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Effect of Water Regime and Potassium Fertilization on Productivity of Two Chickpea (*Cicer Arietinum* L.) Cultivars

Amal G. Ahmed, Magda H. Mohamed, M.S. Hassanein, Nabila M. Zaki, S.F. El Habbasha, M.M. Tawifk and Manal F. Mohamed

Field Crops Research Dept., National Research Centre, 33 El Bohouth st., 12622, Dokki, Giza, Egypt.

Abstract: Two field experiments were carried out at Wadi El-Rayan, Fayoum Governorate, Egypt, during the two successive winter seasons of 2011-2012 and 2012-2013 to study the effect of water regime (normal irrigation and omitting the 4th irrigation) and potassium fertilization (0, 60 and 90 kg K_2O/ fad.) on growth parameters, yield, yield components and some chemical constituents of two chickpea cultivars (Giza-3 and Giza-88). The results show that omitting the 4th irrigation led to significant reduction in all growth parameters expect number of branches/plant in the both seasons at 105 days after sowing. There were significant varietal differences between Giza-3 and Giza-88 in all growth parameters at 105 days after sowing in the both seasons. Increasing potassium fertilizer levels up to 90 kg K_2O/fad. significantly increased all the growth parameters at 105 days after sowing in the both seasons. Omitting the 4th irrigation significantly decrease yield, its components and chemical constituents of chickpea expect shelling % and straw yield/fad. in the both seasons**.** Giza-3 cultivar surpassed Giza-88 cultivar in yield, yield components and chemical constituents in this study**.** The interactions between water regime and cultivars, water regime and potassium fertilizer**,** cultivars and potassium fertilizer were significant in all growth parameters**,** yield, yield components and chemical constituents**.** The interaction between water regime, cultivars and potassium fertilizer was in all growth parameters**,** yield, yield components and chemical constituents and the best treatment was Giza-3 cultivar applied by 90 kg K_2O/fad. with normal irrigation.

Kew words: Chickpea- Water regime- Potassium fertilizer- Productivity.

Introduction

Chickpea (*Cicer arietinum* L.) is one of the most important pulse crop grown and consumed all over the world, especially in the Afro-Asian countries. In Egypt it is ranked the third after faba bean and lentil from the stand point of its importance as legume crop. It is a good source of carbohydrates and protein, and its quality of protein is considered to be better than other pulses. Chickpea has significant amounts of all the essential amino acids except sulphur-containing amino acids, which can be complemented by adding cereals to the daily diet. Starch is the major storage carbohydrate followed by dietary fiber, oligosaccharides and simple sugars such as glucose and sucrose [1]. It can be a very useful legume crop for incorporation into short-term rotation and for nitrogen fixation in soil and its fertility [2]. Chickpea production is affected by different factors such as cultivars, irrigation and soil fertility. Increasing chickpea yield per unit area can be achieved by breeding high yielding cultivars. Significant differences in chickpea cultivars have been shown by many investigators [3, 4, 5, 6, 7].

Drought stress is one of the major abiotic stresses in agriculture worldwide. It impacts include growth, yield, membrane integrity, pigment content, osmotic adjustment water relations and photosynthetic activity.

Increasing crop tolerance to water limitation would be the most economical approach to enhance productivity and reduce agricultural use of fresh water resources [8]. Water plays a vital role in all living organisms [9].

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 [10]. 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 [11, 12]. Thus the objective of this study is to investigate the effect of water regime and potassium fertilization on growth parameters, yield, yield components and some chemical constituents of two chickpea cultivars.

Materials and Methods

Two field experiments were carried out at Wadi El-Rayan, Fayoum Governorate, Egypt, during the two successive winter seasons of 2011-2012 and 2012-2013 to study the effect of water regime and potassium fertilization on growth, yield, yield components and some chemical constituents of two chickpea cultivars (*Cicer arietinum* L.). Some physical and chemical characters of soil (30 depths) in the experimental site were as follows: sand 52.5%, silt 20%, clay 27.5%, pH 8.02, organic matter 0.84 % ,$CaCO_3$, 20.9%, EC 2.9 mmhos/cm^3, soluble N 74 ppm soil measured as described by [13]. The experimental design was split- split plots design with four replicates, water regime (normal irrigation as a control and omitting the 4th irrigation) were assigned in the main plots, two cultivars (Giza-3 and Giza-88) were randomly distributed in the sub plots and three levels of potassium fertilizer (0, 60 and 90kg/fad.) were randomly distributed in the sub-sub plots. NP fertilizer was added at the rate of 15kg N/fad. as ammonium nitrate 33% N, 150 kg /fad. as calcium super phosphate (15.5% P_2O_5). Potassium fertilizer as potassium sulfate, 48 % K_2 O was added during the seedbed preparation. Chickpea seeds were planted on first week of December 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 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 of growing chickpea in this district were practiced till harvest as recommended by Legumes Research Dept. A.R.C., Giza.

Plant height (cm), total plant dry weight (g), number of branches/plant, number of capsules/plant, dry weight of capsules (g/plant), and dry weight of leaves (g/plant) were obtained at 105 days after sowing by harvesting ten guarded plants at random from the middle ridges of every plot. At full maturity, a random sample of ten plants was taken from each plot to determine to weight of capsules (g/plant), seed yield (g/plant), shelling % and seed index. While, seeds, straw and biological yields per fad. were determined from the total plants of each plot. Harvest index was measured by dividing seed yield/fad. on biological yield/fad. X 100. Protein and carbohydrate percentages in seed were determined of infratec1241 Grain Analyzer.

All data were subjected to statistical analysis according to procedure outlined by [14]. Since the trend was similar in both seasons, Bartlett's test was applied and the combined analysis of the two growing seasons was done. LSD ($P<0.05$) was used to compare means.

Results and Discussions

1-Effect of water regime

A-Growth parameters

Data reported in Table (1) that omitting the 4th irrigation led to reduction in all growth parameters i.e. plant height, total dry weight / plant (g), number of branches /plant, number of capsules /plant, dry weight of capsules /plant (g) and dry weight of leaves /plant (g) at 105days after sowing compared with the normal irrigation (control).The previous parameters significantly decreased expect number of branches /plant when chickpea plants were subjected to omitting the 4th irrigation. It could be concluded that 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 plant. In this regard, [6, 15] indicated that omitting one irrigation led to significant reduction in all growth characters. Similar

results were reported by [16] who showed that water restriction during the post-flowering period in chickpea considerably affect growth and N_2- fixation.

Table (1): Effect of water regime on some growth parameters of chickpea plants at 105 days after sowing (combined analysis of 2011-2012 and 2012-2013 seasons).

parameters / Water regime	Plant height (cm)	Total dry weight(g)	Number of branches per plant	Number of capsules per plant	Weight of capsules(g) per plant	Dry weight of leaves(g) per plant
Normal irrigation	64.59	78.48	4.52	25.89	40.95	25.08
Omitting the 4th irrigation	53.88	74.97	4.45	24.98	40.01	24.29
LSD at 5%	1.64	1.07	NS	0.40	0.74	0.48

B- Yield, yield components and chemical constituents

Data recorded in Table (2) concluded that omitting the 4th irrigation significantly decrease weight of capsules/plant, seed yield/plant, seed index, seed, biological yields/fad. harvest index, protein and carbohydrate percentages, except shelling % and straw yield/fad. 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 [17]. The higher seed yield /fad. under normal irrigation can be attributed to higher weight of capsules/ plant (g), seed yield / plant (g), seed index and shelling %. The increased crop yield may be due to more partitioning of dry matter to reproductive parts. The results are almost same as were reported by [18] who noticed that grain yield and yield components were significantly affected by irrigation regime. Results were in accordance with those obtained by [6, 15].

Decrease in protein and carbohydrate percentages of chickpea seeds resulted from omitting the 4th irrigation may be due to decrease of growth and yield which in turn reflected negative impact on chemical of chickpea seeds. Decreasing water availability under drought conditions generally results in reduced nutrient uptake and frequently reduced concentrations of elements in crop plants [19]. These results are in a harmony with those obtained by [20] who found that decreasing water availability under drought conditions generally results in reduced total nutrient uptake and frequently reduces the concentrations of mineral nutrients in chickpea.

Table (2): Effect of water regime on some yield components chickpea plants (combined analysis of 2011-2012 and 2012-2013 seasons).

Parameters Water regime	Weight of capsules per plant(g)	Seed yield per plant(g)	Shelling %	Seed index (g)
Normal irrigation	40.35	31.22	76.70	25.31
Omitting the4th irrigation	38.82	29.60	75.65	23.51
LSD at 5%	0.97	0.53	NS	0.28

Table (2cont): Effect of water regime on yields and chemical constituents of chickpea plants (combined analysis of 2011-2012 and 2012-2013 seasons).

Parameters Water regime	Seed yield (kg/fad.)	Straw yield (kg/fad.)	Biological yield (kg/fad.)	Harvest index	Protein %	Carbohydrate %
Normal irrigation	950.68	1830.45	2781.13	34.05	24.13	58.30
Omitting the4th irrigation	921.14	1816.14	2737.28	33.48	23.04	57.62
LSD at 5%	3.34	NS	31.72	0.45	0.72	0.20

2-Effect of chickpea cultivars

A-Growth parameters

Data presented in Table (3) indicated that chickpea cultivars significantly differed in plant height, total dry weight/ plant, number of branches and capsules/plant and dry weight of capsules and leaves/plant (g) at 105 days after sowing. Giza-3 cultivar surpassed Giza-88 cultivar in all growth parameters. It could be concluded that varietal differences between chickpea cultivars may be due to genetical differences between cultivars and growth habit as well as the differences between genotypes concerning partition of dry matter. These results of varietal differences in growth parameters are in agreement with those obtained by [3, 5, 6, 7].

Table (3): Effect of chickpea cultivars on some growth parameters of chickpea plants at 105 days after sowing (combined analysis of 2011-2012 and 2012-2013 seasons)

Parameters Cultivars	Plant height (cm)	Total dry weight(g)	Number of		Weight of capsules	Dry weight of leaves(g)
			branches	capsules		
		per plant				
Giza -3	60.69	85.71	5.16	29.83	45.82	28.61
Giza -88	57.78	67.75	3.80	21.04	35.14	20.77
LSD at 5%	0.91	0.95	0.16	0.24	0.34	0.38

B- Yield, yield components and chemical constituents

Data presented in Table (4) show that significant differences between Giza-3 and Giza-88 cultivars in the yield and yield components, i.e. weight of capsules/plant (g), seed yield/plant(g), seed index (g), shelling %, seed yield (kg/fad), straw yield (kg/fad) and biological yield (kg/fad). Where, Giza -3 surpassed Giza -88 in most of studied parameters. These results are in a harmony with those obtained by [21] who recorded that there were significant differences among cultivars for seed yield, biological yield and 100-seed weight. Several studies pointed out to the significant differences in chickpea cultivars [3, 4, 5, 6, 7]. Giza-3 cultivar exceeded Giza-88 cultivar in protein and carbohydrate percentages. These results may be due to increase of growth and yield which in turn reflected positively on chemical constituents of chickpea seeds [22, 5].

Table (4): Effect of chickpea cultivars on some yield components of chickpea plants (combined analysis of 2011-2012 and 2012-2013 seasons).

Parameters Cultivars	Weight of capsules	Seed yield	Shelling %	Seed index (g)
	per plant(g)			
Giza -3	44.87	35.63	79.20	27.15
Giza -88	34.30	25.19	73.15	21.67
LSD at 5%	0.34	0.26	0.63	0.23

Table (4cont): Effect of chickpea cultivars on yields and chemical constituents of chickpea plants (combined analysis of 2011-2012 and 2012-2013 seasons).

Parameters Cultivars	Seed	Straw	Biological	Harvest index	Protein %	Carbohydrate %
	yield (kg/fad.)					
Giza -3	1047.52	1913.15	2960.67	35.33	25.01	59.29
Giza -88	824.30	1733.44	2557.74	32.20	22.17	56.62
LSD at 5%	8.77	21.40	18.06	0.41	0.67	0.17

3-Effect of potassium fertilization rates

A-Growth parameters

From the data manifested in Table (5), noticeably those plants fertilized with 90kg K_2O/fad rate of potassium fertilizer had higher growth vigor than that unfertilized. The positive action of potassium fertilizer application on growth parameters of chickpea plants might be enhanced the photosynthetic activity which

resulted in improving the growth. In this respect, [23, 24] who reported that number of branches per plant in chickpea increased with increasing K rate. The potassium fertilization at 150 kg K_2O $ha^{-1}$to chickpea improved shoot biomass. The results are in conformity with [15] they reported that increasing potassium fertilizer levels significantly increased all the growth characters of chickpea.

Table 5: Effect of potassium fertilization rates on some growth parameters of chickpea plants at 105 days after sowing (combined analysis of 2011-2012 and 2012-2013 seasons).

Parameters Fertilizer rates	Plant height (cm)	Total dry weight(g)	Number of		Weight of capsules(g)	Dry weight of leaves(g)
			branches	capsules		
		per plant				
0kgK_2O/fad.	54.95	73.14	4.06	23.87	36.22	21.87
60kgK_2O/fad.	59.37	76.19	4.57	25.84	41.18	25.61
90kgK_2O/fad.	63.39	80.86	4.82	26.59	44.04	26.58
LSD at 5%	0.55	0.57	0.15	0.21	0.23	0.32

B- Yield, yield components and chemical constituents

As shown in Table 6, data revealed that weight of capsules/plant, seed yield/plant, shelling %, seed index, seed, straw, biological yields/fad. harvest index, protein and carbohydrates percentages of seed were increased with increasing potassium application up to 90kg K_2O /fad. These results may be due to increase of growth which in turn reflected positively on yield and its components of chickpea. 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 [25]. Several studies pointed out to the positive response of yield to potassium fertilization [23, 24]. The vital role of potassium in photosynthesis, translocation of photosynthates, protein synthesis, ionic balance, regulation of plant stomata and water use, activation of plant enzymes and many other processes is well recognized [19]. Similar conclusion was also reported by [15] they reported that K fertilization markedly increased seed yield of chickpea and improved seed quality**.**

Table 6: Effect of potassium fertilization rates on some yield components of chickpea plants (combined analysis of 2011-2012 and 2012-2013 seasons).

Parameters Fertilizer rates	Weight of capsules	Seed yield	Shelling %	Seed index (g)
	per plant(g)			
0kgK_2O/fad.	35.47	26.14	73.32	21.21
60kgK_2O/fad.	40.21	30.32	74.84	24.68
90kgK_2O/fad.	43.08	34.77	80.38	27.33
LSD at 5%	0.33	0.24	0.88	0.14

Table (6cont): Effect of potassium fertilization rates on yields and chemical constituents of chickpea plants (combined analysis of 2011-2012 and 2012-2013 seasons).

Parameters Fertilizer rates	Seed	Straw	Biological	Harvest index	Protein %	Carbohydrate %
	yield (kg/fad.)					
0kgK_2O/fad	862.45	1759.40	2621.85	32.81	22.81	57.48
60kgK_2O/fad	920.59	1835.84	2756.43	33.28	23.60	58.07
90kgK_2O/fad	1024.69	1874.65	2899.34	35.21	24.35	58.32
LSD at 5%	5.96	17.05	16.89	0.28	0.93	0.17

4-Effect of interaction between water regime and cultivars

A-Growth parameters

Data recorded in Table (7), indicated that the highest values of almost studied growth parameters were recorded to Giza -3 cultivar under normal irrigation, while the lowest values of same parameters were recorded to Giza -88 cultivar under omitting the 4 th irrigation. Although omitting the 4 th irrigation affects whole plant growth in chickpea, distinct genotypic differences were observed between the two cultivars. It is worthy to mention that [26] showed that there was wide variation in tolerance to drought stress among chickpea genotypes.

Table 7: Effect of interaction between water regime and chickpea cultivars on some growth parameters of chickpea plants at 105 days after sowing (combined analysis of 2011-2012 and 2012-2013 seasons).

Parameters Water regime Cultivars		Plant height (cm)	Total dry weight(g)	Number of		Weight of capsules(g)	Dry weight of leaves(g)
				branches	capsules		
			per plant				
Normal irrigation	Giza -3	66.65	88.27	5.25	30.71	46.59	29.33
	Giza -88	62.54	68.70	3.79	21.08	35.31	20.83
Omitting the 4th irrigation	Giza -3	54.74	83.15	5.08	28.95	45.05	27.89
	Giza -88	53.03	66.79	3.81	21.00	34.98	20.70
LSD at 5%		1.29	1.34	0.22	0.34	0.47	0.54

B- Yield, yield components and chemical constituents

As for the interaction effect between omitting the 4th irrigation and chickpea cultivars Table 8, show that the highest values of yield, its components and chemical constituents were recorded in Giza-3 under normal irrigation, meanwhile Giza-88 under omitting the 4th irrigation produced the lowest values of the same parameters.

Table 8: Effect of interaction between water regime and chickpea cultivars on some yield components of chickpea plants (combined analysis of 2011-2012 and 2012-2013 seasons).

Parameters Water regime Cultivars		Weight of capsules	Seed yield	Shelling %	Seed index (g)
		per plant(g)			
Normal irrigation	Giza -3	45.64	36.49	79.72	28.09
	Giza -88	35.05	25.96	73.69	22.53
Omitting the4th irrigation	Giza -3	44.10	34.77	78.69	26.21
	Giza -88	33.54	24.42	72.62	20.81
LSD at 5%		0.48	0.37	0.89	0.33

Table (8cont): Effect of interaction between water regime and chickpea cultivars on yields and chemical constituents of chickpea plants (combined analysis of 2011-2012 and 2012-2013 seasons).

Parameters Water regime Cultivars		Seed	Straw	Biological	Harvest index	Protein %	Carbohydrate %
		yield (kg/fad.)					
Normal irrigation	Giza -3	1056.96	1920.29	2977.25	35.45	25.73	59.81
	Giza -88	844.41	1740.61	2585.01	32.64	22.53	56.79
Omitting the4th irrigation	Giza -3	1038.07	1906.01	2944.09	35.21	24.28	58.78
	Giza -88	804.20	1726.27	2530.47	31.76	21.80	56.45
LSD at 5%		12.41	30.27	25.54	0.59	0.95	0.24

5-Effect of interaction between water regime and potassium fertilization rates

A-Growth parameters

Chickpea plants fertilized with 90 K_2O kg/fad. under normal irrigation gave the highest values of growth parameters while the lowest values of the same parameters were recorded when omitting the 4th irrigation without potassium fertilization (Table 9). Potassium application under drought stress resulted in the protection of membranes resulting in keep the cell water content, increase in photosynthesis and enhanced partitioning of photo-assimilates to the roots [27]. Such results confirmed the data reported by [15].

Table 9: Effect of interaction between water regime and potassium fertilization rates on some growth parameters of chickpea plants at 105 days after sowing (combined analysis of 2011-2012 and 2012-2013 seasons).

Parameters Water regime Fertilizer rates		Plant height (cm)	Total dry weight(g)	Number of		Weight of capsules(g)	Dry weight of leaves(g)
				branches	capsules		
			per plant				
Normal irrigation	0 kg K_2O /fad.	60.17	74.94	4.10	24.34	36.85	22.47
	60 kg K_2O/fad.	64.71	78.05	4.59	26.47	41.66	25.90
	90 kg K_2O/fad.	68.90	82.47	4.87	26.87	44.34	26.87
Omitting the 4th irrigation	0 kg K_2O/fad.	53.24	63.21	3.40	20.36	31.53	18.39
	60 kg K_2O/fad.	54.03	74.33	4.54	25.21	40.70	25.33
	90 kg K_2O/fad.	57.88	79.25	4.78	26.31	43.75	26.30
LSD at 5%		0.77	0.80	0.21	0.30	0.32	0.45

B- Yield, yield components and chemical constituents

Concerning the effect of interactions between water regime and potassium fertilizer in Table 10, showed that the greatest values of weight of capsules/plant, seed yield/plant, shelling %, seed index, seed, straw and biological yields/fad. harvest index, protein and carbohydrates percentages were recorded when normal irrigation with 90kg K_2O fad. was applied, while the lowest values for the same parameters were recorded when omitting the 4th irrigation was done with no potassium fertilization. Potassium is reported to improve plant's resistance against drought stress [19]. The beneficial effect of K on yield chickpea could be resulted from saving water loss through reducing transpiration rate and facilitating water uptake; consequently, increasing water use efficiency.

Table (10): Effect of interaction between water regime and potassium fertilization rates on some yield components of chickpea plants (combined analysis of 2011-2012 and 2012-2013 seasons).

Parameters Water regime Fertilizer rates		Weight of capsules	Seed yield	Shelling %	Seed index (g)
		per plant(g)			
Normal irrigation	0kgK_2O/fad.	35.99	26.63	73.62	21.74
	60kgK_2O/fad.	41.18	31.29	75.44	25.67
	90kgK_2O/fad.	43.87	35.75	81.05	28.52
Omitting the4th irrigation	0kgK_2O/fad.	31.24	21.90	70.11	19.66
	60kgK_2O/fad.	39.23	29.35	74.25	23.68
	90kgK_2O/fad.	42.29	33.78	79.71	26.15
LSD at 5%		0.47	0.34	1.24	0.20

Table (10cont): Effect of interaction between water regime and potassium fertilization rates on yields and chemical constituents of chickpea plants (combined analysis of 2011-2012 and 2012-2013 seasons).

Parameters Water regime Fertilizer rates		Seed	Straw	Biological	Harvest index	Protein %	Carbohydrate %
		yield kg/fad					
Normal irrigation	0kgK_2O/fad.	877.00	1768.53	2645.54	33.08	23.79	58.14
	60kgK_2O/fad.	934.22	1838.32	2772.54	33.59	23.81	58.31
	90kgK_2O/fad.	1040.83	1884.50	2925.33	35.47	24.80	58.45
Omitting the4th irrigation	0kgK_2O/fad.	765.21	1644.33	2409.54	31.75	20.98	56.40
	60kgK_2O/fad..	906.97	1833.35	2740.32	32.97	23.39	57.83
	90kgK_2O/fad	1008.55	1864.81	2873.35	34.95	23.91	58.19
LSD at 5%		8.43	24.11	23.89	0.39	1.31	0.25

6-Effect of interaction between chickpea cultivars and potassium fertilization rates

A-Growth parameters

Regarding the interaction between chickpea cultivars and potassium fertilization rates, data in Table (11) collected that Giza-3 cultivar fertilized with 90 K_2O kg/fad. was the most effective treatments for growth parameters.

Table (11): Effect of interaction between chickpea cultivars and potassium fertilization rates on some growth parameters of chickpea plants at 105 days after sowing (combined analysis of 2011-2012 and 2012-2013 seasons).

Parameters Cultivars Fertilizer rates		Plant height (cm)	Total dry weight(g)	Number of		Weight of capsules(g)	Dry weight of leaves(g)
				branches	capsules		
			per plant				
Giza - 3	0 kg K_2O/fad.	56.66	83.06	4.72	27.39	40.91	25.34
	60 kg K_2O /fad.	60.54	86.01	5.24	30.38	46.83	29.83
	90 kg K_2O /fad.	64.88	88.06	5.53	31.71	49.71	30.66
Giza - 88	0 kg K_2O /fad.	53.24	63.21	3.40	20.36	31.53	18.39
	60 kg K_2O /fad.	58.21	66.36	3.90	21.30	35.52	21.40
	90 kg K_2O /fad.	61.90	73.66	4.11	21.48	38.38	22.51
LSD at 5%		0.77	0.80	0.21	0.30	0.32	0.45

B- Yield, yield components and chemical constituents

Table (12) showed that the interaction between cultivars and potassium fertilization rates significantly affected yield and its components i.e weight of capsules/ plant (g), seed yield / plant (g), shelling %, seed index, seed, straw and biological yields/fad. and harvest index .The superiority of Giza- 3 with potassium fertilizer rate 90 K_2O kg/fad. in yield and its components compared to other treatments. Genotypic differences in efficiency of K uptake and utilization have been reported for all major economically important plants.

Table (12): Effect of interaction between chickpea cultivars and potassium fertilization rates on some yield components of chickpea plants (combined analysis of 2011-2012 and 2012-2013 seasons).

Parameters Cultivars Fertilizer rates		Weight of capsules	Seed yield	Shelling %	Seed index (g)
		per plant(g)			
Giza -3	0kgK_2O/fad.	39.70	30.38	76.52	22.77
	60kgK_2O/fad.	46.04	36.23	78.67	28.17
	90kgK_2O/fad.	48.87	40.29	82.42	30.51
Giza -88	0kgK_2O/fad.	31.24	21.90	70.11	19.66
	60kgK_2O/fad.	34.37	24.42	71.02	21.19
	90kgK_2O/fad.	37.28	29.25	78.33	24.16
LSD at 5%		0.47	0.34	1.24	0.20

Table (12cont): Effect of interaction between chickpea cultivars and potassium fertilization rates on yields and chemical constituents of chickpea plants (combined analysis of 2011-2012 and 2012-2013 seasons).

Parameters Cultivars Fertilizer rates		Seed	Straw	Biological	Harvest index	Protein %	Carbohydrate %
		yield (kg/fad.)					
Giza -3	0kgK_2O/fad.	959.69	1874.47	2834.16	33.86	24.64	58.56
	60kgK_2O/fad.	1031.32	1907.15	2938.48	35.10	24.63	59.52
	90kgK_2O/fad.	1151.54	1957.84	3109.37	37.03	25.76	59.80
Giza -88	0kgK_2O/fad.	765.21	1644.33	2409.54	31.75	20.98	56.40
	60kgK_2O/fad.	809.86	1764.52	2574.38	31.46	22.57	56.62
	90kgK_2O/fad.	897.84	1791.47	2689.31	33.38	22.95	56.83
LSD at 5%		8.43	24.11	23.89	0.39	1.31	0.25

7-Effect of interaction between water regime, chickpea cultivars and potassium fertilization rates

A-Growth parameters

With respect of the three-way interaction, water regime, cultivars and potassium fertilization rates, data in Table (13) showed that Giza-3 cultivar fertile with 90 K_2O kg/fad. under normal irrigation resulted the highest significant values of plant height (cm) total dry weight/ plant, number of branches and capsules/plant and dry weight of capsules and leaves/plant (g) at 105days from sowing. While, Giza-88 cultivar without fertilized under omitting the 4 th irrigation gave the lowest values of growth parameters previous.

Table (13): Effect of interaction between water regime, chickpea cultivars and potassium fertilization rates on some growth parameters of chickpea plants at 105 days after sowing (combined analysis of 2011-2012 and 2012-2013 seasons).

Parameters Water	Fertilizer		Plant height (cm)	Total dry weight (g)	Number of		Weight of capsules (g)	Dry weight of leaves (g)
					branches	capsules		
				per plant				
Normal irrigation	Giza -3	0 kg K_2O /fad.	63.15	85.85	4.75	28.27	41.82	26.48
		60 kg K_2O/fad.	66.23	88.87	5.27	31.59	47.74	30.34
		90 kg K_2O /fad.	70.57	90.08	5.72	32.26	50.20	31.17
	Giza-88	0 kg K_2O/fad.	57.19	64.02	3.44	20.41	31.88	18.46
		60 kg K_2O /fad.	63.20	67.22	3.92	21.35	35.57	21.46
		90 kg K_2O /fad.	67.23	74.86	4.01	21.49	38.47	22.57
Omitting the4th irrigation	Giza -3	0kg K_2O/fad.	50.18	80.27	4.69	26.51	40.01	24.19
		60 kg K_2O /fad.	54.85	83.15	5.21	29.18	45.92	29.32
		90 kg K_2O /fad.	59.19	86.03	5.34	31.16	49.22	30.14
	Giza-88	0 kg K_2O /fad	49.29	62.41	3.35	20.30	31.18	18.33
		60 kg K_2O /fad	53.22	65.51	3.87	21.25	35.47	21.33
		90 kg K_2O/fad	56.57	72.46	4.21	21.47	38.29	22.45
LSD at 5%			1.09	1.14	0.29	0.42	0.45	0.64

B- Yield, its components and chemical constituents:-

Yield, yield components and chemical constituents of chickpea plants were significantly affected of the interaction between water regime, cultivars and potassium fertilization. Data in table (14) show the highest values were recorded Giza-3 cultivar fertile with 90 kg K_2O/fad under normal irrigation. Application of potassium improves relative water content of plants under normal as well as water stress conditions. The maintenance of plant water economy by K application in terms of high relative water content could be ascribed to the supposed role of K in stomatal resistance, water use efficiency and lowered transpiration rate [23].

Table (14): Effect of interaction between water regime, chickpea cultivars and potassium fertilization rates on some yield components of chickpea plants (combined analysis of 2011-2012 and 2012-2013 seasons).

Water regime		Parameters	Weight of capsules	Seed yield	Shelling %	Seed index (g)
	Cultivars	Fertilizer rates	per plant(g)			
Normal irrigation	Giza -3	0 kg K_2O /fad.	40.17	30.87	76.86	23.31
		60kg K_2O/fad.	47.20	37.28	78.90	29.13
		90kg K_2O/fad.	49.56	41.32	83.40	31.83
	Giza-88	0 kg K_2O /fad.	31.81	22.38	70.39	20.18
		60kg K_2O/fad.	35.17	25.31	71.97	22.21
		90kg K_2O/fad.	38.18	30.18	78.70	25.20
Omitting the4th irrigation	Giza -3	0 kg K_2O /fad.	39.23	29.89	76.18	22.23
		60kg K_2O/fad.	44.89	35.18	78.44	27.21
		90kg K_2O/fad.	48.19	39.25	81.45	29.18
	Giza-88	0 kg K_2O /fad.	30.66	21.41	69.83	19.13
		60kg K_2O/fad.	33.58	23.53	70.06	20.16
		90kg K_2O/fad.	36.38	28.32	77.96	23.12
LSD at 5%			0.67	0.48	1.76	0.29

Table (14cont): Effect of interaction between water regime, chickpea cultivars and potassium fertilization rates on yields and chemical constituents of chickpea plants (combined analysis of 2011-2012 and 2012-2013 seasons).

Water regime		Parameters	Seed	Straw	Biological	Harvest index	Protein %	Carbo hydrate %
	Cultivars	Fertilizer rates	yield (kg/fad.)					
Normal irrigation	Giza -3	0 kgK_2O /fad.	968.84	1883.21	2852.05	33.97	25.78	59.63
		60kgK_2O/fad.	1041.87	1921.15	2963.02	35.16	24.80	59.83
		90kgK_2O/fad.	1160.16	1956.52	3116.68	37.23	26.61	59.97
	Giza-88	0 kg K_2O/fad.	785.16	1653.86	2439.02	32.19	21.79	56.64
		60kgK_2O/fad.	826.56	1755.49	2582.05	32.02	22.83	56.79
		90kgK_2O/fad.	921.50	1812.47	2733.97	33.70	22.99	56.93
Omitting the4th irrigation	Giza -3	0 kgK_2O/fad.	950.53	1865.74	2816.27	33.75	23.49	57.50
		60kgK_2O/fad.	1020.77	1893.16	2913.93	35.03	24.46	59.21
		90kgK_2O/fad.	1142.91	1959.15	3102.06	36.84	24.91	59.63
	Giza-88	0 kg K_2O/fad.	745.26	1634.81	2380.07	31.31	20.17	56.16
		60kgK_2O/fad.	793.16	1773.55	2566.71	30.90	22.32	56.46
		90kgK_2O/fad.	874.19	1770.46	2644.65	33.06	22.92	56.74
LSD at 5%			11.93	34.10	33.79	0.55	1.86	0.35

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