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Influence of Boron and/or Potassium Accompanied By Two Irrigation Systems on Chickpea Growth, Yield and Quality under Sandy Soil Conditions

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Abstract

Chickpea is among the most widely grown pulse crops contributing major part in fulfilling the nutritional requirements of human diet. Thus, this study was done to evaluate the effect of foliar treatment of boron and /or potassium accompanied by either surface or subsurface irrigation system on growth, some physiological aspects (*Chlo* a, *Chlo* b, carotenoids) endogenous indole acetic acid and total soluble sugar contents), yield quantity and quality of chickpea plant at the experimental farm of the Agricultural Research Station, National Research Center, El-Nubaria district, Egypt during the winter seasons of 2018/2019 and 2019/2020.Results show that subsurface irrigation system led to significant increases in all characters of growth and yield attributes as well as, seed quality compared with surface irrigation system. Treatments of boron and /or potassium showed significant increments on chickpea growth, yield quantity and seed quality, via increments in chlolorophyll a,chlolorophyll b, carotenoids, endogenous indole acetic acid and total soluble sugar contents. However, treatment with potassium individually (500 mg/l) cause more increases than boron treatment in all the studied parameters. Moreover, B+K application caused the greatest levels of different studied seed quality (nitrogen, potassium, phosphors, crude protein, carbohydrate, phenolic and ascorbic acid contents). The interaction between subsurface water irrigation and B+K application is the most optimum and effective application for maximizing chickpea plant growth and productivity.

Key words: Boron, Yield. Chickpea, Water irrigation, Potassium, Seed quality

1. Introduction

The agricultural sector uses the greatest amount of water, accounting for over 70% of all freshwater supply to produce more than 40% of the world's food[1 & 2].By 2025, with the predicted increases in population needing to be fed, agricultural productivity must be increased via increasing irrigated soils and plant productivity by 20 & 40% respectively [3]. Moreover, sandy soil suffers from specific problems in management, these problems includes high permeability, limited water and nutrient storing capabilities [4 & 5].So, the agricultural water usage efficiency must be optimized to provide optimum productivity with minimum water uptake. Improving irrigation water management could be one way to achieve that goal[6 & 7], because it allows water energy and soil reserves to be conserved while meeting the growing needs of plants[8].Drip irrigation, which uses a low pressure emitter to drip water onto the soil, provides an equitably spread and regular water distribution to plant as well as, this method is suited for various soil types and all topographic circumstances [9]. Emitters could be used on the soil surface as surface drip irrigation (DI), resulting in the construction of a shallow lake and buried or subsurface drip irrigation, (SDI), resulting in the production of a saturated bulb encircled by a wet-bulb of unsaturated soil [10]. Subsurface irrigation (SSDI) could boost productivity as well as net profit margin, decrease nitrate lost from deep percolation, reducing water evaporation, and improving water efficiency [11, 12 & 13].Sandy soils are of poor nutrient nature which affects growth and productivity of vegetables including chickpea plant.

Foliar treatments with macro and micro-element are considered to be an important method to enhance crop production. Macronutrients, especially nitrogen, phosphorus and potassium are vital nutrients for plant growth and development [14].Despite, applying these nutrients to plants

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using chemical fertilizers is expensive and addition of chemical fertilizers can generate environmental problems posing a harm to agricultural systems along term viability [15]. Next to nitrogen, potassium (K) is known as the second largest nutrient used by all crops [16]. K plays an important role in maintaining electrochemical equilibrium in plant cells and cell components, in addition to enzyme activities regulation [17]. Potassium has an important role for transfer and storage of assimilates and preservation of tissue water balance [18]. Furthermore, K is the key element in improving quantity and quality of plant yield due to its role in stimulating the formations of carbohydrates and sugars translocation [18]. In addition, K is not only an important macronutrient [19 & 20] but it is also a principal osmoticum in maintaining plant low water potential. Thus, K build up in plant cells under variety of environmental conditions might have a key impact in water absorption across a soil-plant range [21]. Its sufficient amount during growth stages enhance water relations of plant and photosynthesis process [22], sustain cell turgor pressure which is important for cell expansion, cell osmotic-regulation, helping in stomata opening and closing [23], activates more than 60 enzymes [24] and protein formation [25], promotes the transfer of photosynthesis, regulates of ionic balance, controls of water use [26] thus enhances the crop yield [27 & 28].

Micronutrients are group of elements which important for plant growth in small quantity. Boron (B) is an important micronutrient for different plant species. B is required for appropriate growth and tissues development of plants [29]. Its amounts vary greatly throughout plant species and are considered to have a narrow range between deficiency and toxicity levels [30]. Boron is one of cell wall components and also it used as enzyme activator, membrane stabilization, nucleic acid metabolism, and sugar transfer [31]. Furthermore, B plays a mechanical impact in maintaining cell wall flexibility, but under B-deficient conditions the cell wall turns hard, inelastic, and brittle [32]. Boron could help plant reproduction, cell differentiation, stomatal control, seed production, carbohydrate consumption. Furthermore, the effect of boron on plant is related to flowers persistence and pollen generation, in addition, germination also influenced and lowered with decreased boron supply [33]. Boron nutrition is affected by various factors. The most significant are soil texture, organic materials level, and pH. Raising soil pH lowers B accessibility to plants. Boron deficiency happens in soils with pH levels near 7.0 and above [34]. The increased nutrient treatments are not advised because of economic and environmental concerns. In addition, low nutrient treatment will not be sufficient for maintaining plant demands throughout time during plant growth stages. Therefore, various fertilizers will be given with the proper quantities and timing [35].

Chickpea (*Cicer arietinum* L.) is a popular winter legume, with a high demand in human diets due to its cheap and well- balanced seed nutrients content. Chickpea known as protein source (15.7–28.0 percentage) [36], carbohydrate, fat, minerals (P, K, Ca, Mg, Fe and Zn), β-carotene and amino acids except sulphur-containing amino acids [37]. It cultivated all over the world, in Egypt, the cultivated area was 623 ha that yielded 1323 ton in 2014 [38]. Chickpea production could be improved via using high productivity cultivar, cultivation in sandy soil, in addition to the treatment of the optimum agricultural practices. Chickpea crop is known by its resilience under restricted water availability. It relies more on residual soil moisture during germination, establishment and early growth. Additional water supply through irrigation at later stages in the season particularly during grain filling stage plays critical role in improving yield and water productivity of chickpea. The performance of chickpea plants depends not only on its genetic characteristics and nutrition but also on the surrounding environmental conditions particularly methods of irrigation and water supply.

Therefore, the aim of this investigation was to investigate the impact of two irrigation methods (surface and subsurface) and/or foliar treatment of potassium and boron (K, B and K+B) on growth, some biochemical, physiological aspects and productivity of chickpea plant grown under sandy soil conditions.

2. Materials and methods

Two field experiments were conducted at Research and Production Station, National Research Centre,El-Nubaria district, Al-Behaira Governorate, Egypt(latitude 30˚30'1.4"N, and longitude 30˚19'10.9"E, and mean altitude 21 m above sea level), during two successive winter seasons 2018/2019 and 2019/2020to study the impact of foliar treatment (potassium, boron and potassium + boron) on growth, some physiological aspects and yield of chickpea plants grown under two systems of water irrigation (surface and subsurface irrigation).Soil of the experimental site was sandy soil. Mechanical, chemical and nutritional properties of the experimental soil site (30 depths) were analysed as [39] and stated in Table (1).

Table(1): Mechanical, chemical and nutritional analysis of the experimental soil. Mechanical analysis.

Mechanical analysis	Sand		Silt 20-0μ %	Clay < 2μ %	Soil texture
	Course 2000-200μ%	Fine 200-20μ %			
	47.46	36.19	12.86	4.28	Sandy

Chemical analysis.

Chemical analysis.	pH 1:2.5	EC dSm^{-1}	$CaCO_3$ %	OM%	Soluble cations (meq/l)				Soluble anions (meq/l)			
					Na^+	K^+	Mg^+	Ca^{++}	CO_3^{--}	HCO_3^-	Cl^-	SO_4^{--}
	8.25	0.11	0.9	0.9	0.7	0.02	0.1	0.3	0.0	0.2	0.8	0.12

Nutritional analysis.

Nutritional analysis.	Available nutrients						
	Macro element (ppm)			Micro element (ppm)			
	N	P	K	Zn	Fe	Mn	Cu
	12.9	3.6	52.9	0.12	1.98	0.46	0.06

Chickpea seeds (cv. Giza 531) were brought from Agriculture Research Centre, Ministry of Agriculture Chickpea healthy seeds were planted after inoculated with Rhizobium strain and irrigated just after sowing on November 16 and 20 in 2018 and 2019, respectively, 10 cm between hills at a seeding rate of 60kg/fed. Normal cultural practices were followed as usual in chickpea fields. NP fertilizer were added at the rate of 15kg N/fad as ammonium nitrate 33% N, 150 kg /fad as calcium super phosphate (15.5% P2O5) before sowing. The experimental unit consisted of five ridges, three meter in length and 60 cm apart. The experimental design was split plot design with three replicates where the main plots allocated to method of irrigation. Two drip irrigation systems (surface and subsurface) were constructed and tested before used in the experimental location. Subplots allocated to boron and / or potassium foliar application.

After 45 and 60 days from sowing, chickpea plants were sprayed with potassium and/or boron. Potassium was added in the form of potassium nitrate (KNO_3)(500 mg/l) and boron in the form of boric acid (100 mg/l). After 75 days from sowing, plant samples Spekol Spectrocolourimeter Carl Zeiss. K level was determined using flame photometer. Protein content was calculated by multiplying N% x6.25. Total carbohydrates were analysed by colorimetric method as Albalasmeh [44].Phenolic content was measured as the method described by [45] Ascorbic acid was analysed as [46].

Statistical analysis:

Combined analysis was made for the two growing seasons and performed using ANOVA according to [47]. For comparison between means, L.S.D test at 5% probability level was used.

were taken to measure some morphological characters such as plant height, number of branches/plant, shoot fresh and dry weight, root length and root weight). Fresh samples were taken to determine some chemical parameters. At harvest, random of ten plants of each treatment was taken for determination of seed yield and its components (plant height, number of branches/plant ,number of pods/plant, weight of plant, pods, seed and 100 seeds weight, weight of seed/plot (kg), seeds, straw and biological yield (ton/fed)) and harvest index (%) and some chemical analysis, i.e. N, P, K, crude protein, carbohydrates phenolic content and vitamin C of the yielded seeds

.**Chemical analysis:**

Photosynthetic pigments of fresh leaves were determined as described by Lichtenthaler and Buchmann [40]. Endogenous indole acetic acid (IAA) was extracted and determined according to [41]. Total soluble sugars were extracted as Homme [42] and estimated as [43]. Nitrogen (N), phosphorus (P) and potassium (K) contents were determined by method of [39]. N and P were estimated by

3. RESULTS

3.1. Growth characteristics

The changes in different growth characteristics of chickpea plant under the effect of irrigation systems (surface and subsurface) and foliar treatment of potassium (500 mg/l) and/or boron (100 mg/l) are presented in Table (2). The irrigation system significantly affected the plant height and branches number/plant of chickpea plant. Subsurface drip irrigation resulting in 3.67, 17.33% higher in plant height and branches number/plant, than surface irrigation system (Table 2). There were also significant differences in shoot fresh and dry weight as well as root length and root weight respectively, between the two irrigation systems (SDI and SSDI).

Furthermore, Table (2) stated the effect of foliar treatment of K and/or B on growth characteristic of chickpea plant grown under sandy soil. Foliar treatment of either potassium with 500 mg/l concentration or boron with 100 mg/l concentration induced significant increments in various growth parameters in comparison with control plants. Results clearly stated that, potassium treatment were superior over boron foliar treatment on increasing different morphological parameters. Moreover, foliar treatment of K+B caused more higher and significant increases compared with control and either K or B treated plants in all the studied yield characters (Table 2).

Table (2): Irrigation systems and foliar treatments effects on growth characteristics of chickpea (Data are combined of two seasons).

Treatments	Plant height (cm)	Branches number/plant	Shoot fresh weight (g)	Shoot dry weight(g)	Root length (cm)	Root weight (g)
Irrigation systems						
SDI	49.00	1.50	10.31	4.87	12.58	1.99
SSDI	50.80	1.76	15.16	6.11	15.58	2.56
LSD at 5%	0.52	0.03	0.53	0.22	0.71	0.01
Foliar treatments						
Control	40.17	1.33	10.32	4.08	11.33	1.43
K	49.67	2.50	16.26	8.32	14.62	2.43
B	43.83	1.83	13.36	6.01	12.84	1.96
K+B	50.50	3.50	18.01	10.21	17.50	3.25
LSD at 5%	0.91	0.04	0.72	0.62	0.63	0.21

Regarding interaction impact of irrigation systems (surface & subsurface irrigation) and foliar treatment of potassium and/or boron of chickpea plant on growth characteristics. Data recorded in Table (3) showed that, foliar treatment of K and/or B induced significant increments of studied growth characters in comparison by untreated controls under surface or subsurface irrigation. Data clearly show the superiority of foliar treatment of K+B over the rest of treatments (K or B alone) under the two irrigation methods.

Table(3): The interaction effects between irrigation systems and foliar treatments on growth characteristics of chickpea. (Data are combined of two seasons).

Treatments		Plant height (cm)	Branches number/plant	Shoot fresh weight (g)	Shoot dry weight (g)	Root length (cm)	Root weight (g)
SDI	Control	39.11	1.00	8.44	3.34	1.33	10.33
	K	40.21	1.67	10.17	5.26	1.90	12.42
	B	39.82	1.33	9.89	4.40	1.75	11.40
	K+B	40.88	2.00	12.22	6.47	2.10	13.66
SSDI	Control	41.76	1.72	12.87	4.84	1.88	12.48
	K	44.44	2.85	18.46	11.46	2.67	15.74
	B	43.54	2.02	16.83	7.66	2.22	14.67
	K+B	49.93	3.71	19.97	12.54	3.11	16.98
LSD at 5%		0.82	0.01	0.48	0.63	0.39	0.11

Table (4) states the impact of the used two irrigation systems and/or foliar treatment of K and or B on chlorophyll a chlorophyll a, chlorophyll b, carotenoids and total pigments, IAA & total soluble sugars (TSS) contents of chickpea plant under sandy soil. Results showed the significant difference between surface and subsurface drip irrigation on different photosynthetic pigments constituents and TSS, meanwhile the difference was non-significant in indoleacetic acid (IAA) contents of chickpea plants. Furthermore it is clearly the superiority of subsurface irrigation over surface irrigation systems regarding to the above mentioned parameters. Potassium (500 mg/l) and / or Boron (100 mg/l) foliar treatments induced significant increments of photosynthetic pigments constituents IAA &TSS levels compared with untreated controls either under surface irrigated or subsurface irrigated systems, except Boron treatment that caused non-significant increases (Table 4). It is obvious that K treatment was more effective than Boron treatment in improving various studied parameters. Furthermore, data show the synergistic effect of K+B foliar treatment was over control as well as other treatments (K or B alone) under the two tested irrigation systems.

Table (4): Irrigation systems and foliar treatments effects on photosynthetic pigments, IAA and TSS levels of chickpea plant.

Treatments	Chlo a	Chlo b	Carotenoids	Total pigments	IAA µg/g fresh wt	TSS mg/g dry wt
	µg/g fresh leaf weight					
Irrigation systems						
SDI	1.366	0.813	0.465	2.664	67.01	5.58
SSDI	1.385	0.845	0.509	2.714	72.22	6.61
LSD at 5%	0.003	0.005	0.005	0.006	5.800	0.11
Foliar treatments						
Control	1.260	0.795	0.446	2.503	55.46	5.92
K	1.435	0.839	0.504	2.779	65.44	6.07
B	1.330	0.834	0.483	2.647	62.17	6.18
K+B	1.465	0.847	0.513	2.827	95.39	6.22
LSD at 5%	0.010	0.007	0.008	0.016	8.37	0.07

The effect of foliar treatments of B and/or K in addition to the effect of irrigation systems (SDI or SSDI) on photosynthetic pigments are presented in Table (5). Exogenous application of B and/or K increased photosynthetic pigments components as well as IAA and TSS contents of fresh leaves of chickpea plant irrigated either by surface irrigation system or subsurface irrigation system (Table 5). Data clearly show that different used treatments were more effective under subsurface irrigation system more than surface irrigation system. The highest increases were obtained from K+B under subsurface irrigation system.

Table (5): Interaction effects between irrigation systems and foliar treatments on photosynthetic pigments, IAA and TSS levels of chickpea plant.

Treatments		Chlo a	Chlo b	Carotenoids	Total pigments	IAA µg/g fresh weight	TSS mg/g dry weight
		µg/g fresh leaf weight					
SDI	Control	1.25	0.79	0.43	2.47	36.55	5.90
	K	1.48	0.83	0.48	2.79	52.23	6.04
	B	1.32	0.82	0.46	2.60	42.91	6.04
	K+B	1.49	0.82	0.49	2.80	57.21	6.19
SSDI	Control	1.27	0.80	0.46	2.54	54.22	6.00
	K	1.39	0.85	0.53	2.77	72.12	6.23
	B	1.34	0.85	0.51	2.70	68.03	6.14
	K+B	1.44	0.88	0.53	2.85	73.68	6.30
LSD at 5%		0.01	0.01	0.02	0.04	0.58	N.S

3.2. -Yield and its attributes:

Results presented in Table (6) clearly stated that, yield and its aspects expressed by plant height (cm), number of branches & pods /plant, plant weight (g), pods & seeds weight/plant (g), and weight of 100 seeds (g) also, Table (7) show that seed yield/plot(Kg), seed yield(ton/fed.), straw yield (ton/fed.) and biological yield (ton/fed) in addition to harvest index (%) were slightly affected by systems of water irrigation, however little increases were recorded by subsurface drip irrigation than surface drip irrigation in all studied characters. The maximum seed yield and biological yield (6.05 and 13.43 ton/fed. respectively) of chickpea were recorded under subsurface irrigation compared with surface irrigation. Furthermore, harvest index of chickpea plant was slightly higher by subsurface irrigation than surface irrigation (Table 7).

Foliar treatment of either potassium with 500 mg/l concentration or boron with 100 mg/l concentration induced significant increments in yield criteria in comparison with controls. Data clearly show that, potassium treatment were superior over boron foliar treatment. Moreover, foliar treatment of K+B caused more significant increases in all the studied yield characters (Table 6 & 7). The highest significant values of harvest index (46.25%) were obtained by B+K treatment while the lowest significant value (42.03%) in the untreated plants (control).

Table (6): Irrigation systems and foliar treatment effects on chickpea yield and its components. (Data are combined of two seasons)

Treatments	Plant height (cm)	Branches number /plant	Pods number /plant	Plant weight (g)	Pods wt/plant (g)	Seeds wt/plant (g)	100 Seeds (g)
Irrigation Systems							
SDI	53.33	2.58	39.75	18.81	15.92	100.9	35.21
SSDI	53.38	2.84	46.42	20.49	16.37	136.07	37.76
LSD at 5%	3.45	0.23	4.7	3.36	1.47	1.41	1.78
Foliar treatments							
Control	45.17	1.83	24	13.51	12.94	75.06	30.15
K	54.33	3.17	49.83	21.51	17.58	125.56	39.35
B	53.83	2.83	48.00	19.54	15.72	105.53	36.45
K+B	60.05	3.33	50.33	24.05	18.34	168.65	39.99
LSD at 5%	2.13	0.94	2.1	1.19	1.97	14.72	1.14

Table (6) continuous

Treatments	Seed yield (Kg/plot)	Seed yield (ton/fed)	Straw yield ton/fed	Biol. Yield (ton/fed)	Harvest index%
Irrigation Systems					
SDI	9.36	5.99	7.31	13.30	45.05
SSDI	9.46	6.05	7.38	13.73	45.08
LSD at 5%	1.29	0.83	0.89	1.34	2.21
Foliar treatments					
Control	8.74	5.09	7.02	12.11	42.03
K	9.68	6.21	7.25	13.46	46.14
B	9.52	6.09	7.20	13.29	45.82
K+B	9.71	6.69	7.91	14.6	46.25
LSD at 5%	0.64	0.41	0.48	1.19	3.01

Concerning the interaction effect between foliar treatment of potassium and/or boron and the irrigation systems (surface and subsurface irrigation) of chickpea plant on yield and its components. Results recorded in Table (7) and Fig (1) stated that, foliar application of K and/or B caused significant increases in different studied yield characters compared with untreated controls either under surface or subsurface irrigation. Except, the increases of plant height with K and B treatment, pods weight/plant and seeds weight/plot with K, B and K+B and seed weight/plant with B treatment under surface irrigation, In addition to pods no/plant and pods weight/plant with K and B, plant weight and seeds weight/plant with B under subsurface irrigation the increases were non-significant compared with their corresponding controls. Moreover, the data showed that subsurface irrigation system significantly surpassed surface irrigation system with all tested treatments (K and /or B) or control treatment. It could be noted that subsurface irrigation with B+K fertilizer produced the highest amount of seed yield (7.51 ton/fed), straw yield (9.19 ton/fed) and biological yield (16.7 ton/fed).Then followed by foliar treatment with K under subsurface irrigation as it gave the highest values of seed, straw and biological yield (7.17, 8.86 and 16.03 ton/fed).

Table (7): Interaction effect between irrigation systems and foliar treatments on chickpea yield and its components. (Data are combined of two seasons).

Treatments		Plant height (cm)	Branches no/plant	Pods no/plant	Plant weight (g)	Pods wt/plant (g)	Seeds wt/plant (g)	100 Seeds wt (g)	Harvest index (100%)
SDI	Control	41.67	1.33	20.33	11.75	11.75	10.56	24.07	47.49
	K	51.67	1.67	26.00	16.48	12.92	12.49	36.23	43.41
	B	48.67	1.67	25.00	15.27	12.22	10.97	35.28	45.44
	K+B	51.87	2.0	27.67	18.21	12.96	14.85	37.61	42.68
SSDI	Control	56.00	2.0	38.00	20.88	17.27	11.82	38.3	46.51
	K	57.66	4.67	74.67	25.38	19.69	15.17	40.41	44.73
	B	57.00	2.33	58.00	22.72	18.14	12.58	38.92	46.93
	K+B	64.00	4.67	76.67	26.62	23.76	17.81	41.07	44.97
LSD at 5%		4.43	0.03	7.22	4.51	4.19	0.88	3.01	4.22

Table (7) continuous

Treatment		Seeds yield (kg/plot)	Seeds yield (ton/fed)	Straw yield (ton/fed)	Biological yield (ton/fed
Surface	Control	7.69	4.92	5.44	10.36
	K	8.08	5.17	6.74	11.98
	B	7.72	4.99	5.99	10.98
	K+B	8.28	5.29	7.09	12.37
Subsurface	Control	9.78	6.26	7.2	13.46
	K	11.11	7.17	8.86	16.03
	B	10.96	7.11	8.04	15.15
	K+B	11.73	7.51	9.19	16.7
LSD at 5%		0.91	0.58	0.66	1.68

Data represented in Table 8stated the impact of irrigation systems (SDI and SSDI) on seed quality (Nitrogen, Phosphorus, Potassium, Crude protein%, Carbohydrates% (CHO%), Vitamin C (V.C) and phenols) of chickpea plant yielded seeds grown under sandy soil. Data showed significant differences in different studied components among the two used systems of water irrigation. Data in Table (8) show the superiority of subsurface irrigation in all the above mentioned parameters.

Regarding to the effect of foliar treatment of K and/or B, data presented in (Table (8)indicated that, different seed nutritional contents (nitrogen, phosphorus, potassium, crude protein, carbohydrate, ascorbic acid, vitamin C, and phenols) of chickpea seeds were significantly increased in response to the above mentioned treatments (K and /or B) as compared to the untreated control plants. Foliar treatments of K+P caused the maximum significant increases in nitrogen % (3.95%),phosphorus% (0.39%),potassium% (2.42%)potassium% (2.42%), crude protein % (24.67%), carbohydrate % (63.91 %),Vitamin C (15.04 mg/100wtfresh weight) and phenols (49.66 mg/100 g dry wt)compared with the other treatments (Table 8).

Table (8): The nutritional contents of the yielded chickpea seeds under irrigation systems and foliar treatments.

Treatments	N%	P%	K%	Crude protein %	CHO%	Phenols mg/100 g dry weight	V.C.m g/100 weight fresh
Irrigation systems							
SDI	3.17	0.36	2.26	21.91	59.77	32.21	13.57
SSDI	4.32	0.38	2.46	24.89	61.87	50.33	14.51
L.S.D at 5%	0.03	0.02	0.21	0.04	0.56	0.57	0.07
Foliar treatments							
Control	3.41	0.35	2.15	21.31	57.50	29.60	12.86
Boron(B)	3.69	0.37	2.26	23.06	60.92	40.60	13.87
Potassium (K)	3.93	0.39	2.29	24.56	60.95	45.24	14.39
B+K	3.95	0.39	2.42	24.67	63.91	49.66	15.04
L.S.D at 5%	0.16	0.01	0.05	0.72	0.93	0.44	0.03

The effect of interaction between foliar treatment of K and/or B and the irrigation systems (surface and subsurface)on seed quality such as Nitrogen, Phosphorus, Potassium Fig (2), Crude protein%, Carbohydrates% (CHO%), phenolic and Vitamin C (V.C) Fig (3). Data clearly show that different exogenous treatment increased significantly the above mentioned parameters (Nitrogen, Phosphorus, Potassium, Crude protein%, CHO%, phenolic and Vitamin C) as compared with untreated controls under both used irrigation systems. While, the changes in P, K were Non-significant (Fig 2 and Fig 3). Moreover, different studied parameters under subsurface irrigation system show higher increases over surface irrigation studied of chickpea seeds by different foliar treatments of K and/or B. Foliar treatment with K+B was more effective than other treatments either K or B alone under both irrigation systems (Fig 2& Fig 3). Foliar treatment of chickpea plant with K+B was the most effective treatment under subsurface irrigation system (N: 4.2%, P: 0.40%, K: 2.45%, crude protein: 24.1%, Carbohydrates: 64.02%, phenols (61.42, mg/100 g dry weight and Vitamin C (14.97 mg/100 g fresh weight).

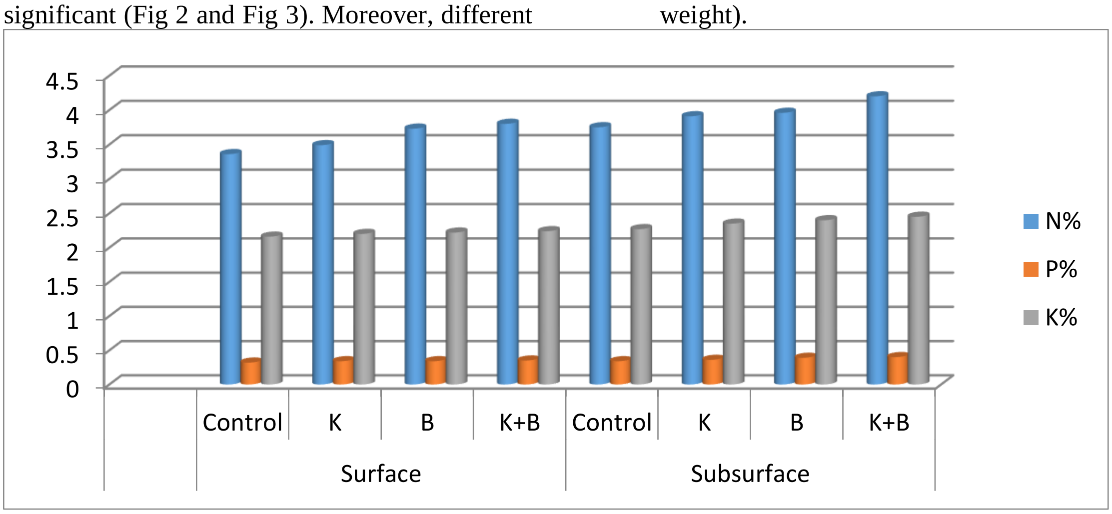

Fig (2): The interaction effect between irrigation systems and foliar treatments on nutritional (N, P, K) contents of the yielded chickpea seeds. LSD at 5%, N% 0.11,P % NS,K% N.S.

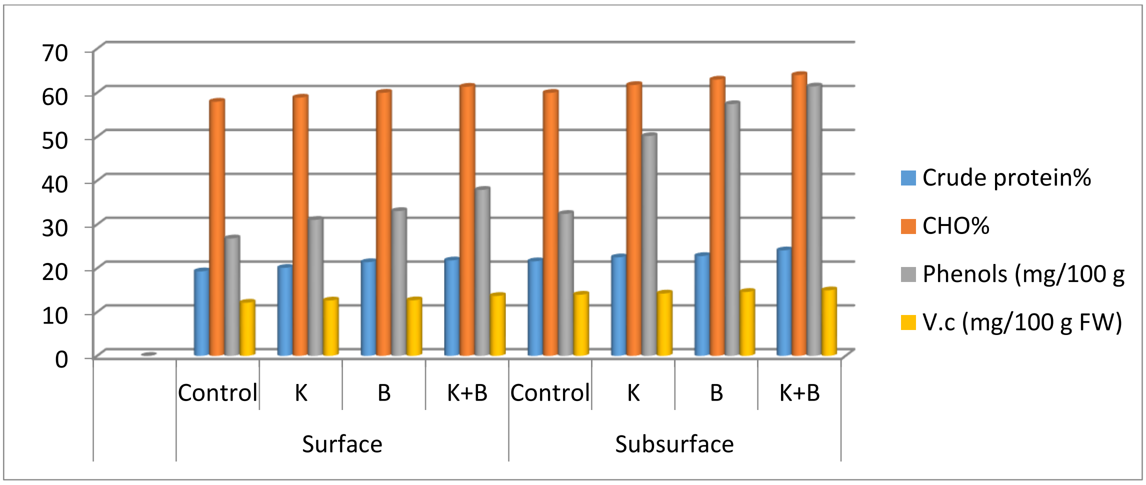

Fig (3): The interaction effect between irrigation systems and foliar treatments on some nutritional contents of the yielded chickpea seeds. LSD at 5%: Crude protein%0.24, CHO%0.71, Phenols (mg/100 g 0.89),V.C(mg/100 0.04).

4. DISCUSSIONS

The effect of irrigation systems on chickpea plant growth characteristics, photosynthetic pigments, IAA, TSS, yield, its components and seed nutritional value shows the superiority of subsurface irrigation system over surface irrigation system. The superiority of subsurface irrigation to enhance various investigated parameters may be related to lower water loss from soil surface via evaporation, [48]. Furthermore, subsurface drip irrigation provides preservation of optimal soil moisture level in the root zone, resulting in increased water and fertilizers use efficiency which reflected in better performance of different physiological and biochemical metabolic processes such as photosynthesis, as well as increased endogenous indole acetic acid contents [49].Moreover, subsurface irrigation system provides the plant with required water that improved cell division and enlargement and consequently increased its performance. The data obtained by [50, 51, 52, 53, 54&55] on different plant species are in concurrent with our data. Moreover, [56] stated that ideal distribution of roots beneath sweet corn resulted by drip placement and fertilization treatment. In addition, [57] reported that, increased root length was found below 0.30 m in subsurface drip irrigation than in surface drip. Moreover, the more seed yield with subsurface irrigation might be due to increased branches and pods number/plant, higher pods weight / plant (g)and seed yield / plant (g). The increased harvest index resulted in chickpea plant subjected to subsurface irrigation might be resulted by increased partitioning of dry matter to reproductive parts [58] reported that subsurface irrigation system is a method of applying water flows equivalent to surface drip irrigation by putting drip lines below the surface (15-20 cm).

Potassium treatment (500 mg/l) individually or in combination with boron (100 mg/l) increased morphological characteristics, photosynthetic pigments, endogenous IAA, TSS, yield quantity and quality of chickpea plant under either surface or subsurface irrigation systems in sandy soil conditions. It is worthy to mention that potassium treatment as individual was more pronounced than that of boron. These results of potassium effect on growth parameters are matching with many earlier studies reported by,[59]on artichoke plant, Rajput [60]on chickpea plant,[61] on soybean plant. Potassium is an important macro-element for plant development and involved in a variety of cellular metabolic activities including photosynthesis, water use, biosynthesis of amino acid and protein as well as sugar transportation and assimilates and accumulation of high molecular carbohydrates which necessary for fruit formation, plant growth and development [62].Potassium is more frequent cation in plant metabolic functions, serving as a stimulator or cofactor in a variety of enzymes. Moreover, potassium treatment boosted chickpea growth through increasing biosynthesis of photo-assimilates [63, 64 & 65]. Furthermore, increased potassium supply was shown to increase root surface that was exposed to soil as a result of increased root water uptake, which is essential for the transportation of photo assimilates in root growth [63].
Chickpea plant treated with 500 mg/l K, showed significant increases in photosynthetic pigment constituents, endogenous IAA and TSS (Table 3).

Potassium treatments improved photosynthesis metabolism by improving the leaf internal CO_2concentration and leaf stomatal conductance which regulates the stomatal opening. Furthermore, potassium plays an important role in the formation of photosynthetic pigment by preventing decomposition of newly formed chlorophyll and δ-amino levulinic acid (ALA) synthase formation [66 &67] stated that exogenous treatment of K decreased electrolyte leakage, resulted in total chlorophyll increments. With respect to the effect of K on endogenous IAA contents, IAA increased by K treatment might be due to the increases in its biosynthesis and/or decrease its degradation.

Regarding to the increments of yield of chickpea plants under the effect of K, these data are confirmed with those results obtained earlier by [68&61].Moreover,[69,70&71] mentioned that potassium plays an important role in many metabolic activities of plants and proper availability of potassium ultimately leads to higher yield. Potassium application caused higher stomatal regulation, stimulated translocation of photosynthesis from source to sink and increased water uptake could, presumably, lead to higher dry matter production, root growth, number of seeds and their weights under drought stress conditions [63 & 69]. Moreover, the essential roles of K are found in energy transfer and utilization, protein synthesis, carbohydrate metabolism, transport of sugars from leaves to seeds [63].[72] found that the application of K_2SO_4 stimulates wheat grain yield by improving growth conditions. These higher seed yield can be attributed to more number of pods /plant, number of seeds/ pod and higher 1000-seed weight.

Regarding to the promotive effect of K treatment on protein content of chickpea plant, potassium treatment has synergistic effect on nitrogen uptake, facilitates protein synthesis and activate different enzymes [73]. Application of K to chickpea plants caused an increase in endogenous K, these increases might resulted from improved K absorption from soil. The positive effect of K treatment on the carbohydrates content of chickpea yielded seeds under study resulted from the key role of K in sugar metabolism and sugar remobilization [74& 75].Phenolics contents increased by K treatment. These increments might be due to total phenols effect on different plant metabolic processes regulation [76]. In addition, phenols considered as a substrate for many antioxidants enzymes, so, it mitigates the adverse environmental conditions injuries [77].

With respect to Boron effect, the increments in different studied growth and yield characteristics of chickpea plant under the effect of boron treatment are in concurrent with those reported by [78, 79, 80 &81]. B is a micro nutrient that is required for plant growth and development [16]. Also, it is important element for metabolic activity maintenance since it is involved in nitrogenous bases biosynthesis, like uracil, which is necessary for RNA synthesis [82].Results of various researches concluded that boron is mainly involved in carbohydrate metabolism. Many scientists have revealed that boron is very essential in carbohydrate synthesis and its translocation across the membrane towards meristem regions of roots and tops [83]. The second major role of boron in plant metabolism is cell division and maintaining the cell wall structure [84& 85]. Other findings also disclosed that boron is essential for cell division, differentiation, maturation, development and growth especially near the tips of shoots and roots. Likewise, it is crucial for cell wall structure and function [86 & 87].

With respect to the effect of Boron on photosynthesis, the obtained increases in Chlo a, Chlo b, carotenoids and total pigments, IAA are in accordance with earlier reports of [88,79 &81] on soybean, eggplant and onion plants respectively. [89] found that boron treatment enhanced photosynthesis efficiency of soybean by membrane maintenance and photosynthesis products translocation.[90] attributed the positive effect of boron on photosynthetic pigments constitutes to the indirect effect of boron treatment on increasing K ions uptake which in turn affected on increasing photosynthetic pigments.

The increases in yield characteristics which recorded by B treatment may be explained in terms of the involvement of these nutrients in regulating carbohydrate metabolism and translocation. Boron is also essential for cell division in growing plant tissue; good pollination, fruit set, and seed development; synthesis of amino acids and proteins; and regulation of carbohydrate metabolism [34]. The obtained results are in concern with those reported by [91,92&93] suggested that adequate boron nutrition is critical not only for obtaining higher yields but also for yield quality.

Treatment of boron increased N, P and K of chickpea yielded seeds. These increases may be due to the enhancing effect of boron treatments on some metabolic activities [79]. The influence of applied treatments on the mechanism of ions uptake may be related to their effects on membrane permeability and rate of ion entry through the membrane, or enhancing their translocation to the fruits [95].Seed total carbohydrates contents were significantly increased in response to boron treatments might be due to the activation of photosynthetic machinery, as a result of the stimulatory effects of Bon photosynthetic process. Moreover, [91]concluded that these increases in carbohydrate contents could be explained in terms of the involvement of this nutrient in regulating carbohydrate metabolism and its translocation [34].Boron significantly increased the levels of phenolics in chickpea seeds (Table 8&Fig 2). These increases in total phenols might resulted by the increase in carbohydrate synthesis [79]. Furthermore, [94& 95] stated that the increase in phenolic was concur with the increase in IAA contents and led to the suggestion that most of phenolic compounds are diphenols and polyphenols which may inhibit IAA oxidase activity which resulting in auxin accumulation, which reflected in stimulating the growth and yield of plant.

5. Conclusion:

Finally, this study can recommend that, using SSDI drip irrigation system was more effective than SDI system on increasing growth and productivity of chickpea plant. Moreover, foliar spray of chickpea plant with K and /or B could be effective in increasing growth and productivity as well as improving the chemical constituents of the yielded seeds under sandy soil conditions. The most optimum treatment was resulted from interaction between boron + potassium and subsurface irrigation system.

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