

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studied traits. And highly significantly excelled in most of the studied traits of Kabuli over Desi cultivar. Most of the binary and triple interactions recorded a significant difference between the bacterial inoculum and the seeds of the Kabuli cultivar.

Keywords: Chickpea; bacterial inoculums; phosphate fertilization.

1. INTRODUCTION

Cicer arietinum L. is one of important leguminous crops that are adapted to the conditions of semi-arid and arid regions of the world, due to the crop's ability to absorb water from the soil with high efficiency because it has a deep root system that can reach the water in the depths of the soil [1]. The consumption of chickpeas in Iraq among legumes comes in the second place after the beans, and the third place after the beans and peas in the world [2]. The nutritional importance of chickpeas is due to the high rate of protein digestibility in it compared to other legumes, as well as the high percentage of essential amino acids and the low anti-nutrients [3]. The percentage of protein in its seeds can reach up to (21.5%), chickpea seeds contain a high percentage of carbohydrates and protein, as well as fiber, oils, calcium, and phosphorous [4]. Chickpea seeds are divided into two main types according to the size and texture of the seeds: Kabuli and Desi. The first type is Kabuli (its seeds are large, soft to the touch, yellowish-white, with an average seed weight of 270-550 mg), and the second type is Desi (small seeds, it has a rough texture with a brown to a black color and an average seed weight of 170-250 mg) [5]. Al-Nouri and Al-Abadi (2014) found that the cultivar (Al-Rafidain) was significantly excelled on the trait of seed yield, while the cultivar (Ghab4) was significantly superior in the trait of total pods weight/plant (gm). There were no significant differences between the cultivars in the trait of a number of seeds/plants. Kanouni et al. (2015) mentioned through a study (14) of chickpea genotype, where the genotype FLIP 00-39C and SEL 99 TH150454) was superior to seed yield. Almahasneh [6] found significant differences between the studied chickpea cultivars in the number of full pods. plant^{-1}, the number of seeds/pod, seed yield, vital yield, and harvest index for the Ghab 5 cultivar compared with the other cultivars (Gab 1, Ghab 2, Ghab 3, and Ghab 4) that he used. In the study of AL-Amrei and Alnori [7], the heights of plants of Mexican cultivars were significantly excelled on other cultivars.

Ali et al. [8] found the difference between the sizes of the seeds he studied with the traits of the yield and its components for the local cultivar. Muthanna et al. [9] found a significant difference between seed sizes in the traits of the yield components. Chickpeas also have an important role in the human diet and improve soil fertility by fixing nitrogen from the atmosphere by nitrogen-fixing bacteria. Most countries of the world have resorted to using the bacterial vaccine in agriculture due to its importance in improving agricultural production of leguminous that are rich in vegetable protein in light of population growth and high prices of animal proteins. One of the most essential biological processes is atmospheric nitrogen fixation. that take place in the soil by certain groups of microorganisms that release the enzyme nitrogenase, which is the main factor in reducing atmospheric nitrogen to ammonia, which is the first step in the nitrogen fixation process. Through the process of nitrogen fixation, the bulk of the nitrogen of leguminous plants can be met. From bacterial pollination studies, El-Hadi and El-Sheikh, [10] mentioned that inoculation with Rhizobium led to a significant increase in the weight of 100 seeds and seed crop yield (70-72%). Inoculation of chickpea seeds with appropriate Rhizobium strain before planting was found to make maximum use of chickpea yield and improve the soil. Experiments [11] with bacteria showed that inoculation with Rhizobium bacteria increased productivity by 20% compared to no pollination, dry matter, and a number of pods/plants. And [8,12] showed that inoculation of chickpea seeds with Rhizobium bacteria, in general, as a result of which plant growth has increased, yield, and components, and chickpea plant biological yield. Among both [13,14] seed inoculation with Rhizobium bacteria led due to a rise in chickpea yield and growth. Fertilization is one of the important agricultural operations that lead to raising agricultural production in terms of quantity and quality by improving the traits of the crop. Phosphorous is one of the nutrients necessary for plant growth due to its direct role in most of the plant's metabolic processes, as these processes cannot occur without it within the plant cells. Togay et al. [15] found a significant increase in the number of seeds/plant when the level of phosphate fertilizer was increased. Singh et al. [16] There were no significant variations in phosphate fertilizer amounts the number of pods/plant. Al-Abadi [17]. The researchers came to the conclusion revealed there were no significant differences in phosphate fertilization levels in the trait of seed yield. This experiment aimed to study the effect of bacterial vaccine and phosphate fertilization on the traits of two local chickpea cultivars grown in Nineveh province.

2. MATERIALS AND METHODS

This research took place during the 2020 agricultural season, and it comprised a field trial in the Al-Shallalat region 5 km north-east of the city of Mosul. The study included three factors: the first two levels, which is the treatment of soaking seeds (water and bacterial inoculum) soaking the seeds for an one and a half hour (according to the recommendation of the Agricultural Research Department of the Ministry of Science and Technology in Baghdad, Rhizobium cicer was obtained from its). The second factor included two local cultivars of chickpea: a local cultivar with large seeds Kabuli and small seeds Desi. And the third factor: Three levels of phosphate fertilization (0 , 50 and 100 kg P_2O_5. h^{-1}) using triple super phosphate fertilizer (46% P_2O_5) as a source of phosphorous and added at once before planting when preparing the land (Griffin and Brandon, 1983). The study was carried out according to the factorial experiment system, designing randomized complete sectors (R. C. B. D) and three sectors in the Shalalat / Abbasiya. Experiment consists of 12 units, the area of the experimental unit is (2.25 m^2) and it consists of (5) lines, with a distance of (30 cm) between one line and another and (15) cm between one plant and another, and the length of one line is (1.5 m) and the distance between each experimental unit and another (1m) and between each repeater and another (1m) and the transactions will be distributed to the experimental units randomly. The studied traits are: plant height (cm), height of the first pod from the ground (cm), pod length (cm), number of seeds / pod, number of pods / plant (kidney), number of pods / plant (full) number of split pods (empty), the percentage of abandonment through the following equation: % of abandonment = [(number of split pods / plant)/ (total number of pods / plant)] x 100, weight of 100 seeds (gm), vital yield (gm / plant), seed yield (g/plant), harvest index (%): using the equation mentioned by Sharma and Smith, [18] which are: harvest index = (seed yield/biological yield) x 100. The data for the studied traits were statistically analyzed (according to the used design) using the computer and using the SAS program (2004) and the comparison between the means was done using Duncan's multiple range test.

3. RESULTS AND DISCUSSION

1-1: Effect of soaking treatments, cultivars, phosphate fertilization treatments, and the interaction between them on plant height. It is evident from Table 1 that the treatment of soaking with a bacterial solution was significantly superior, as it reached (41.594) cm in plant height. This result is consistent with what was stated by Ali et al., [8] and Fatima, et al., [12] and Erman et al. [14] Namvar et al., [19]. The superiority of the cultivar (Kabuli) significantly, as the plant height reached (41.338) cm mainly due to the large size of the plants of the cultivar Kabuli, and therefore this increase in the size of the plants was accompanied by an increase in the height of the plants, and this reason is often genetically specific to the cultivars used in this experiment. This is in line with what AL-Amrei and Alnori reported. [7]. No significant differences were recorded in the fertilization treatments, as the highest average plant height when the treatment without fertilization was (40.308) cm. From this result, the effect was for soaking and not for phosphorous. From the binary interaction between the soaking treatments and the cultivars, we notice that the soaking treatment with the bacterial solution of the Kabuli cultivar was significantly superior to the rest of the treatments, where the mean value of plant height was recorded (43.055).As for the interaction of the soaking treatments with the fertilization treatments, we notice that all the bacterial solution soaking treatments for all levels of fertilization were significant compared to the treatments of soaking with water for all levels of fertilization. No significant differences were observed between the treatments of soaking with a bacterial solution for all levels of fertilization, and from the bilateral interaction between cultivars and fertilization treatments, we notice that the Kabuli cultivar with all fertilization levels was significantly superior to Daisy cultivar with all fertilization levels for the plant height characteristic. From the triple interactions of all factors, we notice a significantly excelled of the treatments of soaking with bacteria for the Kabuli cultivar and for all levels of fertilization over the rest of the experimental factors.

1-2: Effect of soaking treatments, cultivars, and phosphate fertilization treatments and the interaction between them on trait of the height of the first pod above the surface of the earth (cm).The results of Table 2 show significantly excelled of the treatment of soaking with bacterial solution, and the value of (28.288) cm was recorded in trait of the height of the first pod from the surface of the earth. These results agreed with the study Ali et al., [8] and Fatima, et al., [12] and Erman et al. [14] Namvar et al., [19]. The interaction between the soaking treatments and the cultivars showed significantly excelled of the seeds of the cultivar Kabuli treated with the bacterial solution over the rest of the treatments, where the value of (30.744) cm was recorded. From the bilateral interaction between the levels of fertilization and chickpea cultivars, we note the superiority of the Kabuli cultivar for all levels of fertilization over the Daisy cultivar, and no significant differences were observed for the Kabuli cultivar between the three levels of fertilization. It was found from the triple interaction of the experimental treatments that the Kabuli cultivar treated with bacterial solution recorded the highest average height of the first pod above the ground at the three levels of fertilization (100, 50,and zero kg P_2O_5. h^{-1}, where the values reached (31.467, 31.067 and 29.700) cm respectively.

1-3: Effect of soaking treatments, cultivars, and phosphate fertilization treatments, and the interaction between them on trait of average pod length (cm). The data in Table 3 indicates a significantly excelled of the bacterial solution soaking treatments, which reached (2,225) cm. The Kabuli cultivar was significantly superior to the Daisy cultivar, as the average pod length of the Kabuli cultivar was (2.193). No significant differences were recorded for all levels of fertilization in the length of the pod, where the highest mean was (2.175) cm at the level of 100 kg P_2O_5. h^{-1}. The interaction between the two factors, the treatment of soaking with a bacterial solution for the cultivar Kabuli was significantly superior to the rest of the treatments, as its value reached (2.266) cm for the length of the pod. The binary interaction between the two treatments of soaking and the levels of fertilization gave a significantly excelled of the treatment of bacterial soaking for all levels of fertilization over the treatment of soaking with water. The highest averages of treatments for the Kabuli cultivar and for all levels of fertilization were recorded on the Daisy cultivar, where the non-fertilizer treatment for the Kabuli cultivar recorded the highest mean value of (2.216) cm for the length of the pod. From the triple interaction of the experimental factors, a significantly excelled was found for the treatment of soaking with the bacterial solution of the Kabuli cultivar at the level of the first fertilization (without fertilization), where the value reached (2.313) cm for the length of the pod.

1-4: Effect of soaking treatments, cultivars, and phosphate fertilization treatments, and the interaction between them on the number of seeds/pod. The data in Table 4 indicates a significantly excelled of soaking with a bacterial solution with a value of (1.216) over-soaking with water for a number of seeds/pods, and this is similar to the results Ali et al., [18] and Fatima, et al., [12]. No significant differences were recorded between the two cultivars of this study in the number of seeds/pods, the averages of Kabuli and Daisy cultivars (1.156 and 1.155), respectively, and this result agrees with the results of Al-Nouri and Al-Abadi (2014). We notice a significantly excelled of the first two phosphate fertilization treatments (without fertilization) and the second fertilization of 50 kg P2O5.H-1, which recorded a value of (1.208) and (1.167), respectively, for the number of seeds/pod. This result is in line with what Togay et al. [15] mentioned. As a result of the binary interaction, we notice a significantly excelled of the seeds of the two cultivars Kabuli and Daisy soaked in the bacterial solution, where the values reached (1.222) for the Kabuli and (1.211) for the daisy for the number of seeds/pods. From the bilateral interaction of the soaking treatments with the fertilization levels, it was found that the treatment of soaking with a bacterial solution at the first fertilization level (without fertilization) was significantly superior, as its value reached (1.266) for the number of seeds/pods. It is evident from the triple interaction of all the experimental factors that the two treatments of soaking in the bacterial solution of the two cultivars Kabuli and Daisy at the level of the first fertilization (without fertilization) and the second kg P2O5.H-1 were superior to (1.267) and (1.233) for the cultivar Kabuli for the number of seeds/ Pod.

1-5: Effect of soaking treatments, cultivars, and phosphate fertilization treatments and the interaction between them on trait of total pods/plant. Table 5 shows a significantly excelled of soaking with the bacterial solution, and the total number of pods in the plant was (6,811) pods, and this result agrees with the results of Ali et al., [8] and Fatima, et al., [12], Karadavut and Ozdemir, [11].The Kabuli cultivar was significantly superior as the number of pods reached (6,561) over Daisy (5.838) pods. No significant differences were observed for all levels of phosphate fertilization in trait of the number of total pods/plant. This result is consistent with what was mentioned by Singh et al. [16]. The binary interaction of the soaking treatments with the cultivars shows a significantly excelled of the seeds of the cultivar Kabuli soaked with the bacterial solution, where the total number of pods in the plant reached (7.311) pods. Through the binary interaction of the treatments of soaking and fertilization, we notice that there is a significantly excelled for trait of the total number of pods in the plant when treating the soaking with a bacterial solution for all levels of fertilization without a significant difference. Among the three interactions, we note the superiority of the treatment of soaking with a bacterial solution of the Kabuli cultivar at the level of the first fertilization (without fertilization) and the second fertilization of 50 kg P_2O_5. h^{-1}, where the number of pods reached (7,500) pods and (7.433) pods, respectively.

1-6: Effect of soaking treatments, cultivars, and phosphate fertilization treatments, and the interaction between them, on the mean number of pods full/plant. Table (6) indicates a significantly excelled of soaking with a bacterial solution in the number of full pods/plant with a value of (5.778) pods. This results is similar with what was said by Ali et al., [8] and Fatima, et al., [12]. It was noticed from Table 6 that the Kabuli cultivar was significantly superior with a value of (5.538) pods/plant, and this result is consistent with the results of [6]. While there were no significant differences for all levels of phosphate fertilization (5.225, 5.183, and 5.116) for trait of the number of filled pods/plant this is similar to the results of Singh et al. [16]. The binary interaction of the soaking treatments with the cultivars shows a significantly excelled of the soaking treatment with the bacterial solution of the cultivar Kabuli in the number of filled pods/plant, where a value of (6.278) pods/plant was recorded. Significantly excelled was recorded for the treatments of soaking with a bacterial solution for all levels of phosphate fertilization without a significant difference between the three levels over the treatments of soaking with water for the number of filled pods/plant. It was found that there was a significantly excelled for the two treatments of Kabuli cultivar with the first level (without fertilization) and the second level fertilizing 50 kg P_2O_5. h^{-1}, where the number of full pods/plant was recorded (5,700) pods and (5,650) pods, respectively. From the triple interaction of all the experimental factors, we notice a significantly excelled of the treatments of soaking with the bacterial solution of the cultivar Kabuli without a significant difference between the levels of fertilization, where the highest average (6.433) at the second level fertilization 50 kg P_2O_5. h^{-1}, and the lowest average of the number of filled pods/plant was (6.033). At the third fertilization level, fertilize 100 kg P_2O_5. h^{-1}.

1-7: Effect of soaking treatments, cultivars, and phosphate fertilization treatments, and the interaction between them on trait of the number of (empty) pods/plant. The data in Table 7 indicates a significantly excelled of seeds soaked in water, which gave the least number of (empty) split pods (1,000) pods. These results agreed with Ali et al., [8] and Fatima, et al., [12]. The Kabuli cultivar gave the lowest number of split pods (0.916), thus significantly outperforming the Daisy cultivar.It was found that there was a significantly excelled for the third level fertilization 100 kg P_2O_5. h^{-1}, where the lowest average number of (empty) split pods was (0.875) pods. And from the binary interaction between the soaking agent and the cultivars, we notice a significantly excelled of the water-drenched Kabuli cultivar, where the lowest average (0.900) for the number of (empty) split pods/plant was recorded. As for the bilateral interaction between the factors of soaking and fertilization, we note the significantly excelled of the bacterial solution and the third fertilization level of 100 kg P_2O_5. h^{-1}. Where the lowest average (0.850) was recorded for the number of (empty) pods/plant, while we notice a significantly excelled of Daisy cultivar at the third fertilization level 100 kg P_2O_5. h^{-1} with an average of (0.800) pods in trait of the number of (empty) pods/plant.

1-8: Effect of soaking treatments, cultivars, phosphate fertilization treatments, and the interaction between them on the percentage of deficiencies. The data in Table 8 indicate a significantly excelled of soaking with a bacterial solution in the percentage of inversion, as it gave the lowest average (16.590%) compared to soaking with water, which recorded the highest significant mean of (18.515%). Whereas, the Kabuli cultivar recorded a significantly excelled with the lowest deviation rate of (14.393%) compared with the Daisy cultivar which reached (20.711%).We also note that the third level of phosphate fertilization 100 kg kg P_2O_5. h^{-1} was significantly superior to the lowest rate of fertilization (15.371%). From the bilateral interaction between the two factors of soaking and the cultivars, we notice that the treatment of soaking with the bacterial solution of kabuli cultivar was significantly superior, as it recorded the lowest percentage of inversion (12.983%). Also, the treatment of soaking with a bacterial solution at the third level of phosphate fertilization kg P_2O_5. h^{-1} was superior to the lowest percentage of inversion (13.201%), as well as the treatment of Kabuli cultivar at the first level (without fertilization) and the second level 50 kg P_2O_5. h^{-1}, which gave the lowest values For the percentage of deviation (13.235%) and (13.775%) for the first and second levels, respectively. From the triple interactions of the experimental factors, we notice a significantly excelled of the soaking treatment with the bacterial solution of Capoli cultivar at the second level of phosphate fertilization 50 kg P_2O_5. h^{-1} and yielded the least inversion rate (12.120%).

1-9: Effect of soaking treatments, cultivars and phosphate fertilization treatments, and the interaction between them on the weight of 100 seeds (gm). Table 9 shows the weight of (100) seeds, where we notice that there are no significant differences between soaking with water and soaking with bacterial solution, and the highest value was (31.479) for the average weight of (100) seeds when soaking with a bacterial solution. This result is consistent with the results of El- Hadi and El-Sheikh, [10]. We notice a significantly excelled of the Kabuli cultivar, as it recorded the highest average (36,606) gm, weight (100) seeds. This result is in line with what was mentioned by Al-Nouri and Al-Abadi (2014), Muthanna et al. [9] and Ali et al. [8]. From the binary interaction between the two factors of soaking and the cultivars, it was found that there was a significantly excelled for the treatment of soaking with bacterial solution and water for the Kabuli cultivar, where the highest weight of (100) seeds was recorded (36.970 and 36.241) gm, respectively. No significant differences were recorded when the soaking factor interacted with the levels of phosphate fertilization, where the highest weight of 100 seeds was recorded (32.148) gm for the soaking treatment with water at the first level of phosphate fertilization (without fertilization). The dual interaction of the Kabuli cultivar with the first fertilization levels (without fertilization) and the second 50 kg P_2O_5. h^{-1} recorded the highest values of (38.715) g and (38.303) for the first and second levels, respectively, for the 100-seed weight trait. As for the triple interaction between the experimental factors, it gave the highest weight of 100 seeds when soaking with water treatment of the Kabuli cultivar at the second level of phosphate fertilization 50 kg P_2O_5. h^{-1} amounted to (39.970) gm.

1-10: Effect of soaking treatments, cultivars, and phosphate fertilization treatments, and the interaction between them on the character of the biological yield (gm/plant). Table 10 shows that there is a significantly excelled for the treatment of soaking with bacterial solution, where a value of (6.169) g was recorded for trait of the biological yield. These results agreed with what was found by [8,12,14]. The Kabuli cultivar also outperformed significantly and recorded a value of (6.293) gm for the biological yield, and this is similar to what was found by Almahasneh [6], Muthanna et al. [9]] and Ali et al. [8]. While there were no significant differences in the three levels of phosphate fertilization, where the highest value of (5.890) gm was recorded at the second level of phosphate fertilization 50 kg P_2O_5. h^{-1}. And from the binary interaction of the soaking factor with the cultivar factor, no significant differences were observed at the interaction, while no significant differences were recorded for the soaking treatments at the three levels of phosphate fertilization, where the highest value of the biological yield (6.630) gm at the second level of phosphate fertilization 50 kg P_2O_5. h^{-1}. No significant differences were observed for the treatments of the cultivars with the three levels of fertilization, where the highest vital yield (6.433) g was recorded for the treatment of the Kabuli cultivar at the second fertilization level of 50 kg P_2O_5. h^{-1}. Among the triple interactions, there were no significant differences for all treatments, where the highest value was recorded (6.7533) Grams of biological yield when soaking treated with a bacterial solution of Kabuli cultivar at the second level of phosphate fertilization 50 kg P_2O_5. h^{-1} for the character of the biological yield.

1-11: From the binary interaction, it was found a significantly excelled with a value of (3.305) gm for the treatment of soaking with the bacterial solution of the Kabuli cultivar. While the interaction of soaking treatments at the three levels of fertilization for seed yield (gm/plant) recorded the highest significant value of seed yield (3.181) gm for soaking treatment with a bacterial solution at the second level of phosphate fertilization 50 kg P_2O_5. h^{-1}. It was found from the triple interaction of the experimental factors that there were no

Table 1. Effect of soaking treatments, cultivars, and phosphate fertilization treatments, and the interaction between them on plant height (cm)

Soaking treatments	Cultivars	Phosphate fertilization treatments			Soak * Cultivars
		0 kg P_2O_5. h^{-1}	**50 kg P_2O_5. h^{-1}**	**100 kg P_2O_5. h^{-1}**	
Water	Kabuli	39.967 bc	39.567 bc	39.333 bc	39.622 b
	desi	38.500 cd	36.800 d	38.467 cd	37.922 cd
bacterial solution	Kabuli	43.000 a	43.100 a	43.067a	43.055 a
	desi	39.767 bc	41.200 ab	39.433 bc	40.133 b
Average Phosphate Fertilization Treatments		40.308 a	40.166 a	40.075 a	
Soaking treatments					Soaking averages
Water		39.233 b	38.183 b	38.900 b	38.772 b
bacterial solution		41.383 a	42.150 a	41.250 a	41.594 a
Cultivars					Cultivars averages
Kabuli		41.483 a	41.333 a	41.200 a	41.338 a
Desi		39.133 b	39.000 b	38.950 b	39.027 b

Similar characters within the factors or their interactions do not differ from each other significantly

Table 2. Effect of soaking treatments, cultivars and phosphate fertilization treatments and the interaction between them on trait of the height of the first pod above the ground surface (cm)

Soaking treatments	Cultivars	Phosphate fertilization treatments			Soak * Cultivars
		0 kg P_2O_5. h^{-1}	**50 kg P_2O_5. h^{-1}**	**100 kg P_2O_5. h^{-1}**	
Water	Kabuli	27.70 abc	26.700abc	27.367 abc	27.256 b
	Desi	23.267 cd	22.033d	24.200 cd	23.167 c
bacterial solution	Kabuli	29.700 ab	31.067 a	31.467 a	30.744 a
	Desi	24.733 bc	27.167abc	25.600 bcd	25.833 b
Average Phosphate Fertilization Treatments		26.350 a	26.742 a	27.158 a	
Soaking treatments					Soaking averages
Water		25.483 bc	24.367 c	25.783 abc	25.211 b
bacterial solution		27.217abc	29.117 a	28.533 ab	28.288 a
Cultivars					Cultivars averages
Kabuli		28.700 a	28.883 a	29.417 a	29.000 a
Desi		24.000 b	24.600 b	24.900 b	24.500 b

Similar characters within the factors or their interactions do not differ from each other significantly

Table 3. Effect of soaking treatments, cultivars, and phosphate fertilization treatments, and the interaction between them on pod length (cm)

Soaking treatments	**Cultivars**	**Phosphate fertilization treatments**			**Soak * Cultivars**
		0 kg P_2O_5. h^{-1}	**50 kg P_2O_5. h^{-1}**	**100 kg P_2O_5. h^{-1}**	
Water	Kabuli	2.120 ef	2.110 ef	2.133def	2.121 c
	Desi	2.090 f	2.063 f	2.110 ef	2.087 c
bacterial solution	Kabuli	2.313 a	2.236 bc	2.250 ab	2.266 a
	Desi	2.173	2.173 cde	2.206 bcd	2.184 b
Average Phosphate Fertilization Treatments		2.174 a	2.145 a	2.175 a	
Soaking treatments					Soaking averages
Water		2.105 b	2.086 b	2.121 b	2.104 b
bacterial solution		2.243 a	2.205 a	2.228 a	2.225 a
Cultivars					Cultivars averages
Kabuli		2.216 a	2.173 abc	2.191 ab	2.193 a
Desi		2.131 bc	2.118 d	2.158 bcd	2.136 b

Similar characters within the factors or their interactions do not differ from each other significantly

Table 4. Effect of soaking coefficient, cultivars, phosphate fertilization treatments and the interaction between them on average number of seeds/pods

Soaking treatments	**Cultivars**	**Phosphate fertilization treatments**			**Soak * Cultivars**
		0 kg P_2O_5. h^{-1}	**50 kg P_2O_5. h^{-1}**	**100 kg P_2O_5. h^{-1}**	
Water	Kabuli	1.167 ab	1.067 b	1.033 b	1.089 b
	Desi	1.133 ab	1.133 ab	1.033 b	1.100 b
bacterial solution	Kabuli	1.267 a	1.233 a	1.167 ab	1.222 a
	Desi	1.267 a	1.233 a	1.133 ab	1.211 a
Average Phosphate Fertilization Treatments		1.208 a	1.167 a	1.091 b	
Soaking treatments					Soaking averages
Water		1.150 b c	1.100 cd	1.033 d	1.094 b
bacterial solution		1.266 a	1.233 ab	1.100 cd	a1.216
Cultivars					Cultivars average
Kabuli		1.216 a	1.150 abc	1.100 bc	1.156 a
Desi		1.200 a	1.183 a	1.083 c	1.155 a

Similar characters within the factors or their interactions do not differ from each other significantly

Table 5. Effect of soaking treatments, cultivars and phosphate fertilization treatments, and the interaction between them on trait of the mean number of total pods/plants

Soaking treatments	Cultivars	Phosphate fertilization treatments			Soak * Cultivars
		0 kg P_2O_5. h^{-1}	**50 kg P_2O_5. h^{-1}**	**100 kg P_2O_5. h^{-1}**	
Water	Kabuli	6.167 bcd	5.767 cd	5.500 cd	5.811 bc
	Desi	5.400 cd	5.400 cd	5.300 d	5.367 c
bacterial solution	Kabuli	7.500 a	7.433 a	7.000 ab	7.311 a
	Desi	6.367 bc	6.233 bcd	6.333 bcd	6.311 b
Average Phosphate Fertilization Treatments		6.358 a	6.208 a	6.033 a	
Soaking treatments					Soaking averages
Water		5.783 b	5.783 b	5.400 b	5.589 b
bacterial solution		6.933 a	6.833 a	6.667 a	6.811 a
Cultivars					Cultivars averages
Kabuli		6.833 a	6.600 a	6.250 a	6.561 a
Desi		5.883 b	5.816 b	5.816 b	5.838 b

Similar characters within the factors or their interactions do not differ from each other significantly

Table 6. Effect of soaking treatments, cultivars and phosphate fertilization treatments and the interaction between them on trait of the average number of full pods/plants

Soaking treatments	Cultivars	Phosphate fertilization treatments			Soak * Cultivars
		0 kg P_2O_5. h^{-1}	**50 kg P_2O_5. h^{-1}**	**100 kg P_2O_5. h^{-1}**	
Water	Kabuli	5.033 bcd	4.867 cd	4.500 cd	4.800 cd
	Desi	4.300 d	4.300 d	4.433 cd	4.344 c
bacterial solution	Kabuli	6.367 a	6.433 a	6.033 ab	6.278 a
	Desi	5.200 bcd	5.133 bcd	5.500 abc	5.278 b
Average Phosphate Fertilization Treatments		5.225 a	5.183 a	5.116 a	
Soaking treatments					Soaking averages
Water		4.667 b	4.583 b	4.467 b	4.572 b
bacterial solution		5.783 a	5.783 a	5.767 a	5.778 a
Cultivars					Cultivars averages
Kabuli		5.700 a	5.650 a	5.267 ab	5.538 a
Desi		4.750 b	4.716 b	4.967 ab	4.811 b

Similar characters within the factors or their interactions do not differ from each other significantly

Table 7. Effect of soaking coefficient, cultivars and phosphate fertilization treatments and the interaction between them on trait of the average number of (empty) pods/plant

Soaking treatments	Cultivars	Phosphate fertilization treatments			Soak * Cultivars
		0 kg P_2O_5. h^{-1}	50 kg P_2O_5. h^{-1}	100 kg P_2O_5. h^{-1}	
Water	Kabuli	0.800 e	0.900 d	1.000 c	0.900 d
	Desi	1.000 c	1.500 a	0.800 e	1.100 b
bacterial solution	Kabuli	1.000 c	0.900 d	0.900 d	0.933 c
	Desi	1.500 a	1.400 b	0.800 e	1.233 a
Average Phosphate Fertilization Treatments		1.075 b	1.175 a	0.875 c	
Soaking treatments					Soaking averages
Water		0.900 d	1.200 b	0.900 d	1.000 b
bacterial solution		1.250 a	1.150 c	0.850 e	1.083 a
Cultivars					Cultivars averages
Kabuli		0.900 d	0.900 d	0.9500 c	0.916 b
Desi		1.250 b	1.450 a	0.800 e	1.167 a

Similar characters within the factors or their interactions do not differ from each other significantly

Table 8. Effect of soaking treatments, cultivars and phosphate fertilization treatments, and the interaction between them on trait of the average percentage of failure

Soaking treatments	Cultivars	Phosphate fertilization treatments			Soak * Cultivars
		0 kg P_2O_5. h^{-1}	50 kg P_2O_5. h^{-1}	100 kg P_2O_5. h^{-1}	
Water	Kabuli	13.050 efg	15.430 ef	18.933 cd	15.804 b
	Desi	19.807 c	27.723 a	16.150 de	21.226 a
bacterial solution	Kabuli	13.420 efg	12.120 g	13.410 efg	12.983 c
	Desi	24.083 b	23.513 b	12.993 fg	20.1967 a
Average Phosphate Fertilization Treatments		17.590 b	19.696 a	15.371 c	
Soaking treatments					Soaking averages
Water		1.100 cd	21.576 a	17.541 bc	18.515 a
bacterial solution		18.751 b	17.816 bc	13.201 d	16.590 b
Cultivars					Cultivars averages
Kabuli		13.235 d	13.775 d	16.171 c	14.393 b
Desi		21.945 b	25.618 a	14.571 cd	20.711 a

Similar characters within the factors or their interactions do not differ from each other significantly

Table 9. Effect of soaking treatments, cultivars, and phosphate fertilization treatments, and the interaction between them on the weight of 100 seeds (gm)

Soaking treatments	Cultivars	Phosphate fertilization treatments			Soak * Cultivars
		0 kg P_2O_5. h^{-1}	50 kg P_2O_5. h^{-1}	100 kg P_2O_5. h^{-1}	
Water	Kabuli	38.880 a	39.970 a	29.873 bc	36.241 a
	Desi	25.417 c	23.247 c	28.440 bc	25.701 b
bacterial solution	Kabuli	38.550 a	36.637 ab	35.723 ab	36.970 a
	Desi	25.097 c	26.390 c	26.477 c	25.988 b
Average Phosphate Fertilization Treatments		31.986 a	31.561 a	30.128 a	
Soaking treatments					Soaking averages
Water		32.148 a	31.608 a	29.157 a	30.971 a
bacterial solution		31.823 a	31.513 a	31.100 a	31.479 a
Cultivars					Cultivars averages
Kabuli		38.715 a	38.303 ab	32.798 bc	36.606 a
Desi		25.257 d	24.818 d	27.458 dc	25.844 b

Similar characters within the factors or their interactions do not differ from each other significantly

Table 10. Effect of soaking treatments, cultivars, phosphate fertilization treatments, and the interaction between them on the bio yield (gm/plant)

Soaking treatments	Cultivars	Phosphate fertilization treatments			Soak * Cultivars
		0 kg P_2O_5. h^{-1}	50 kg P_2O_5. h^{-1}	100 kg P_2O_5. h^{-1}	
Water	Kabuli	5.913 ab	6.360 a	5.243 ab	5.838 ab
	Desi	5.006 ab	3.943 b	5.366 ab	4.772 b
bacterial solution	Kabuli	6.756 a	6.506 a	6.980 a	6.747 a
	Desi	5.283 ab	6.753 a	4.736 ab	5.591 ab
Average Phosphate Fertilization Treatments		5.740 a	5.890 a	5.581 a	
Soaking treatments					Soaking averages
Water		5.460 a	5.151 a	5.305 a	5.305 b
bacterial solution		6.020 a	6.630 a	5.858 a	6.169 a
Cultivars					Cultivars averages
Kabuli		6.335 a	6.433 a	6.111 a	6.293 a
Desi		6.111 a	5.348 a	5.051 a	5.181 b

Similar characters within the factors or their interactions do not differ from each other significantly

Table 11. Effect of soaking treatments, cultivars and phosphate fertilization treatments, and the interaction between them on seed yield (gm/plant)

Soaking treatments	Cultivars	Phosphate fertilization treatments			Soak * Cultivars
		0 kg P_2O_5. h^{-1}	**50 kg P_2O_5. h^{-1}**	**100 kg P_2O_5. h^{-1}**	
Water	Kabuli	2.783 a	3.010 a	2.316ab	2.703 b
	Desi	2.256 ab	1.420 b	2.503 a	2.060 c
bacterial solution	Kabuli	3.326 a	3.343 a	3.246 a	3.305 a
	Desi	2.586 a	3.020 a	2.500 a	2.702 b
Average Phosphate Fertilization Treatments		2.738 a	2.698 a	2.641 a	
Soaking treatments					Soaking averages
Water		2.520 ab	2.215 b	2.410 b	2.381 b
bacterial solution		2.956 ab	3.181 a	2.873 ab	3.003 a
Cultivars					Cultivars averages
Kabuli		3.055 ab	3.176 a	2.781 abc	3.004 a
Desi		2.421 bc	2.220 c	2.501 abc	2.381 b

Similar characters within the factors or their interactions do not differ from each other significantly

Table 12. Effect of soaking treatments, cultivars and phosphate fertilization treatments and the interaction between them on trait of harvest index

Soaking treatments	Cultivars	Phosphate fertilization treatments			Soak * Cultivars
		0 kg P_2O_5. h^{-1}	**50 kg P_2O_5. h^{-1}**	**100 kg P_2O_5. h^{-1}**	
Water	Kabuli	47.211 ab	46.622 ab	44.824 ab	46.219 a
	Desi	47.696 ab	36.559 b	47.318 ab	43.858 a
bacterial solution	Kabuli	48.933 ab	52.790 a	47.637 ab	49.787 a
	Desi	52.626 a	43.535 ab	54.031 a	50.064 a
Average Phosphate Fertilization Treatments		49.117 a	44.877 a	48.452 a	

Soaking treatments				Soaking averages
Water	47.454 a	41.591 a	46.071 a	45.038 b
bacterial solution	50.780 a	48.163 a	50.834 a	49.925 a
Categories				Cultivars averages
Kabuli	48.072 ab	49.706 a	46.230 ab	48.003 a
Desi	50.161 a	40.047 b	50.675 a	46.961 a

Similar characters within the factors or their interactions do not differ from each other significantly

significant differences between most of the treatments, where the highest value of seed yield was recorded (3.343) gm for the treatment of soaking in the bacterial solution of the cultivar Kabuli at the second level of phosphate fertilization 50 kg P_2O_5. h^{-1}. Muthanna et al. [9] and Ali et al. [8].

1-12: Effect of soaking treatments, cultivars and phosphate fertilization treatments, and the interaction between them on trait of harvest index (%). The results in Table 12 indicate a significantly excelled for the treatment of soaking with bacterial solution, which recorded a value of (49.925)% for trait of the harvest index. This result is in line with what they mentioned [8,12]. While no significant differences were observed between the two cultivars Kabuli and Daisy, where the highest value was recorded for the Kabuli cultivar (48.003%). These results agreed with what was found by Almahasneh [6]. There were no significant differences between the three levels of fertilization, where the highest harvest index reached (49.117) % at the first level (without fertilization) and the lowest harvest index was (44.877) % at the second level of phosphate fertilization 50 kg P_2O_5. h^{-1}. From the binary interaction, it was found that no significant difference was noted between the two factors of soaking and cultivars, where the highest harvest index (50.064) was recorded when soaking with the bacterial solution of the Daisy cultivar. The bilateral interaction between the soaking factor and the three levels of phosphate fertilization did not register significant differences, as it recorded the highest harvest index (50.834) % for the treatment of soaking with a bacterial solution at the third level of phosphate fertilization. While the highest harvest index was recorded (50.161)% when soaking with water for the first level of phosphate fertilization zero kg P_2O_5. h^{-1} for the interaction between the cultivars and the three levels of fertilization, And from the triple interaction of all the experimental factors, we notice a significantly excelled of the soaking treatment with the bacterial solution of Daisy cultivar at the third level of phosphate fertilization, where the harvest index reached (54.031) for trait of harvest index %.

4. CONCLUSION

The study was carried out during the 2020 agricultural season in Al-Shallalat area, 5 km northeast of the city of Mosul. The study included three factors, namely, the treatment of seed soaking with water and the bacterial inoculum of two local varieties of chickpea: a local variety with large seeds (Kabuli and a local variety with small seeds, Desi) . And three levels of phosphate fertilization (zero, 50 kg and 100 kg P2O5. H-1). The study was carried out according to the factorial experiment system, in a randomized complete block design (R. C. B. D) with three sectors. The characteristics of: plant height (cm), height of the first pod from the ground (cm), pod length (cm), number of seeds / pod, number of pods / plant (kidney), number of pods / plant (full) number of carved pods (empty)), percentage of yield, weight of 100 seeds (gm), vital yield (gm/plant). , seed yield (g/plant), harvest guide. The results indicate a significant superiority of the treatment of soaking with bacteria inoculum over the treatment of soaking with water for all the studied traits. And highly significant superiority in most of the studied traits of Kabuli cultivar over Dizi cultivar. Most of the binary and triple interactions recorded a significant significant difference between the bacterial inoculum and the seeds of the cultivar Capoli.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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