Egypt. J. Chem. **Vol. 65,** No. SI:13B pp. 87 - 101 (2022)

Egyptian Journal of Chemistry

http://ejchem.journals.ekb.eg/

BICHEMICAL STUDY OF SOME FABA BEAN (*Vicia faba L.*) CULTIVARS UNDER DIFFERENT WATER REGIMES IN SANDY SOIL

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Abstract

Drought stress is one of the major environmental obstacles that limit production and development of faba bean. In this study, two field experiments were conducted at the experimental station of the National Research Center, Nubaria district, El-Behara Governorate, Egypt, during 2019/2020 and 2020/2021 winter seasons to evaluate the responses of three faba bean cultivars (Nubaria 1, Nubaria 2 and Giza 843) to different water regimes (100%, 75% and 50% water irrigation requirement). The results showed decreases in shoot growth (plant height, shoot dry weight and leaves area), photosynthetic pigments, endogenous indole acetic acid (IAA) total carbohydrates contents (TCHO) of faba bean leaves with decreasing water irrigation from 100% to 75% and 50% WIR and the degree of decreases differed among the tested cultivars. On the contrary, root length and root dry weight were increased under decreased WIR (75% and 50%). Moreover, yield and its components were decreased under water deficit conditions (75% and 50% WIR) accompanied with decreases in total carbohydrates, protein contents while increased phenolic and vicine contents of the yielded seeds. With regard to cultivars, data show a significant varietal variability for most studied parameters. The superior cultivar identified was Nubaria -1, as it gave the highest growth and yield components under the three levels of WIR. In conclusion, it is worthy to mention that, the performance of Nubaria -1 variety was more pronounced than that of Nubaria-2 and Giza-843 cultivars grown under the three levels of water irrigation (100%, 75% and 50% WIR). From the obtained results, it can be concluded that sowing Nubaria -1 cultivar under (75%) water irrigation requirement WIR produced the highest value of water used efficiency (WUE), although 75% WIR significantly reduced seed yield compared with 100% WIR irrigation treatment. Our recommendation is to cultivate cultivar under (75%) WIR, since it produce quit reasonably yield and save nearly 200 m^3 irrigation water especially under the circumstances of climate of Nubaria district, El-Behara Governorate, region.

Key words: Faba bean, Drought, Growth, Yield, Nutritional value**,** Vicine, Water used Efficiency (WUE), Water irrigation requirement (WIR).

1. Introduction:

Water deficit is one of the extremely powerful limiting criteria on plant growth and development over the world. Various plants have been adversely affected by water deficit, triggering many alterations in different biochemical metabolic pathways, evolutionary and genetic levels, suppression of growth and loss of photosynthetic values [1]. Water deficit effects on plants depend on intensity and duration of water deficit and cultivar tolerance [2]. Stomatal conductivity decreased at the starting of water deficit leaves, that restricted absorption of carbon dioxide thus decreased photosynthetic rate [3]. Moreover, the long term water deficit stress not only reduce photosynthetic rate but also reduce chlorophyll content and cause cell membrane lipids peroxidation and cell structure degradation [4]. Also, water deficit affects adversely on physiological and molecular mechanisms resulting in stomatal closing, reduced transpiration rate, decreased cell expansion, variations in plant metabolism and decreased in the activities of different metabolic enzymes thus partially or completely caused growth and developmental inhibition [5 & 6]. In order to maintain water uptake the ability of the inner water should be kept less than that of the soil. This maintenance includes uptake of soil solutes or biosynthesis of osmolytes to improve osmotic pressure [7]. These osmolytes are highly soluble and small molecular weight which allow them not to interfere with biochemical processes of plants and increased

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Receive Date: 19 January 2022, Revise Date: 07 March 2022, Accept Date: 13 March 2022
DOI: 10.21608/EJCHEM.2022.117184.5288

cellular levels as well as, their high levels are non-toxic [8]. These compounds increased water absorption, so the obvious effect of water deficit inside plant cells is balanced. Due to their protective action on different cellular compartments from water deficit related dehydration destruction, these compounds are known as osmoprotectants. These compounds include set of proteins, amino acids, proline and soluble sugars [9]. Moreover, these compounds help in cell osmoregulation and act as free-radical scavengers [10]. Survival of plants under these stress conditions depends on the ability of plants to perceive the stimulus, generate and transmits signals and instigates physiological changes thus adjust metabolism accordingly [11]. Living with water deficit is the only way of sustaining agricultural production in water deficit regions [12].

Faba bean (*Vicia faba L.*) is one of the most beneficial leguminous plant for human food and animals feed all over the world and ranked the sixth globally plant in production [13]. It features high yield capacity and high nutritional value that due to its excellent sources of some vitamins (B1, B2, B3, B6, B9,C and K), 58% carbohydrate, 26% - 35% protein, 2% fat, and some minerals (Ca, Cu, Fe, Mn, Mg, K, Si, Ph, Na and Zn) as well as it is considered as good source of energy and dietary fibre [14, 15]. The increased protein level makes faba bean seeds one of the major-rich pulses (starchy grain legumes) [16]. Despite, the different advantages of faba bean, their productivity and consumption have traditionally been limited due to the pyrimidine glycosides vicine v-c (2, 6, diamino-4, 5-dihydroxypyrimidine, 5, B-glycopyranosoide) [17]. The presence of v-c reduced nutritive value also causes favism, an acute haemolytic anaemia, in human individuals [18]. Vicine also reduced the efficiency of production systems for broiler chickens, laying hens and pigs [19, 20 & 21]. Although this remains a matter of speculation, the ability to synthesize vicine and accumulate high concentrations in seeds is thought to have evolved due to beneficial antibiotic effects during seed germination. [22]. Levels of vicine in faba beans have been shown to be major killers of *Callosobruchus maculatus* (L.) larvae and several other plant pests [23 & 24]. Faba bean and its symbiotic rhizobacteria like other legumes, fix atmospheric nitrogen in different conditions. Around 80% of plant´s nitrogen requirements are provided via fixing atmospheric nitrogen [25] and nearly half of the crop´s fixed nitrogen is remained in soil after plant harvest. Thus, it is regarded necessary for both its participation to residue left nitrogen in crop rotation [26] and its efficiency as green manure [27, 28]. Production of faba bean in the reclaimed sandy soil is affected by different factors as climatic conditions, soil fertility, varieties or genotypes plant, population density and water supply, low water availability [29, 30, 31 & 32]. On the other hand, faba bean is regarded as a drought-sensitive crop and the major factor restricting faba bean cultivation is the high year-to-year yield variability usually due to drought stress, high water availability could cause excessive vegetative growth in indeterminate faba bean. Musallam [33] found that yield of faba bean was decreased under drought condition while, protein content was increased. The reductions in faba bean yield by reduction in water availability, and the loss in yield depended on the cultivar and other environmental conditions [34]. Improving the drought tolerance of faba beans is very important for improving the productivity and stability of faba bean harvest. However, genotype-environment interactions have been shown to be high for faba bean growth and yield vary considerably between seasons, depending on location and weather. For that this investigation aimed to study the performance of three faba bean varieties under different irrigation levels at the newly reclaimed sandy soil.

2. Materials and methods

2.1. Plant materials and experimental conditions:

During two successful growth seasons, 2019/2020 and 2020/2021, two field trials were conducted at the research and production station of the National Research Center of Nubaria State, Beheira Province, Egypt**.** to study the physiological effect of three irrigation levels on growth, some physiological, biochemical, yield and its attributes of three faba bean cultivars (Nubria -1, Nubaria- 2 and Giza 843) under three different water regimes (100%, 75% and 50% water irrigation requirement). Seeds of faba bean were obtained from Legume Research Department, Field Crop Institute, Agricultural Research Center, Giza, Egypt.

2.2. Experimental Layout:

Seeds of faba bean were sown on November 17^{th} and 20^{th} in the first and second seasons, respectively. The experimental design was in a split plot design with three replications where the irrigations levels (100%, 75% and 50% WIR) occupied the main plots, while faba bean cultivars (Nubarai 1, Nubarai 2 and Giza 843) were arranged randomly in the sub plots. The experimental plot area was 10.5 m^2 (3.5 m long and 3 m width) 1/400 fed. Soil of the experimental site was sandy soil. Some mechanical and chemical analysis of soil samples at 30 cm depth in experimental sites before soil preparation was determined according to Carter and Gregorich [35] is presented in Table (1).

Table (1): Mechanical and Chemical analysis of the experimental soil

Mechanical analysis									
sand%	Silt %	clay %	Texture	Organic matter%		pH	EC (mhos/cm)		$CaCO_3$%
90.80	4.00	5.20	Sandy	0.24		8.66	0.11		5.20
Chemical analysis									
Macro nutrients (mg/100g)						Micro nutrients (ppm)			
N	P	K	Ca	Mg	NNa	Fe	Zn	Mn	Cu
4.20	0.12	9.22	80.00	18.20	13.18	8.15	9.12	0.10	0.20

Seeds were sown in hills on each side of a ridge at 20 cm apart. The plants were thinned after (15 days of sown) to two plants/hill. Precipitation was nil in all months of faba bean growing season for both seasons. Nitrogen fertilizer as ammonium nitrate (33 % N) was added at the rate of at the rate of 15 kg N/fed. was added as starter dose before the first irrigation, while phosphorus fertilizer was applied in the form of calcium super phosphate (15 % P_2O_5) at the rate of 200 kg/fed and potassium fertilizer was added in the form of potassium sulphate (48% K_2O) at the rate of 48 kg/fed. at seed bed preparation. All other recommended agricultural practices for faba bean production were applied at the proper time as recommended for this District by the Ministry of Agriculture.

2.3. Water used Efficiency (WUE):

Total irrigation water (m^3/fed./season) was added as recommended of faba bean requirement in sandy soil. Irrigation was carried out using the sprinkler irrigation system where plants were watered every 5 days for 2 h. Each irrigation treatment had valve and flow-meter to control water application, bean cultivars were randomly distributed within each irrigation treatment. A distance of 2 m was left between each two irrigation treatments as a border among the treatments.

The water use efficiency (WUE) was calculated according to Howell [36] with the following equation:

$$WUE = \frac{E_y}{E_t} \times 100$$

Where, WUE is the water use efficiency (Kg m^3), E_y is the economical yield (kg fed^{-1} /season), E_t is the total applied irrigation water, m^3 /fed^{-1} /season.

2.4. Data recorded:

Plant samples were collected after 75 days from sowing for measuring growth characters in terms of plant height (cm), shoot dry weight (g), leaves area (cm^2), root length (cm) and root dry weight (g). At harvest the following characters were recorded at random of ten guarded plants from each plot: number of pods per plant, pods weight per plant (g), seed yield per plant (g), 100-seeds weight (g), seed yield per feddan (kg/ fed) and biological yield (ton /fed).were collected from the whole plot and then converted into yield per feddan.

2.5. Chemical analysis:

The photosynthetic pigments (chlorophyll a, chlorophyll b and carotenoids) in fresh leaves were assessed using this method [37]. Indole acetic acid content were extracted and analysed by the method of Larsen [38]. Total carbohydrate was determined according to Albalasmeh [39]. Crude protein percentages were extracted and determined by Micro-Kjeldahl using methods outlined by Pedrol and Tamayo [40]. The vicine content of the yielded seeds was determined according to Ramasay and Griffiths [41].

2.6. Statistical analysis:

All statistical analyses were performed using ANOVA [42]. The mean was compared to the LSD with the least difference at the 5% probability level.

3. Results

3.1. Vegetative growth:

3.1.1. Impact of water regime:

The presented data in Table (2) showed that decreasing WIR to 75% WIR caused significant decreases in plant height, leaves area and non - significant decrease in shoot dry weight of faba bean. Moreover, 50% WIR decreased significantly plant height, leaves area, while decreased non- significantly shoot dry weight. However, 75% WIR produced reasonable plant height, shoot dry weight and leaves area, from that of 100% WIR. On the other hand, Root length were increased significantly and root dry weight were increased non significantly with decreasing water irrigation requirement to 75% and 50% compared with 100% WIR. The highest growth parameters as values were obtained with 100% WIR followed by75 % WIR and the lowest values with 50% WIR. Except of root length (cm) gives the highest value in 50% WIR (17.50cm) and root weight (16.51g).

3.1.2. Impact of cultivars:

Data presented in (Table 2) indicated that the three tested cultivars Nubaria 1, Nubaria-2 and Giza 843 of faba bean were differed markedly in different studied growth parameters (plant height, shoot dry weight, leaves area, root length and dry weight). Data clearly show that, Nubaria-1 cultivar gives the highest plant height 79.21 (cm), shoot dry weight 55.16 (g), leaves area 15.56 (cm^2) and dry weight of roots 18.39 (g) compared with the other two cultivars, while Giza 843 gave the highest value of root length 17.68(cm) compared with the other cultivars.

3.1.3. Impact of interaction between water regime and faba cultivars:

Table (2) clearly show the effect of interaction of water irrigation requirement WIR (100%, 75% and 50%) and cultivars (Nubaria-1, Nubaria-2 and Giza-843). Decreasing water used efficiency to 75% and 50% caused marked and gradual decreases in different studied growth parameters (plant height, shoot dry weight, leaves area and root dry weight) as compared with control plants (those plants irrigated with 100% WIR), meanwhile root length increased markedly. The percentages of reductions in Nubaria-1 cultivar were the least in plant height 5.4% and 10.7% compared with 6.1% and 18.9% in Nubaria -2 and 7.9% and 20.9% in Giza-843 at 75% and 50% WIR respectively (Table 2). Where the decreases in shoot dry weight were 6.7% and 13.6% of Nubaria 1, 9.6% and 14.5% of Nubaria 2 and 15.4% and 14.6% of Giza 843 at 75% and 50% WIR respectively as compared with 100% WIR.

Table (2): Impact of irrigation levels (WIR), cultivars and their interaction on growth attributes of faba bean grown under sandy soil (Data are means of averages of two seasons).

WIR %		Plant height (cm)	Shoot dry weight (g)	Leaves area (cm^2)	Root length (cm)	Root dry weight (g)
Effect of WIR						
100%		81.98	57.54	16.50	14.25	16.19
75%		76.36	47.59	14.61	15.75	16.39
50%		68.26	46.80	13.70	17.50	16.51
L.S.D at 5%		5.01	11.74	1.11	1.22	2.91
Impact of cultivars						
Nubaria -1		79.21	55.16	15.56	14.25	18.39
Nubarai -2		76.37	50.24	15.02	16.56	16.29
Giza-843		71.01	46.52	14.23	17.68	14.40
L.S.D at 5%		3.70	7.41	1.36	1.41	4.07
Impact of interaction of WIR and cultivars:						
100%	Nubaria -1	84.04	66.29	17.26	13.75	18.78
	Nubarai -2	83.33	54.62	16.72	14.2	16.30
	Giza-843	78.57	51.70	15.53	14.15	13.48
75%	Nubaria -1	<u>79.52</u>	52.66	15.89	14.16	18.40
	Nubarai -2	78.25	49.38	14.19	14.77	16.08
	Giza-843	72.30	43.73	13.74	15.16	14.68
50%	Nubaria -1	<u>75.06</u>	<u>48.53</u>	13.55	16.64	17.99
	Nubarai -2	<u>67.53</u>	46.72	14.16	17.68	16.48
	Giza-843	62.18	44.14	13.41	18.64	15.05
L.S.D at 5%		7.08	16.61	1.57	2.11	4.11

3.2. Photosynthetic pigment:

3.2.1. Impact of water regime:

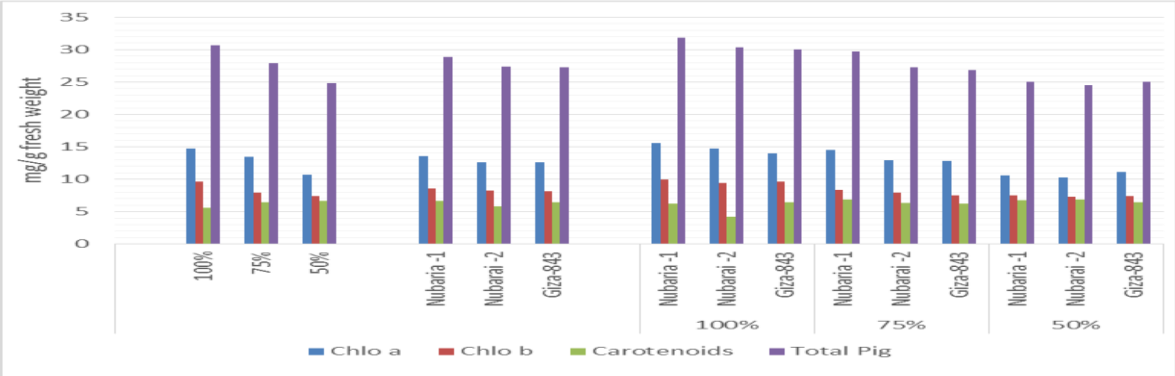
Mean performance of photosynthetic pigments; Chlorophyll a, Chlorophyll b, carotenoids and total pigments as affected by irrigation requirement (WIR) are presented in Fig (1). The obtained data showed that, decreasing water irrigation requirement from 100% WIR to 75% and 50% WIR caused significant and gradual decreases in different photosynthetic pigments components.

3.2.2. Impact of cultivars:

The effect of plants on the composition of photosynthetic pigments (Chlorophyll a, Chlorophyll b, carotenoids and total pigment) of faba bean grown on sandy soil is shown in figure (1). Results clearly show the superiority of Nubaria-1 cultivar over the other two tested cultivar Nubaria-2 and Giza 843 in Chlorophyll a, Chlorophyll b, carotenoids and total pigments contents.

3.2.3. Impact of interaction between water regime and Faba bean cultivars:

Mean performance of photosynthetic pigments; Chlorophyll a, Chlorophyll b, carotenoids and total pigments as affected by the interaction of water irrigation requirement (WIR) and cultivars of faba bean plant grown under sandy soil are presented in Fig (1). The obtained data showed that, decreasing water used efficiency from 100% WIR to 75% and 50% WIR caused significant and gradual decreases in different photosynthetic pigments components of the tested three cultivars Nubaria-1, Nubaria-2 and Giza 843 as compared with plants grown under normal irrigation (100% WIR).



LSD at 5% : Impact of WIR: Chlorophyll a 0.46, Chlorophyll b: 0.33, Carotenoids: 1.81, Total pigments: 0.44
Impact of cultivars: Chlorophyll a 0.41, Chlorophyll: 0.37, Carotenoids: 2.14, Total pigments: 0.42
Impact of interaction Chlorophyll a 0.58, Chlorophyll b: 0.52, Carotenoids: 3.03, Total pigments: 0.59

Fig (1): Impact of irrigation regime (WIR), cultivars and their interaction on photosynthetic pigments (mg/g fresh weight) of faba bean grown under sandy soil.

3.3. Indole acetic acid and total carbohydrates:

3.3.1. Impact of water regime:

Decreasing irrigation water from 75% and 50% caused significant decreases ($p \leq 0.05$) in IAA and TCHO of faba bean plants compared with control plants grown under sandy soil with 100% (Fig 2). The percentages of decreases were 12.38% and 2.30% for IAA and TCHO under 75% WIR and 35.64% and 6.20% under 50% WIR compared with 100% WIR.

3.3.2. Impact of cultivars:

The effect of different cultivar on endogenous IAA and total carbohydrates contents of faba bean plant are presented in Fig (2). Data clearly show that, Nubaria-1 was superior on increasing IAA and TCHO contents compared with the other two cultivars (Nubaria -2 and Giza 843. While Giza 843 gave the least IAA (µg/g fresh weight**)** and TCHO % contents.

3.3.3. Impact of interaction of water regime and cultivars:

Regarding to the effect of interaction between water irrigation requirement (100%, 75% and 50%) and cultivars (Nubaria-1, Nubaria-2 and Giza-843) of faba bean plant grown under sandy soil (Fig 2), the obtained results showed that, subjecting faba bean varieties to 75% and 50% WIR significantly decreased endogenous IAA (µg/g fresh weight and TCHO% compared with 100% WIR allover three tested cultivars.

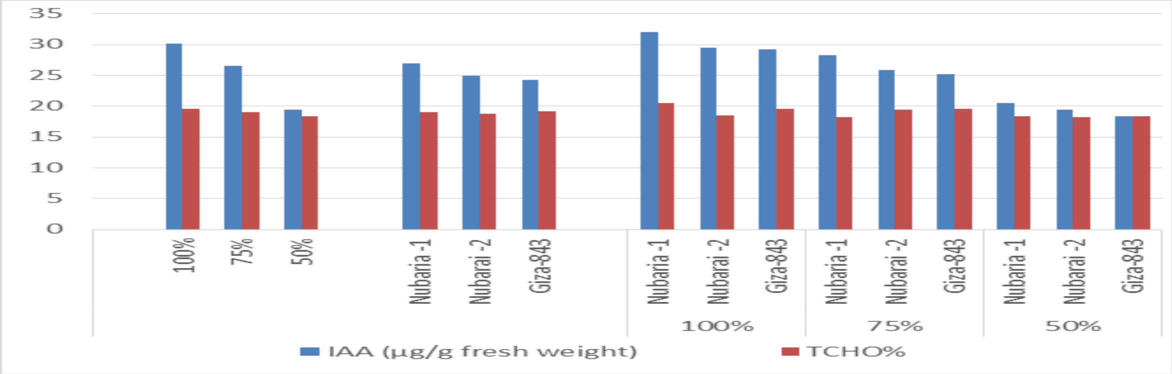
3.4. Osmoprotectants:

3.4.1. Impact of water regime:

Decreasing irrigation water from 100% to 75% and 50% caused significant increases ($p \leq 0.05$) in some osmoprotectants such as proline, free amino acids, total soluble protein TSP and total soluble sugars TSS contents on faba bean plants compared with control plants (100% WIR) under sandy soil (Fig 3 & 4). The percentages of increases were 23.56% and 38.20% of proline, 23.57% and 38.42% of TSP and 26.38% and 12.02% of TSS and 17.02% and 27.47% of free amino acids under 75% and 50% WIR respectively compared with 100% WIR.

3.4.2. Impact of cultivars:

The effect of different cultivars on osmoprotectant contents of faba bean plant are presented in Fig (3 & 4). The obtained results show significant differences ($p \leq 0.05$) between the studied cultivars. Nubaria-1 was superior on high contents of the studied osmoprotectants contents compared with the other two cultivars (Nubaria -2 and Giza 843). While Giza 843 show the least contents of the above mentioned parameters compared with the other two cultivars. Except TSS content Giza 843 show the highest content of TSS meanwhile Nubaria-1 show the least TSS content comparing with other cultivars (Fig 3 & 4).

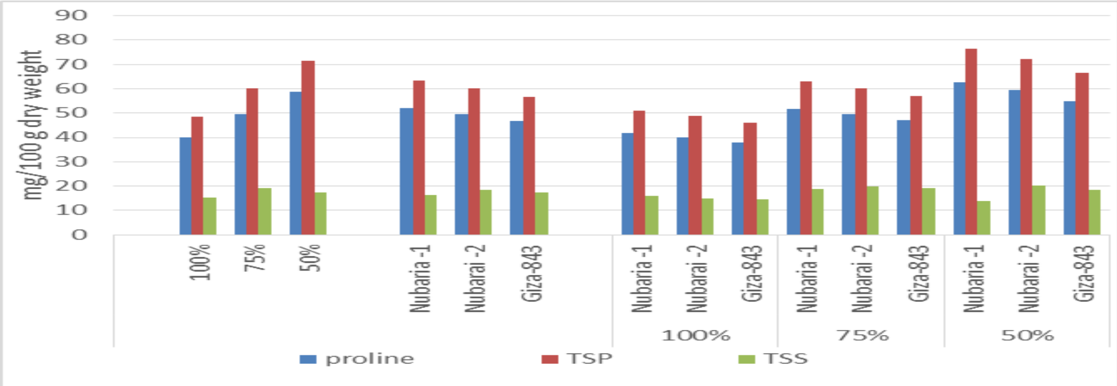


LSD at 5%: Impact of WIR: IAA: 0.85, TCHO: 0.26 , Impact of cultivars: IAA: 0.92, TCHO: 0.24
Impact of interaction: IAA: 1.30, TCHO: 0.33

Fig (2): Impact of irrigation regime (WIR), cultivars and their interaction on endogenous IAA (µg/g fresh weight) and total carbohydrates % of faba bean grown under sandy soil.

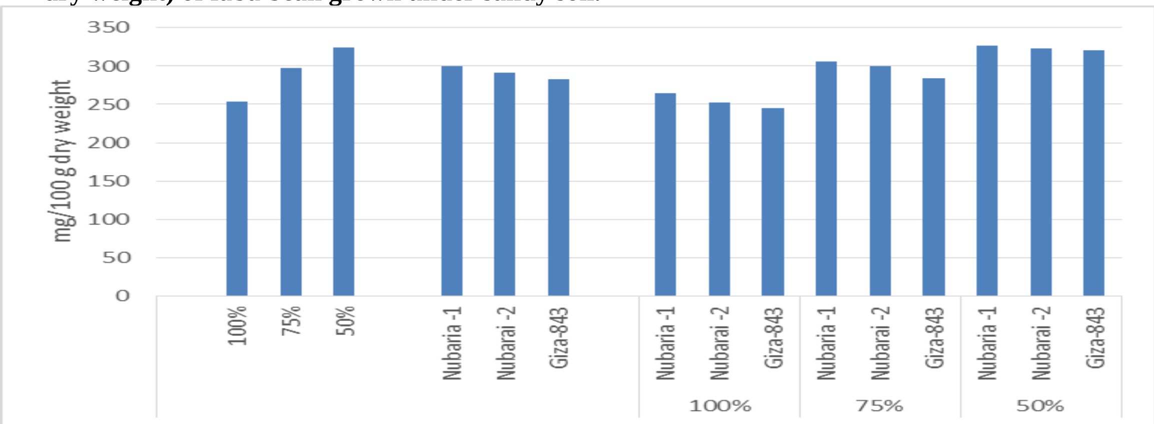
3.4.3. Impact of interaction of water regime and cultivars:

Fig 3 & 4 shows that different water regime levels induced significant ($p \leq 0.05$) increases in proline, TSP and TSS in addition to free amino acids concentration of faba bean plant relative to control plants (100% WIR). Moreover the data show significant differences between faba bean cultivars under normal irrigation 100% WIR and water regime (75% and 50% WIR) Fig 3 & 4.



LSD at 5%: Impact of WIR: proline 0.80, TSP: 0.51 and TSS: 0.53, Impact of cultivars: proline 1.17, TSP: 1.55 and TSS: 0.55, Impact of interaction: proline 1.66, TSP: 2.19 and TSS: 0.78

Fig (3): Effect of irrigation regime (WIR), cultivars and their interaction on proline, TSP and TSS (mg/100 g dry weight) of faba bean grown under sandy soil.



LSD at 5%: Impact of WIR: *3*.80, Impact of cultivars: 3.17, Impact of interaction: 3.68,.

Fig (4): Impact of irrigation regime (WIR), cultivars and their interaction on free amino acids (mg/100 g dry weight) of faba bean grown under sandy soil.

3.5. Yield and its attributes:

3.5.1 Impact of water regime:

The presented data in Table (3) clearly show the effect of water regime on yield and its components of faba bean grown under sandy soil. Decreasing WIR from 100% to 75% significantly decreased pods, seeds weight/plant (g), 100 seeds weight (g), seeds yield (kg/fed), meanwhile decreased non-significantly pods number/plant, Biological yield (ton/fed).While 50% WIR caused significant decreases in all the above mentioned yield and its components (Table 3).

3.5.2. Impact of cultivars:

The data shown in Table (3) clear the effect of cultivars on faba bean yield and its components. The results clearly show that, yield and its components were significantly affected by cultivars. Nubarai- 1 cultivar significantly exceeded Nubarai -2 and Giza-843 cultivars in all studied characters (plant height, number of pods per plant, seeds weight/plant, weight of 100 seeds (gm), seed yield (k/ fed.) and biological Yield (kg/fed.).

3.5.3. Impact of interaction between water regime and Faba bean cultivars on yield, yield attributes:

The data in Table (3) reveal the effect of interaction between the water regime (WIR) and faba bean cultivars (Nubaria -1, Nubaria-2 and Giza 843) on yield and its components. Data show that, different studied yield attributes were decreased markedly and gradually due to decreasing WIR from 100% to 75% and 50% WIR. Under 75%, the decreases were non-significantly in pods number/plant, 100- seeds weight and biological yield, while pods weight/plant, seeds weight /plant, seeds yield (kg/fed) the decreases were significant in Nubaria -1. Nubaria -2 the decreases were non-significant in pods number/plant, 100 seeds weight, while pods weight/plant, pods weight/plant, seeds weight/plant, seeds yield (kg/fed) and biological yield, the decreases were significant. Also, in Giza 843 the decreases in pods number/plant, pods and seeds weight/plant and biological yield, meanwhile, 100-seeds weight and seeds yield the changes were significant. Furthermore, under 50% WIR the decreases in different yield attributes were significant (Table 3). Maintaining proper water levels during faba bean vegetative growth appears to be essential for high yields. As shown in this study, lack of water had a significant negative impact on seed yields (kg / feed) for all broad bean cultivars.

Table (3): Impact of water regime, cultivars and their interaction on yield and yield attributes of faba bean grown under sandy soil (Data are means of averages of two seasons).

Treatments		Pods number/ Plant	Pods weight/plant (g)	Seeds yield /plant (g)	100-seeds weight (g)	Seeds yield (kg/fed)	Biological yield (ton/fed)
Impact of WIR							
100%		6.29	51.41	46.23	104.08	526.61	2.83
75%		5.98	48.44	43.74	98.77	453.94	2.65
50%		4.85	41.77	36.74	85.28	360.67	2.40
L.S.D at 5%		0.84	0.78	2.17	5.14	29.80	0.50
Impact of cultivars							
Nubaria -1		6.17	48.93	43.49	102.22	492.06	2.79
Nubarai -2		5.57	47.08	42.03	99.08	465.28	2.71
Giza-843		5.37	45.62	41.18	86.82	383.89	2.39
L.S.Dat 5%		1.17	1.32	1.01	7.35	43.02	0.48
Impact of interaction of WIR and cultivars							
100%	Nubaria-1	6.85	54.36	49.62	108.74	582.50	3.06
	Nubarai -2	6.31	50.91	45.77	104.82	549.17	2.90
	Giza-843	5.69	48.95	43.29	98.68	448.17	2.53
75%	Nubaria -1	6.81	48.49	42.68	105.02	511.50	2.83
	Nubarai -2	5.88	48.65	44.32	103.89	493.83	2.62
	Giza-843	5.24	48.18	44.22	87.38	356.50	2.51
50%	Nubaria -1	4.86	43.93	38.17	92.90	382.17	2.50
	Nubarai -2	4.52	41.67	36.01	88.54	352.83	2.59
	Giza-843	5.17	39.72	36.05	74.41	347.00	2.13
L.S.D at 5%		1.18	1.87	1.42	7.27	42.14	**0.70**

3.6. Chemical composition of the yielded faba bean seeds:

3.6.1. Impact of water regime:

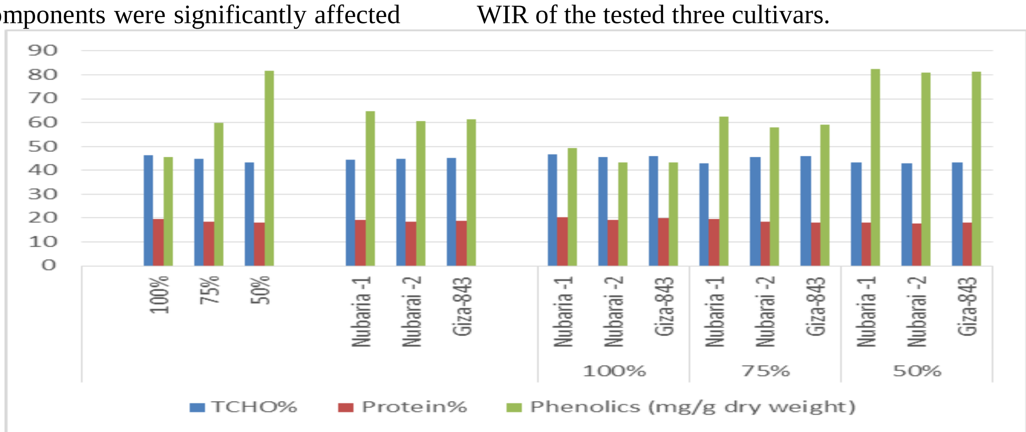
The presented data in Fig (5) and Fig (6) clearly show the effect of water regime on some nutritional values of the yielded seeds of faba bean grown under sandy soil. The studied components were total carbohydrates content (TCHO%), protein% phenolic and vicine contents. Decreasing WIR from 100% to 75% and 50% WIR significantly and gradually decreased THO% and protein%. Meanwhile increased significantly plant phenolics and vicine contents of the yielded faba bean seeds (Fig 3 and 4).

3.6.2. Impact of cultivars:

In Fig (5& 6), data show the effect of cultivars on nutritional contents seeds yield of faba bean plants grown under sandy soil. The results clearly show that, yield and its components were significantly affected by cultivars. Giza- 843 cultivar significantly exceeded Nubarai -1 and Nubaria -2 cultivars in containing TCHO% and vicine content. Nubaria-1 was superior in containg protein% over the two tested cultivars it has 19.28% compared with 18.32 and 18.67% in Nubaria-2 and Giza 843.

3.6.3. Impact of interaction between water regime and Faba bean cultivars on yield, yield attributes

Data presented Fig (5 & 6) reveal the effect of interaction between the water irrigation requirement (WIR) and faba bean cultivars (Nubaria -1, Nubaria-2 and Giza 843) on chemical composition of faba bean yielded seeds. Data in Fig (5and 6) show that, TCHO and protein% were decreased markedly and gradually due to decreasing WIR from 100% to 75% and 50% WIR. Meanwhile phenolic and vicine contents were increased as compared with 100% WIR of the tested three cultivars.



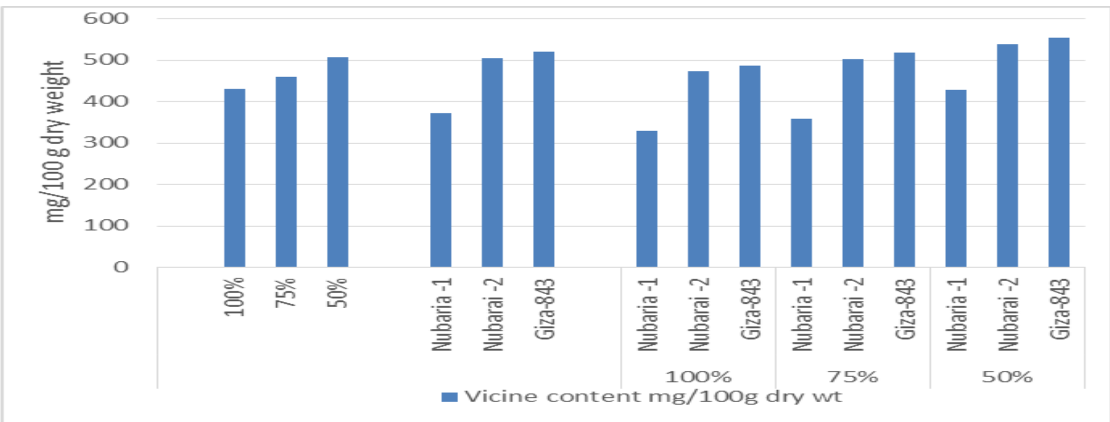
LSD at 5%

Impact of WIR: TCHO%: 0.54, Protein%: 0.45, Phenolic: 1.66

Impact of cultivars: TCHO%: 0.48, Protein%: 0.43, Phenolic: 1.27

Impact of interaction: TCHO%: 0.68, Protein%: 0.61, Phenolic: 1.80

Fig (5): Impact of irrigation regime, cultivars and their interaction on carbohydrates TCHO%, proteins% and phenolics (mg/g dry weight) of faba bean yielded seeds grown under sandy soil.



LSD at 5%

Impact of WIR: 8.90

Impact of cultivars: 13.40

Impact of interaction: 18.96

Fig (6): Impact of irrigation regime, cultivars and their interaction on vicine contents (mg/g dry weight) of faba bean yielded seeds grown under sandy soil.

3.6. 4. Water use efficiency WUE (g/m^3) of some Faba bean cultivars as affected irrigation treatment and their interactions

Results of Table (4) showed the individual effect of irrigation requirements and cultivars as well as the interaction. WUE water use efficiency (g/m^3) significantly affected by irrigation requirements for all the studied bean cultivars. It is clear that irrigation with 50% IR produced the highest values as compared with the other treatments (Table 4).

In our research, water shortage positively influenced WUE (g/m^3) of all faba bean cultivars With respect to the performance of different cultivars, data presented in Table (4), show significant differences among the three tested cultivars of field bean for all the studied characters. From obtained results of this study, it could be concluded that Nubaria-1 cultivar significantly surpassed other studied cultivars and recorded the highest values for WUE (g/m^3). Effect of cultivars and leveles of water were significant.

Table(4): Water use efficiency WUE (g/m^3) of some Faba bean cultivars as affected by irrigation treatments

Irrigation levels	WUE
100%	64.06
75%	80.77
50%	99.96
LSD at 5%	6.29
Cultivars	
Nubaria -1	95.96
Nubarai -2	81.72
Giza-843	67.16
LSD at 5%	4.87

Interaction

	Irrigation	**WUE**
100%	Nubaria -1	75.84
	Nubarai -2	66.59
	Giza-843	49.76
75%	Nubaria -1	95.33
	Nubarai -2	85.73
	Giza-843	61.25
50%	Nubaria -1	116.70
	Nubarai -2	92.83
	Giza-843	90.47
	LSDat 5%	6.89

4. Discussion

4.1. Impact of water regieme

Water deficit stress is a powerful challenges to sustainable faba bean production due to its sensitivity to water stress. It is among the main environmental adverse effects which reduce growth, development and yield of various plant species [43]. This decrease is related to stress intensity, phonological development, physiological and biochemical processes. Therefore, the productivity of plants is negatively affected by drought. [44]. As a result of the osmotic effect of water stress, it could be considered that water stress causes various responses in plant cell such as reductions of growth as well as formation of non-toxic compounds, that are used to increase osmotic potential and metabolic processes, and ultimately increases activity of some antioxidant enzymes [45]. Generally, water scarcity reduced shoot growth parameters (plant height, shoot dry weight and leaves area), meanwhile increased root length and weight (Table 2) of the three tested cultivars (Nubaria -1, Nubaria-2 and Giza 843). These results strengthen the data obtained by Sadak & Bakry [46], Sadak [47] and Abd Elhamid [48] on flax, wheat and moringa plants respectively. This decreases may be due to impairment resulted by increased levels of reactive oxygen species. In addition, water scarcity affects the plant-water relationship, reduces the water content of shoots, induces osmotic stress, slows cell growth, and cell division ultimately reduces overall plant growth [49]. Furthermore, those decreases could be attributed to interruption of water flow from xylem to the surrounding elongating cells, which regulates cell elongation phase of plant growth [50]. Water deficit inhibits mitosis, cell expansion and elongation disrupting the growth cascades [50 & 51]. Moreover, water deficit caused variations in the phytohormones homoeostasis as IAA (Fig 2) appear to be another explanation for growth reduction [52]. On the other hand, the increases in root length and weight as affected by decreasing WIR (Table 2) might be attributed to the preservation of tissue water status helped plant to sustain growth. Sinclair and Muchow [53] found that, root length plays a significant role in drought resistance. When plants are grown under water deficit soils, varieties with longer roots may have little advantage [54]. A lack of water may also increase the amount of dry matter allocated to the roots that could also help in the absorption of soil water [55]. Root properties are most important for improving the ability of plants to extract water from water [56]. Among other properties, deeper roots had been proven to be beneficial for the survival of plant under watertight environments [57].

Various metabolic processes among them photosynthesis were adversely affected by water deficiency. Our results showed that the photosynthetic pigments components were reduced by water deficit (Fig. 1). Suppression in photosynthetic pigments in faba bean cultivars as affected by water stress has been reported previously, Bakry [58] and Sadak & Bakry [46] on flax, Sadak [59] on wheat cultivars. Those decreases in Chlo a, Chlo b, carotenoids and consequently total pigments showed that water-splitting complex and reaction centers of PSII are damaged (photochemically inactive), indicating impairment of photosynthetic electron transport [60]. The reduction in Chloorophyll contents of faba bean leaves might be resulted via the destruction of chlorophyll molecules while producing ROS and causing structural damage in chloroplasts [61]. These decreases in photosynthetic pigments contents under the effect of drought stress might be due to the instability of pigment-protein complex and destruction of pigments [62]. Moreover, the decrease in photosynthetic pigment may be due to a mechanism that reduces the photosynthetic pigment content in leaves due to water deprivation, as mentioned by Herbinger [63] thereby preventing reactive oxygen species (ROS) damage.

Drought stress (moderate and severe) significantly reduced IAA content in fresh leaves of faba bean cultivars (Nubaria-1, Nubaria-2 and Giza 843 (Fig 2). These decreases may be due to increase the destruction of IAA by increasing the activity of IAA oxidase [64]. The disturbance of photosynthetic efficiency are linked with the other primary metabolic processes such as carbohydrate metabolism [50]. The reduction in total carbohydrates of drought affected leaves of faba bean cultivars concomitantly with arrested shoot growth of (Table 2) and reduction in the leaf photosynthetic pigments (Fig 1) that led to the conclusion that water deficit inhibited photosynthetic activity and/or increased partial utilization of carbohydrates into other metabolic pathways.

It can be seen that the yield and biochemical composition of plants depend mainly on the growing conditions, which are largely influenced by the availability of water. Table (3) indicates that drought stress significantly decreased yield and its attributes as well as quality in terms of total carbohydrates%, protein% accompanied by significant increases in vicine and phenolic contents of the yielded seeds. The decrease in yield and its properties is due to a decrease in photosynthetic pigments [65] and a decrease in the enzymatic activity of the Calvin cycle [66]. Ali [67] stated that changes in the chemical composition of seeds may be related to the fact that water deprivation affects many enzymes throughout the life of the plant, leading to decreased activity and changes under water stress conditions. Changes in metabolic activity result in the transfer of anabolic substances to the seed. Carbohydrate changes are particularly important because they are directly related to physiological processes such as photosynthesis, translocation and respiration. Water stress can reduce the concentration of pigments in leaves, inhibiting photosynthetic activity, resulting in less carbohydrate accumulation in mature leaves, and consequently reducing the rate of carbohydrate transport from leaves to the developing seeds. The obtained results show that vicine content increased in different water stressed levels (Fig 4). In this concern, Bjerg [68] concluded that both environmental and genetic factors appear to affect the contents of favism causative agents in faba bean seeds. Increased levels of vicine may be due to the effect of water scarcity on different metabolic pathway of vicine precursor (orotic acid) formation which responsible for the formation of pyrmidine ring of these toxic components [69].

4.2. Impact of cultivars:

Data in Table 2 showed that, Nubarai- 1 cultivar gave the highest value in all growth parameters, yield and its components (Table 3) comparing with the other cultivars. These differences between cultivars may be related to the genetic structure of the genotype and the response of the genotype to environmental conditions. The presence of variability between the tested cultivars can be expected due to the different growth habits of these cultivars, the high variety of genetic components, and the environmental conditions of the tested cultivars under sandy soil [2, 70, 71 &72]. Moreover, Salama and Awad [73] reported similar variations between genotypes of faba bean plants. Moreover, Sadak [34] and Tawfik [74] reported that growth and yield of cultivar Nubaria 1 on reclaimed sandy soil was more pronounced than that of cultivar Giza 843**.** Moreover, Khattab [75] and Abou-El-Seba [76] stated that growth and yield achieved by Nubarai 1 cultivar were higher than Giza 843 cultivar. The superiority of Nubaria -1 cultivar on the studied growth (Table 2) and yield attributes (Table 3) over the two tested cultivars might be resulted from the highest contents of photosynthetic pigments as in Fig (1). These increases may be due to increase in the quenching rate of chlorophyll fluorescence, which resulted in a significant increases in plant biomass, the steady state of which was greater than the other two cultivars. Erdem [77] working on (*Phaseolus vulgaris*) stated that, the availability of sufficient water in the soil leads to improved various physiological processes, improved nutrient uptake, and the highest rate of photosynthesis. Therefore, a higher leaves area of Nubaria-1 cultivar that can lead to more photosynthesis is a desirable physiological reason which can increase plant productivity. Especially under water stress conditions, where soil moisture is often a limiting factor. In addition, the dominance of this cultivar may be due to the dominance of plant height.

According to WUE, it is clear in (Table 4) that irrigation with 50% IR produced the highest values as compared with the other treatments. Similar results were obtained by Hegab [78], they stated that increasing irrigation water more than 60% significantly decrease values of water use efficiency. Meanwhile, increasing irrigation quantity gradually decreased water use efficiency for all irrigation treatments. Rifaat [79] indicated that seed yield and biomass of faba bean were highly dependent on the amount of water availability and its use efficiency. Also, it clear that the highest value of WUE (g/m^3) 116.70 (g/m^3) was obtained as a result of faba bean plants (Nubaria -1 under 50% WIR. Similar results were reported by Loss and Siddique [54] and Ekram [80]. Furthermore, Hirich [81] reported that applying under-irrigation during vegetative growth and using half of the required water supply could achieve higher yield production and water productivity than full irrigation (+ 4% in yield and + 24% in plant water), they added that, under deficit irrigation during vegetative growth applying 50% of full irrigation can save almost 17% of the total amount of water applied, they stated that, under irrigation deficit using half of required water supply we have yield production and water productivity higher than full irrigation. Oweis [82] stated that, 2/3 of supplemental irrigation (SI) level were reported to provide optimal water utilization efficiency for both grains and biomass.

5. Conclusion:

Finally, it could be concluded that, drought stress has a reduced toxic effect on growth, some biochemical aspects, yield and its components as well as, seed quality expressed in total carbohydrates, protein, phenolic and vicine contents of faba bean cultivars. Since, Raising WUE is a key goal of modern agriculture and helps maintain food security and agricultural sustainability. From the obtained results, it can be concluded that Nubaria-1 cultivar under WIR (75%) produced the highest value for WUE, although it significantly reduced seed yield compared with other irrigation treatment. since it produce quit reasonably yield and save nearly 300 m^3 irrigation water especially under the circumstances of climate of Nubaria district, El-Behara Governorate region and moderate

6. Conflict of interest

The authors declare that there is no conflicts of interest

7. Funding:
No funding

8. References:

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