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Effect of Skipping One Irrigation and Potassium Fertilization on Growth and Yield of Chickpea Plants

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Abstract: Two field experiments were conducted at El Rayyan region, Fayoum Governorate, Egypt, during the two successive winter seasons of 2010/2011and 2011/2012 to study the effect of application of potassium fertilizer levels (0, 50 and 75 kg K_2O/faddan, one faddan = 0.42 ha) under skipping one irrigation (3rd or 4th irrigation) on growth and yield of chickpea (*Cicer arietinum* L.) cv. Giza 3. The main findings of this study showed that skipping one irrigation or increasing potassium fertilizer levels led to significant reduction in all characters under study in both seasons (plant height, total dry weight /plant, number of branches/plant, number of capsules/plant, dry weight of capsules/plant and dry weight of leaves/plant at 115 days after sowing. Skipping the 3rd or 4th irrigation led to declined in weight of capsules/plant, seed yield/plant, shelling%, seed index, seed, straw and biological yields /faddan. Meanwhile, application of potassium induced stimulating effect on yield and its components under the present study and the rate of 75 Kg K_2O/faddan increased all characters under this study i.e. weight of capsules/plant, seed yield/plant, shelling % seed index, seed, straw and biological yields. It is clear from the results that skipping the 3rd or 4th irrigation led to reduction in protein and carbohydrate percentages compared with the control, while there was a significant increase in protein and carbohydrate percentages of chickpea seed due to application of potassium fertilization. The interaction between skipping irrigation and potassium fertilizer levels was significant in all characters under study and the best treatment was 75kg K_2O /faddan with normal irrigation.

Kew words: Chickpea · Skipping one irrigation · Growth · Potassium fertilization · Yield

INTRODUCTION

Chickpea (*Cicer arietinum* L.) is one of the important pulse crops that play a vital role in human diet. It is the main source of vegetable protein in human diet as it contains 21% protein and 38-59% carbohydrates [1]. It can be a very useful legume crop for incorporation into short-term rotation and for fixation of nitrogen in soil and its fertility [2]. Drought stress is one of the major abiotic stresses in agriculture worldwide. Plants grown under drought condition have a lower stomatal conductance in order to conserve water. Consequently, CO_2 fixation is reduced and photosynthetic rate decreases, resulting in less assimilate production for growth and yield of plants [3]. Water deficit is a major constraint which reduces the productivity of chickpea [4]. Increasing crop tolerance to water limitation would be the most economical approach to enhance productivity and reduce agricultural use of fresh water resources [5]. Potassium is the third major element taken up by the plant. Plants absorb it in larger amounts as compared to other minerals except nitrogen. It has utmost importance for imparting drought and disease resistance and has synergistic effect with nitrogen and phosphorus [6]. Under water stress, potassium has been suggested to play an important role in different physiological and biochemical processes such as plant water relations, stomatal movement, osmoregulation, CO_2-exchange, carbon and nitrogen metabolism, transpiration, protein synthesis, enzyme activation growth and yield of plant [7, 8].

Therefore, the present study aims to investigate the effect of potassium fertilizer levels on growth, yield and its components as well as some chemical constituents in chickpea under skipping one irrigation.

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MATERIALS AND METHODS

Two field experiments were carried out at El Rayyan region, Fayoum Governorate, Egypt, during the two successive winter seasons of 2010/2011and 2011/2012 to study the effect of potassium fertilizer levels (0, 50 and 75 kg K_2O/faddan, one faddan = 0.42 ha) on growth and yield of chickpea (*Cicer arietinum L.*) cv. Giza 3 when exposed to skip one irrigation. The physical and chemical properties of the experimental soil site (30 depths) were as follows: sand 52.5%, silt 20%, clay 27.5%, pH 8.02, OM 0.84 %, $CaCO_3$ 20.9%, EC 2.9 mmhos/cm^3, soluble N 74 ppm according to Chapman and Pratt [9]. The experimental design was split-plot design with four replicates. Irrigation treatments (normal irrigation as control (I_1), skipping the 3rd irrigation (I_2) and skipping the 4th irrigation (I_3) were assigned to the main plots, while the three levels of potassium fertilizer in the form of potassium sulphate (48-50% K_2O [K_0 (control), K_1 (50 kg K_2O/faddan) and K_2(75 K_2O/faddan)] were randomly distributed in the sub plots. Nitrogen and Phosphorus fertilizers were added before sowing at the rate of 15 kg N/faddan in the form of ammonium nitrate (33.5 % N) and 150 kg calcium super phosphate (15.5% P_2O_5). Also the potassium levels were also added before sowing. Chickpea seeds were planted on the first week of December in the two successive 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 20 cm between rows), 20 cm between hills. Normal irrigation, where six irrigations were applied during the season at 2 weeks intervals. The normal agronomic practices for growing chickpea were practiced till harvest as recommended by Legumes Research Department Agricultural Research Centre, Giza, Egypt.

Growth Characters: A random sample of ten plants from each plot was taken at 115 days after sowing to the laboratory where the following characters were recorded:

- Plant height (cm).
- Number of capsules/plant.
- Number of branches /plant.
- Dry weight of leaves /plant (g).
- Dry weight of capsules/plant (g).
- Total dry weight/plant (g).

Yield and Yield Components: At harvest, a random sample of ten plants was taken from each plot to determine:

- Weight of capsules /plant (g).
- Seed yield /plant (g).
- Shelling %.
- Seed index (g).
- Seed yield (kg/fad.).
- Straw yield (kg/fad.)
- Biological yield (kg/fad.)
- Harvest index

Where, seed, straw and biological yields (kg/faddan) were determined from the whole area of each experimental unit and then converted to yield per fed.

Chemical Constituents: Protein and Carbohydrate in seeds were determined of infratec1241 seed Analyzer.

Statistical Analysis: All data were subjected to statistical analysis according to procedure outlined by Snedecor and Cochran [10]. Treatments means were compared by L.S.D test.

RESULTS AND DISCUSSIONS

Growth Characters: Table 1 show that skipping one irrigation significantly decreased the values of the growth characters at 115 days after sowing. Higher reduction in plant height (12.20%), total dry weight/plant, (11.99%), number of branches/plant (7.03%), number of capsules/plant (12.98%) and dry weight of capsules/plant (7.67%) and dry weight of leaves/plant (9.97%) were occurred when irrigation was skipped in the 3rd irrigation, whereas, omitting the 4th irrigation resulted in less reduction compared to the normal irrigation. The current results are in agreement with those obtained by Leport *et al*. [11] and Nayyar *et al.* [12], who showed that early water stress affected dry matter production and biomass in chickpea. Such results indicate that the reduction of water availability under drought results in reduced photosynthetic rate resulting in less assimilate production for growth of plants. In this respect, Kurdali *et al.* [13] indicated that water restriction during the post-flowering period in chickpea considerably affect growth and N_2- fixation.

Increasing potassium fertilizer levels significantly increased all the growth characters of chickpea plants i.e., plant height, total dry weight/plant, number of branches/ plant, number of capsules/plant, dry weight of capsules/ plant and dry weight of leaves/plant(g) at 115 days after

Table 1: Effect of skipping one irrigation, potassium fertilization and the interaction on some growth characters of chickpea plants at 115 days after sowing.

Characters							
Treatments		Plant height (cm)	Total dry Weight (g/plant)	Number of branches/plant	Number of capsules/plant	Weight of capsules (g/plant)	Dry weight of leaves (g/plant)
Skipping one irrigation	Control (I_1)	66.80	88.20	5.32	31.04	46.76	29.40
	3rd (I_2)	58.65	77.62	4.95	27.01	43.17	26.47
	4th (I_2)	63.02	84.36	5.08	29.07	44.94	28.09
LSD 5%		1.84	1.80	0.14	0.62	1.57	0.52
Potassium fertilizer levels	Control(K_0)	57.91	80.91	4.60	26.77	39.91	17.79
	K_1	62.95	83.59	5.27	29.58	46.38	29.38
	K_2	67.61	85.67	5.48	30.77	48.59	30.19
LSD 5%		4.19	2.09	0.18	1.03	2.10	1.16
Control(I_1)	Control(K_0)	63.32	86.51	4.78	28.83	41.98	26.66
	K_1	66.02	88.09	5.41	32.04	48.10	30.54
	K_2	71.07	90.00	5.78	32.26	50.20	31.00
I_2	Control(K_0)	53.42	75.18	4.35	24.58	37.59	21.82
	K_1	58.66	78.14	5.18	27.55	44.88	28.24
	K_2	63.88	79.54	5.31	28.91	47.05	29.33
I_3	Control(K_0)	57.00	81.06	4.68	26.89	40.15	29.32
	K_1	64.17	84.55	5.21	29.16	46.15	29.35
	K_2	67.89	87.46	5.35	31.15	48.51	30.24
LSD 5%		7.25	3.62	0.32	1.79	3.64	2.00

Table 2: Effect of skipping one irrigation, potassium fertilization and the interaction on yield and yield components of chickpea plant

Characters									
Treatments		Weight of capsules (g/plant)	Seed yield (g/plant)	Seed index (g)	Shelling %	Seed yield (Kg/fad.)	Straw yield (Kg/fad.)	Biological Yield (Kg/fad.)	Harvest Index
Skipping one irrigation	Control (I_1)	45.76	36.58	28.46	79.77	1054.72	1926.23	2980.95	35.33
	3rd (I_2)	41.43	31.84	24.85	76.41	981.24	1877.74	2858.98	34.30
	4th (I_2)	44.38	35.05	26.26	78.97	1037.17	1906.54	2943.71	35.18
LSD 5%		0.73	0.64	1.51	1.84	13.23	3.72	11.83	0.33
Potassium fertilizer levels	Control(K_0)	38.55	29.17	22.39	75.75	942.83	1857.84	2800.67	33.66
	K_1	44.99	35.12	27.25	77.88	1019.16	1895.05	2914.21	34.97
	K_2	48.04	39.18	29.93	81.53	1111.14	1957.62	3068.76	36.19
LSD 5%		1.18	1.62	2.24	3.37	25.63	9.73	28.91	0.58
Control(I_1)	Control(K_0)	40.20	31.09	23.34	77.67	965.33	1883.53	2848.86	33.88
	K_1	47.21	37.34	29.19	78.83	1042.16	1921.66	2963.81	35.16
	K_2	49.89	41.32	32.84	82.81	1156.67	1973.51	3130.18	36.95
I_2	Control (K_0)	36.04	26.43	21.49	72.92	915.99	1821.37	2737.35	33.46
	K_1	42.21	32.19	25.32	76.10	987.33	1868.83	2856.16	34.57
	K_2	46.04	36.91	27.75	80.21	1040.39	1943.02	2983.41	34.87
I_3	Control (K_0)	39.40	30.00	22.34	76.64	947.17	1868.63	2815.80	33.64
	K_1	45.56	35.84	27.23	78.70	1027.99	1894.66	2922.64	35.17
	K_2	48.19	39.31	29.21	81.57	1136.35	1956.33	3092.68	36.74
LSD 5%		2.05	2.81	3.87	5.84	44.40	16.85	50.07	1.00

sowing (Table 1). Significant increase in plant height with potassium application can be attributed to the fact that potassium enhances plant vigor and strengthens the stalk [14]. The positive action of potassium fertilizer application on growth characters of chickpea plants might be enhanced the photosynthetic activity which resulted in improving the growth. Similar results were reported by Boulbaba *et al.* [15] and Asghar *et al.* [14] who reported that number of branches per plant in chickpea increased with increasing K rate. The potassium fertilization at 150 K_2O kg/ha to chickpea improved shoot biomass. As for the interaction effect (skipping one irrigation and potassium fertilizer levels) (Table 1) showed that the greatest plant height, total dry weight/plant, number of branches/plant, number of capsules/plant, weight of capsules/plant (g) and dry weight of leaves/plant (g) values were recorded when normal irrigation with 75kg K_2O/faddan was applied, while the lowest values for the same characters were recorded when skipping the 3rd irrigation was done without fertilization. The differences between control irrigation with 50kg K_2O/faddan and omitting the 4th irrigation with 75kg K_2O/faddan were insignificant for all growth characters under study. Potassium may help in increasing the functional life span by translocating sufficient amount of photosynthesis to the shoot under stress conditions [16]. The results are in conformity with Kurdali *et al.* [13], who reported that potassium fertilization with adequate irrigation improves growth and nitrogen fixation in chickpea plants.

Yield and its Components: It is clear from Table 2 that skipping one irrigation significantly decreased all yield

components i.e. weight of capsules/plant, seed yield/plant, shelling % and seed index. Higher reduction of the abovementioned characters was registered when chickpea plants were exposed skipping the 3rd irrigation. Skipping the 3rd and 4th irrigations led to reduction of seed, straw and biological yields /faddan compared with the normal irrigation (control). Also the previous characters significantly decreased when chickpea plants were subjected to omitting the each irrigation. Harvest index was significantly decreased when chickpea plants were exposed to skipping the 3rd irrigation only. However, the differences between control and skipping of the 4th irrigation were not significant for this parameter. On the other hand, normal irrigation (control) promoted growth and resulted in higher plant height, greater leaves area and large number of branches per plant and thereby increased rate of photosynthesis and better translocation of photosynthates from leaves and stems to the sink, which in turn influenced weight of capsules/plant, seed index and seed yield per plant and consequently per fed. These results are in agreement with those obtained by Leport *et al.* [11] and Paramesh and Salimath, [4]. In this concern, Mafakheri *et al.* [3] stated that photosynthesis is limited by drought stress due to stomatal (stomatal closure) and non stomatal (impairments of metabolic processes) factors, resulting in less assimilate production for growth and yield of plants. Furthermore, application of potassium induced stimulating effect on yield and its component under the present study. Application of 75 Kg K_2O/faddan significantly increased weight of capsules per plant (g), shelling%, seed index, seed yield/plant (g) as well as seed, straw and biological yields/faddan. Consequently, all these characters shared in increasing final seed yield as compared with the untreated (control). The results showed the significant increase in biological yield from 2800 in control to 3068kg/faddan with application of 75 Kg K_2O/faddan which estimated by 9.5% higher biological yield over the control. The increase in yields and its components by increasing potassium fertilization might be related to its effect on water plant relationship as well as metabolic and physiological activities of chickpea plant. Such results confirmed the data reported by Asghar *et al.* [14] and Samiullah and Khan [17].

Concerning the effect of interaction, data presented in Table 2 indicated that the highest values of most studied characters were recorded when the normal irrigation treatment with 75kg K_2O/faddan was applied, while the lowest values of the same characters were recorded when skipping the 3rd irrigation without fertilization was practiced. The differences between normal irrigation with 75kg K_2O/faddan and omitting the 4th irrigation with 75kg K_2O/faddan were not significant for yield and its components. Potassium is reported to improve plant's resistance against drought stress [18] and can alleviate water shortages in many legume crops [19]. These results are in a harmony with those obtained by Singh and Kataria [16], who reported that potassium may help in increasing the functional life span by translocating sufficient amount of photosynthesis to the sink under stress conditions.

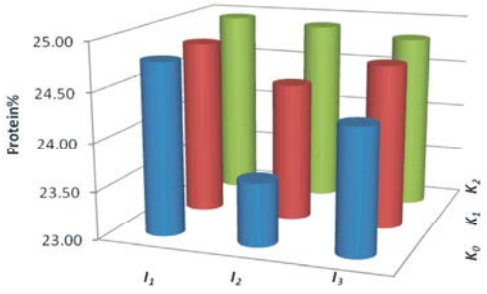

Fig. 1: Effect of interactions between skipping one irrigation and potassium fertilization on protein%

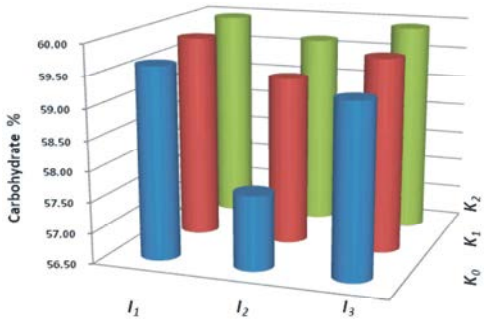

Fig. 2: Effect of interactions between skipping one irrigation and potassium fertilizer on carbohydrate%

Chemical Constituents: Fig. 1and 2 illustrated that skipping the 3rd and 4th irrigations led to reduction in protein and carbohydrate percentages compared with the normal irrigation (control). The differences between normal irrigation and omitting the 4th irrigation were insignificant for carbohydrate percentage. During this study we examined that these results also resemble the findings of Gunes *et al.* [20], who found that decreasing water availability under drought generally results in reduced total nutrient uptake and frequently reduces the concentrations of mineral nutrients in chickpea. It is clear

from Fig. 1 and 2 that there was significant increase in protein and carbohydrate percentages of chickpea seeds due to application of potassium fertilization. These results may be due to increase of growth and yield which in turn reflected positively on chemical of chickpea seeds. Furthermore, Singh and Kataria [16] pointed out that potassium helped to maintain sufficient rates of nitrogen fixation and N- partitioning to meet the requirement of two active sinks i.e. reproductive parts and the nodules at the same time. The interaction between skipping one irrigation and potassium fertilizer levels on protein and carbohydrate percentages of chickpea seeds are presented in Fig. 1 and 2. The highest values of protein and carbohydrate percentages were recorded when the normal irrigation with 75kg K_2O/faddan was applied, while the lowest values for the same characters were recorded by skipping the 3rd irrigation without fertilization.

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