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EFFECT OF PHOSPHORUS AND SULPHUR ON PRODUCTIVITY OF CHICKPEA (*CICER ARIETINUM* L.) UNDER NEW VALLEY CONDITIONS

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Field experiments were conducted for two years at the Desert Research Center (DRC), Agricultural Experimental Station at El-Kharga Oasis, New Valley Governorate, South Western, Egypt, during two winter growing seasons of 2015/ 2016 and 2016/ 2017. This work aimed to study the effect of phosphoric acid foliar application levels of 0, 0.5, 1, 1.5 and 2 L/ feddan (0.42 hectar) and sulphur fertilizer at rates of 0, 50, 100, 150 and 200 kg S/feddan on the yield and quality of chickpea in alkaline soils. Experimental results revealed that yield and quality of chickpea were significantly influenced by phosphorus foliar application, except seed K and S%, which were not significantly affected in both seasons. The maximum values of these parameters were produced by 1 L/feddan. Phosphorus (P) foliar in both seasons as compared with nil P (control), 1.5 and 2 L/feddan, except P% in seeds was increased with the increase of spraying level of P from 0 to 2 L/feddan in both seasons. The results showed that increasing sulphur fertilization rates from 0 to 200 kg S/feddan caused a significant increase in all yield components and seed chemical composition of chickpea plants under this study in the both seasons. The highest values were obtained at 200 kg S/feddan compared with control treatment (without sulphur fertilizer), this is fairly true in both seasons. Yield and quality of chickpea were significantly affected by the interaction between phosphorus foliar application and sulphur fertilizer. While, percentages of phosphorus, potassium and sulphur in seeds have not been affected significantly by the interaction in both seasons.

Keywords: Chickpea, sulphur, phosphorus, yield, chemical composition

Chickpea (*Cicer arietinum* L.), a member of family Fabaceae, is an ancient self-pollinated leguminous crop, diploid annual (2 N=16 chromosomes) grown since 7000 BC, in different area of the world.

Archaeological records bestow information that the cultivated chickpea was the first grain legume to be domesticated in the old World. Average chickpea yield in Egypt is much lower than in developed countries of the world. Many factors restrict the cultivation of chickpeas under the conditions of many Egyptian lands, including the limited elements needed during the growth period; such as phosphorus, sulfur and some micronutrients as a result of the relatively, high soil pH, which reduces the productivity. Under these cases, it should be searched for any solutions for these obstacles in these areas. There are promising newly reclaimed lands in Egypt, in this respect, one of the most suitable locations is New Valley region with its Oases, which represents large land resources and a good hope for agriculture expansion, which is located at the Western Desert of Egypt, since it represents 38% (376000.51 km^2) of the total area of Egypt and has about 3.5 million feddan (0.42 hectar) available for cultivation. But a large part of these lands suffer from high alkalinity, which caused many problems, the most important of which is the unavailability of many nutrients in the rhizosphere, especially phosphorus. Phosphorus (P) and sulphur (S) are major nutrient elements for grain legumes. In many soil types, P is the most limiting nutrient for the production of crops (Jiang et. al., 2006). It plays a primary role in many of the physiological processes, such as the utilization of sugar and starch, photosynthesis, energy storage and transfer. Legumes generally have higher P requirement because the process of symbiotic nitrogen (N) fixation consumes a lot of energy (Schulze et al., 2006).

Whereas, P fertilizer use is very inefficient in agriculture and its recovery is estimated to be between 10-15% of the P applied (Syers and Curtis, 2008), in alkaline soils, P will react with calcium (Ca) forming hydroxyapatite, dicalcium and octacalcium phosphates, all of which are very insoluble, and decrease the availability for plants (Lindsay et al., 1989). Phosphorus is a key element involved in various functions in growth and metabolism of pulses. It is frequently a major limiting nutrient for plant growth in most soils. Only a part of P supplemented through fertilizer is utilized by the plants and a large portion of it is converted into insoluble fixed forms in alkaline soils, the recovery efficiency of P in crops is generally 10-30% (Swarup, 2002). Therefore, the utilization of P as a foliar application becomes increasingly important. The mechanistic processes by foliar applied indicate that nutrients are taken up through leaf stomata (Eichert and Burkhardt, 1999) and hydrophilic pores within the leaf cuticle (Tyree et al., 1990). This can be addressed through the use of P by spraying on the plant instead of adding to the soil. Phosphorus is one of the most important nutrients for chickpea (*Cicer arietinum* L.) and contributes directly to both the yield and quality of it, so it has often been called the "Master key of Agriculture".

Sulphur is one of the most important solutions that contribute directly in overcoming the problems of alkaline soils and the lack of the availability of many elements in these soils such as, P, Fe, Zn, Cu, Mo, B and Mn. In addition, S is now recognized as major plant nutrient, along with nitrogen (N), P, and potassium (K). It is essential for the growth and development of all crops, without exception. Most of the plants requirement of S is absorbed through the roots in the form of sulphate (SO_4^{-2}). Each year, S deficiency is becoming critical, restricting crop more yield and nutrient use efficiency. Like any essential nutrient, S also has certain specific functions to perform in the plant. Thus, S deficiencies can be corrected by the application of S fertilizer (Tondon and Messick, 2007). This study was conducted in order to study the effect of different doses of P as a foliar and S application on some yield components and chemical composition in chickpea plant grown in alkaline soils.

MATERIALS AND METHODS

Two field experiments were carried out in the Desert Research Center (DRC), Agricultural Experimental Station at El-Kharga Oasis, New Valley Governorate, during the two winter growing seasons of 2015/ 2016 and 2016/ 2017. The study inquired into the effect of phosphoric acid foliar at levels of 0, 0.5, 1, 1.5 and 2 L/ per feddan and S fertilizer at rates of 0, 50, 100, 150 and 200 kg S per fedsan on the yield and chemical composition of chickpea. Whereas, the spraying of P was in the form phosphoric acid 85% and was done five times during growing season, first after one month from planting and then every 15 days. Sulphur fertilization was in the form agricultural S and was added during the preparation of soil for planting. Soil samples collected were analyzed for mechanical and chemical analysis. Soil pH of experimental site was found to be vary from 8.73 to 8.67, while EC- 617 to 589 ppm, organic matter- 0.54 to 0.59%, available N- 62 to 67 ppm, available P- 0.49 to 0.53 ppm, available K- 29 to 33 ppm and available S- 2.27 to 3.11. Soil samples analyzed was found to be of sandy clay loam texture.

The experiment included 25 treatments which were the combinations between the five levels of phosphoric acid foliar application and five rates of S fertilizer The experimental design was split plots design with three replicates, five levels of phosphoric acid foliar application (spraying with water only as a control) were assigned in the main plots and five rates of S fertilizer were randomly distributed in the sub plots. NPK fertilizers were added at the rate of 15 kg N/fedsan as ammonium nitrate 33% N, 50 kg /fedsan as calcium super phosphate (15.5% P_2O_5) and 50 kg K_2O /feddan (48%) as potassium sulfate, respectively and were added during the seedbed preparation. Chickpea seeds Giza-88 cultivar were planted on the last week of November in the two seasons, after inoculated with rhizobium strain and irrigated just after sowing. The experimental unit area was 10.5 m^2 consisting of fifteen rows (3.5 m long and 0.20 m between rows), 0.20 m between hills. Drib irrigation was applied during the two seasons. The normal agronomic practices of growing chickpea in this district were practiced till harvest as recommended. At harvest, five guarded plants at random from the middle ridges of every plot were taken after 103 and 107 days from sowing in the two growing seasons, respectively, to determine the following characters: plant height (cm), number of branches /plant, number of bods /plant, 100 seed weight (g), seed yield (kg/feddan) and harvest index %. As well as, in seeds: protein (%), carbohydrates (%), N (%), P (%), K (%) and S (%), at harvest seed yield (kg) of each plot were recorded and then transformed into yield (kg/ feddan). Harvest index was measured by dividing seed yield/feddan on biological yield/feddan X 100. Protein and carbohydrate percentages in seeds were determined by infratec1241 Grain Analyzer. All the obtained data were subjected to analysis of variance according to the method described by Gomez and Gomez (1984). Means comparison were done using least significant difference (LSD) at 5% level of probability.

RESULTS AND DISCUSSION

1. Effect of Phosphoric Acid Foliar Application

Table (1) shows the effect of different levels of foliar P in the form of phosphoric acid on some of yield components and seed chemical composition of chickpea, i.e. plant height (cm), number of branches/plant, number of bods/plant, 100 seed weight (g), seed yield (kg/feddan), harvest index (%), N (%), P (%), K (%), S (%), carbohydrates (%) and protein (%) under alkaline soils at New Valley. Data showed that applying P spray levels from zero to 2 L/feddn to chickpea caused a significant increase in all these parameters, except seed K and S %, which were not significantly affected by P foliar application in both seasons. While, the differences between P foliar application by 1 and 1.5 L/ feddan had insignificant effect on number of branches/plant only in the two seasons. Maximum values of these parameters were produced by 1 L/ feddan of P foliar in both seasons as compared with nil P (control) and the rest levels, except P % in seeds was increased with the increase of spraying level of P from 0 to 2 L/feddan in both seasons. The increasing percentages outcome the foliar application of P by 1 L/feddan compared with control for plant height were 55.69 and 56.95; number of branches /plant were 85.65 and 77.38; number of bods /plant were 48.17 and 47.46; 100 seed weight were 47.52 and 49.82; seed yield were 30.86 and 32.09; harvest index were 14.38 and 12.48; N % were 35.68 and 35.91; carbohydrates were 9.45 and 9.59 and protein were 36.32 and 35.89% in the first and second seasons, respectively. The increasing percentages outcome of the foliar application of P by 2 L/feddan for P % in seeds compared with control were 159.09 and 160.87% in the first and second seasons, respectively.

Table (1). Effect of phosphoric acid on yield and chemical composition of chickpea during 2015/2016 and 2016/2017 growing seasons under New Valley conditions.

Character / Phosphoric acid (L/fed)	Yield and its components						Chemical composition of seed					
	Plant height (cm)	**No. of branches /plant**	**No. of bods/ plant**	**100 seed weight (g)**	**Seed yield (kg/fed)**	**Harvest index (%)**	**N (%)**	**P (%)**	**K (%)**	**S (%)**	**Carboho hydrates (%)**	**Protein (%)**
2015/ 2016 Season												
0.0	38.64	4.25	42.64	16.54	446.8	36.15	2.55	0.22	2.12	0.24	55.34	15.94
0.5	49.25	5.32	56.92	19.27	517.0	39.24	2.84	0.36	2.17	0.26	59.34	17.75
1.0	60.16	7.89	63.18	24.40	584.7	41.35	3.46	0.42	2.19	0.27	60.57	21.73
1.5	59.49	7.72	60.36	23.05	559.6	40.19	3.28	0.48	2.26	0.29	58.20	20.50
2.0	55.24	6.64	48.67	20.79	491.4	38.73	2.98	0.57	2.33	0.30	56.32	18.63
LSD at 5%	**2.57**	**0.78**	**2.14**	**1.31**	**33.6**	**0.49**	**0.17**	**0.05**	**NS**	**NS**	**1.12**	**1.15**
2016/ 2017 Season												
0.0	40.23	4.51	44.31	16.64	451.2	37.34	2.59	0.23	2.14	0.25	55.76	16.19
0.5	50.46	5.74	57.25	20.46	520.4	39.78	2.87	0.36	2.18	0.28	59.68	17.94
1.0	63.14	8.00	65.34	24.93	596.0	42.00	3.52	0.45	2.21	0.29	61.11	22.00
1.5	61.09	7.93	61.19	22.16	572.1	40.51	3.34	0.52	2.27	0.30	58.67	20.58
2.0	58.73	6.83	49.66	19.58	501.3	38.64	3.00	0.60	2.35	0.31	56.81	18.75
LSD at 5%	**2.65**	**0.63**	**1.98**	**1.11**	**44.8**	**1.10**	**0.16**	**0.06**	**NS**	**NS**	**1.38**	**1.38**

Results indicated that foliar application of P at 1 L/feddan is a quite enough to achieve the highest values of the studied parameters under the current experiment. Where, spray of P at a rate higher than 1 L / feddan resulted in a significant decrease in all studied parameters values due to burning of plant leaves, which observed during the growing seasons as a result of the increase in rates of spraying, which negatively affected on the plant growth rate. The good effect of phosphorus on the plant growth is due to that phosphorus enhanced development of meristematic tissue, number of flower buds, photosynthetic activity, biosynthesis of chlorophyll, mobilization of photosynthates, photosynthetic CO_2 fixation, cell division, and carbohydrate metabolism. These results agree with those obtained by Syers and Curtis (2008), Basir et al. (2008), Islam et al. (2011), Ryan et al. (2012), Singh and Singh (2012), Dotaniya et al. (2014) and Saeed et al. (2017).

2. Effect of Sulphur Fertilizer

Data in table (2) reveal that increasing S fertilization rates from 0 to 200 kg S/ feddan caused a significant increase in all yield components and seed chemical composition of chickpea plants under this study, in the both seasons. The highest values of plant height (cm), number of branches/plant, number of bods/plant, 100 seed weight (g), seed yield (kg/feddan), harvest index (%), N (%), P (%), K (%), S (%), carbohydrates (%) and protein (%) were obtained at 200 kg S/feddan, compared with control treatment (without S fertilizer) in both seasons. The increasing percentages attribute with using the high rate of S (200 kg S/feddan), as comparing with control treatment, for plant height (cm) were 87.20 and 84.35; number of branches/plant were 96.21 and 96.92; number of bods /plant were 75.33 and 77.84; 100 seed weight (g) were 73.76 and 74.93; seed yield (kg/ feddan) were 43.75 and 44.74; harvest index (%) were 36.18 and 34.36; N seeds (%) were 59.49 and 60.58; P seeds (%) were 107.41 and 103.57; K seeds (%) were 30.16 and 30.59; S seeds were 86.36 and 87.50, carbohydrates seeds (%) were 21.37 and 19.13 and protein seeds (%) were 59.55 and 60.62 in the first and second seasons, respectively.

The results indicated that S has improved the growth rate and yield of chickpea under alkaline soil condition, because availability of nutrients in soils depends on soil acidity, where availability becomes more by decreasing pH. On the contrary, high pH results in unavailability of many nutrients including phosphorus, iron, zinc, manganese, copper and other nutrients as well as, poor soil construction and permeability, which negatively effects on plant growth in these soils. Previous studies indicated that S application in alkaline soils reduced pH levels and increased SO_4 content, furthermore, increased the availability of more nutrients in rhizosphere (Abrol, 1990; Lopez et al., 1999 and Stamford et al., 2002). studies refer to role of S in increasing growth and yield of pulses besides, its involvement in various metabolic and enzymatic process including photosynthesis, respiration and legume-rhizobium symbiotic nitrogen fixation and is required in the formation of protein, vitamins and enzymes and it's a constituent of amino acids, viz., cystine, cystein and methionine (Rao et al., 2001). This finding is in agreement with those obtained by Kumar et al. (2003), Jaggi et al. (2005), Skwierawska et al. (2008), Khan et al. (2011), Nawange et al. (2011), Islam (2012), Mohammad et al. (2012), George (2017) and Kala et al. (2017).

3. Effect of the Interaction between Phosphoric Acid Foliar Application and Sulphur Fertilizer

Results in tables (3 and 4) indicate that plant height (cm), number of branches/plant, number of bods/plant, 100 seed weight (g), seed yield (kg/ feddan), harvest index (%), N (%), carbohydrates (%) and protein (%) were significantly affected by the interaction between P foliar application and S fertilizer. While, percentages of P, K and S in seeds have not been affected significantly by the interaction in both seasons. Maximum increments for yield and its components and seed chemical composition of chickpea plants under this study were obtained by spraying chickpea plants by 1 L/feddan phosphoric acid with 200 kg S/ feddan in both seasons. In this respect, the lowest values were achieved by the control treatment for the two factors (P and S) in the two seasons. The increasing percentages attributes due to spraying of 1 L phosphoric acid/ feddan and 200 kg S/ feddan as comparing with control treatment for plant height (cm) were 70.94 and 72.77, number of branches/plant were 97.49 and 86.59, number of bods/plant were 60.87 and 61.58, 100 seed weight (g) were 59.83 and 61.71, seed yield (kg/ feddan) were 43.74 and 44.84, harvest index (%) were 24.96 and 23.04, N (%) were 47.15 and 48.00; carbohydrates (%) were 15.19 and 14.20 and protein (%) were 47.46 and 47.79 in the first and second seasons, respectively. Saeed et al. (2017) found that the spraying of chickpea plants with different concentrations of phosphoric acid had a significant effect on the yield and its components. The pods yield increased by 46% when spraying at 1 L/feddan phosphoric acid, while the concentration of 3 L/ feddan resulted in burning the edges of the leaves due to which final yield was decreasing. The increase in the productivity of chickpea could be attributed to role played by S in the formation of disulphide linkages, which are associated with structural characteristic of the protoplasm (Kala et al., 2017). Application of S with P have systematic and antagonistic effect with each other on their varying levels, maintain favorable balance between the applied nutrient in the plant for its optimum growth and had effect on metabolism (Biswas and Tewatia, 2016).

Table (2). Effect of sulphur on yield and chemical composition of chickpea during 2015/ 2016 and 2016/ 2017 growing seasons under New Valley conditions.

Characters / Sulphur (kg/fed)	Yield and its components						Chemical composition of seed					
	Plant height (cm)	No. of branches /plant	No. of bods/ plant	100 seed weight (g)	Seed yield (kg/fed)	Harvest index (%)	N (%)	P (%)	K (%)	S (%)	Carboho hydrates (%)	Protein (%)
2015/ 2016 Season												
0.00	36.24	4.22	37.34	14.67	422.4	34.05	2.37	0.27	1.89	0.22	51.20	14.81
50	52.16	5.76	48.94	17.39	479.3	39.22	2.83	0.31	2.10	0.27	55.26	17.69
100	61.22	6.84	57.17	20.83	511.2	41.74	3.19	0.40	2.22	0.31	57.00	19.94
150	63.24	7.39	61.29	23.15	562.5	43.10	3.54	0.48	2.34	0.36	59.38	22.13
200	67.84	8.28	65.47	25.49	607.2	46.37	3.78	0.56	2.46	0.41	62.14	23.63
LSD at 5%	**1.86**	**0.44**	**3.25**	**1.56**	**30.2**	**1.21**	**0.23**	**0.08**	**0.10**	**0.04**	**1.70**	**1.48**
2016/ 2017 Season												
0	37.12	4.55	38.68	14.96	429.6	34.87	2.41	0.28	1.90	0.24	52.39	15.06
50	52.94	5.82	50.25	18.00	492.5	39.56	2.89	0.34	2.13	0.30	56.10	18.06
100	62.87	7.24	58.49	21.06	533.7	42.32	3.24	0.41	2.25	0.34	57.94	20.25
150	65.70	8.17	63.94	24.36	576.9	44.14	3.59	0.50	2.37	0.39	60.27	22.44
200	68.43	8.96	68.79	26.17	621.8	46.85	3.87	0.57	2.50	0.45	62.41	24.19
LSD at 5%	**2.62**	**0.59**	**4.16**	**1.84**	**29.8**	**1.63**	**0.27**	**0.06**	**0.11**	**0.05**	**1.83**	**1.51**

Table (3). Effect of the interaction between phosphoric acid and sulphur on yield and its components of chickpea during 2015/ 2016 and 2016/ 2017 growing seasons under New Valley conditions.

P X S / Characters		Plant height (cm)	No. of branches /plant	No. of bods/ plant	100 seed weight (g)	Seed yield (kg/ fed)	Harvest index (%)	Plant height (cm)	No. of branches /plant	No. of bods/ plant	100 seed weight (g)	Seed yield (kg/ fed)	Harvest index (%)
P (L/fed)	S (kg/fed)	2015/ 2016 Season						2016/ 2017 Season					
0.0	0	37.44	3.99	39.99	15.61	414.60	35.10	38.68	4.25	41.50	15.80	420.40	36.11
	50	45.40	4.51	45.79	16.97	463.05	37.69	46.59	4.67	47.28	17.32	471.85	38.45
	100	49.93	5.05	49.91	18.69	479.00	38.95	51.55	5.38	51.40	18.85	492.45	39.83
	150	50.94	5.32	51.97	19.85	504.65	39.63	52.97	5.84	54.13	20.50	514.05	40.74
	200	53.24	5.77	54.06	21.02	527.00	41.26	54.33	6.04	56.55	21.41	536.50	42.10
0.5	0	42.75	4.77	47.13	16.97	469.70	36.65	43.79	5.10	47.97	17.71	475.00	37.33
	50	50.71	5.54	52.93	18.33	498.15	39.23	51.70	5.68	53.75	19.23	506.45	39.67
	100	55.24	5.51	57.05	20.05	514.10	40.49	56.67	5.61	57.87	20.76	527.05	41.05
	150	56.25	6.13	59.11	21.21	539.75	41.17	58.08	6.26	60.60	22.41	548.65	41.96
	200	58.55	6.10	61.20	22.38	562.10	42.81	59.45	6.35	63.02	23.32	571.10	43.32
1.0	0	48.20	5.24	50.26	19.54	503.55	37.70	50.13	5.38	52.01	19.95	512.80	38.44
	50	56.16	6.15	56.06	20.90	532.00	40.29	58.04	6.18	57.80	21.47	544.25	40.78
	100	60.69	6.89	60.18	22.62	547.95	41.55	63.01	7.94	61.92	23.00	564.85	42.16
	150	61.70	7.44	62.24	23.78	573.60	42.23	64.42	7.52	64.64	24.65	586.45	43.07
	200	64.00	7.88	64.33	24.95	595.95	43.86	65.79	7.93	67.07	25.55	608.90	44.43
1.5	0	47.87	4.95	49.85	18.86	491.00	37.12	49.11	5.02	50.94	18.56	500.85	37.69
	50	55.83	5.73	55.65	20.22	519.45	39.71	57.02	5.86	56.72	20.08	532.30	40.04
	100	60.36	6.66	59.77	21.94	535.40	40.97	61.98	6.72	60.84	21.61	552.90	41.42
	150	61.37	7.20	61.83	23.10	561.05	41.65	63.40	7.29	63.57	23.26	574.50	42.33
	200	63.67	7.93	63.92	24.27	583.40	43.28	64.76	8.11	65.99	24.17	596.95	43.68
2.0	0	45.74	4.17	43.01	17.73	456.90	36.39	47.93	4.30	44.17	17.27	465.45	36.76
	50	53.70	5.71	48.81	19.09	485.35	38.98	55.84	5.80	49.96	18.79	496.90	39.10
	100	58.23	6.54	52.92	20.81	501.30	40.24	60.80	6.65	54.08	20.32	517.50	40.48
	150	59.24	7.02	54.98	21.97	526.95	40.92	62.22	7.21	56.80	21.97	539.10	41.39
	200	61.54	7.46	57.07	23.14	549.30	42.55	63.58	7.51	59.23	22.88	561.55	42.75
LSD at 5%		**0.30**	**0.31**	**0.39**	**0.58**	**0.12**	**0.36**	**0.28**	**0.74**	**0.42**	**0.51**	**0.13**	**0.28**

Table (4). Effect of the interaction between phosphoric acid and sulphur on chemical composition of chickpea during 2015/ 2016 and 2016/ 2017 growing seasons under New Valley conditions.

P X S (Characters)		N (%)	P (%)	K (%)	S (%)	Carbohohydrates (%)	Protein (%)	N (%)	P (%)	K (%)	S (%)	Carbohohydrates (%)	Protein (%)
P (L/fed)	S (kg/fed)	2015/ 2016 Season						2016/ 2017 Season					
0.0	0	2.46	0.20	2.01	0.22	53.27	15.38	2.50	0.22	2.52	0.23	54.08	15.63
	50	2.69	0.27	2.11	0.25	55.30	16.82	2.74	0.29	2.14	0.26	55.93	17.13
	100	2.87	0.32	2.17	0.28	56.17	17.94	2.92	0.35	2.20	0.30	56.85	18.22
	150	3.05	0.39	2.23	0.31	57.36	19.04	3.09	0.42	2.26	0.33	58.02	19.32
	200	3.17	0.44	2.29	0.36	58.74	19.79	3.23	0.48	2.32	0.38	59.09	20.19
0.5	0	2.61	0.27	2.03	0.23	55.27	16.28	2.64	0.28	2.54	0.25	56.04	16.50
	50	2.84	0.34	2.14	0.26	57.30	17.72	2.88	0.36	2.16	0.28	57.89	18.00
	100	3.02	0.39	2.20	0.29	58.17	18.85	3.06	0.41	2.22	0.31	58.81	19.10
	150	3.19	0.46	2.26	0.32	59.36	19.94	3.23	0.48	2.28	0.34	59.98	20.19
	200	3.31	0.51	2.32	0.37	60.74	20.69	3.37	0.55	2.34	0.40	61.05	21.07
1.0	0	2.92	0.30	2.04	0.23	55.89	18.27	2.97	0.33	2.56	0.25	56.75	18.53
	50	3.15	0.37	2.15	0.27	57.92	19.71	3.21	0.40	2.17	0.28	58.61	20.03
	100	3.33	0.42	2.21	0.29	58.79	20.84	3.38	0.46	2.23	0.32	59.53	21.13
	150	3.50	0.49	2.27	0.33	59.98	21.93	3.56	0.53	2.29	0.35	60.69	22.22
	200	3.62	0.54	2.33	0.37	61.36	22.68	3.70	0.59	2.36	0.40	61.76	23.10
1.5	0	2.83	0.33	2.08	0.24	54.70	17.66	2.88	0.36	2.59	0.26	55.53	17.82
	50	3.06	0.40	2.18	0.28	56.73	19.10	3.12	0.44	2.20	0.29	57.39	19.32
	100	3.24	0.45	2.24	0.30	57.60	20.22	3.29	0.49	2.26	0.32	58.31	20.42
	150	3.41	0.52	2.30	0.34	58.79	21.32	3.47	0.56	2.32	0.35	59.47	21.51
	200	3.53	0.57	2.36	0.38	60.17	22.07	3.61	0.63	2.39	0.41	60.54	22.39
2.0	0	2.68	0.38	2.11	0.25	53.76	16.72	2.71	0.40	2.63	0.26	54.60	16.91
	50	2.91	0.45	2.22	0.28	55.79	18.16	2.95	0.48	2.24	0.29	56.46	18.41
	100	3.09	0.49	2.28	0.31	56.66	19.29	3.12	0.53	2.30	0.33	57.38	19.50
	150	3.26	0.57	2.34	0.34	57.85	20.38	3.30	0.60	2.36	0.36	58.54	20.60
	200	3.38	0.61	2.40	0.39	59.23	21.13	3.44	0.67	2.43	0.41	59.61	21.47
LSD at 5%		**0.09**	**NS**	**NS**	**NS**	**0.47**	**0.52**	**0.07**	**NS**	**NS**	**NS**	**0.31**	**0.45**

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تأثير الفوسفور والكبريت على إنتاجية الحمص تحت ظروف الوادي الجديد

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أقيمت تجربتان حقليتان بالمزرعة البحثية التابعة لمركز بحوث الصحراء بواحة الخارجة، محافظة الوادي الجديد (جنوب غرب مصر) خلال موسمي ٢٠١٥/٢٠١٦ و ٢٠١٦/ ٢٠١٧، لدراسة تأثير الرش بالفوسفور في صورة حامض الفوسفوريك (تركيز ٨٥٪) بمعدلات صفر، ٠.٥، ١، ١.٥ و٢ لتر/ فدان والتسميد بالكبريت الزراعي بمعدلات صفر، ٥٠، ١٠٠، ١٥٠و٢٠٠ كجم/ فدان على المحصول الحمص ومكوناته وبعض صفات الجودة تحت ظروف الأراضي القلوية.
وكانت النتائج المتحصل عليها كالتالي:

١. تأثر المحصول ومكوناته وصفات الجودة تحت الدراسة لنباتات الحمص معنويًا بالرش بالمعدلات المختلفة من الفوسفور، حيث أدى الرش بمعدل ١ لتر/ فدان إلى الحصول على أعلى القيم لجميع الصفات التي تم دراستها مقارنة بمعاملة الكنترول (الرش بالماء فقط)، باستثناء نسبة البوتاسيوم والكبريت بالبذور لم تتأثر معنويًا بمعاملة الرش بالفوسفور، فضلًا على أن نسبة الفوسفور بالبذور زادت طرديًا بزيادة معدل الرش بالفوسفور في كلا الموسمين.
٢. أدت زيادة معدل التسميد بالكبريت من صفر إلى ٢٠٠ كجم كبريت / فدان إلى زيادة معنوية في جميع الصفات التي درست في كلا الموسمين، حيث أمكن الحصول على أعلى القيم بإستخدام أعلى معدل إضافة (٢٠٠ كجم كبريت للفدان) في كلا الموسمين.
٣. إستجابت كافة الصفات التي تم دراستها لنباتات الحمص معنويًا نتيجة التفاعل بين عاملي الدراسة بإستثناء نسبة الفوسفور، البوتاسيوم والكبريت بالبذور لم تتأثر بالتفاعل في كلا الموسمين.
٤. توصي الدراسة برش نباتات الحمص المنزرعة بالأراضي القلوية بمعدل ١ لتر/ فدان حامض فوسفوريك والتسميد بمعدل ٢٠٠ كجم كبريت/ فدان.