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YIELD AND PROLINE CONTENT OF FABA BEAN GENOTYPES UNDER WATER STRESS TREATMENTS

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ABSTRACT

Drought stress is one of the most serious problems for agriculture production and sustainability.This study was carried out to investigate seed yield and its components in addition to estimate free proline content in leaves of nine faba bean genotypes with different types grown under three water regimes (well-watered, mild and severe drought). A field experiment was laid out in split plot with three replications during two growing seasons, 2013/14 and 2014/15. The results indicated that drought had pronounce negative effects on yield and its components for all faba bean yield characters, while the effect was positive with leaves proline content. Hassawi 2 out yielded all genotypes under all water treatments and was followed by Giza 843 and ILB 1814 under well irrigation and by Giza Blanka and Giza 843 under high drought stress. Furthermore Hassawi 2 and Giza Blanka showed higher drought tolerance efficiency (42.3 and 39.5), less drought stress susceptibility index (0.6) and minimum reduction in seed yield 58.3 and 60.4%, respectively. Proline content ranged from 46.3µg/g for Gazira 2 to 69.7 for ILB 1814 under well-watered and from 89.8 for Kamline to 264.0 for Gazira 1 under severe drought. Proline content and seed yield/plant negatively correlated ($r = -0.65^{**}$) over all treatments and was insignificant under both well-watered (r= 0.62) and high drought stress (r= 0.43). To a limit, results indicated that proline content could be used as an indication toward selection for drought tolerant genotype.

Key words: Faba bean, Water regimes, Proline, Tolerance, Seed yield.

INTRODUCTION

Faba bean (*Vicia faba* L.) is an annual legume crop, belongs to *Fabaceae* family, commonly known in a worldwide by different names. In this species only two subspecies were recognized (*paucijuga* and *eu-faba*), the subspecies *eu-faba* was subdivided into three types 1-*minor* with small rounded seeds, 2-*equina* with medium sized seeds and 3- *major* with large broad flat seeds (Bond *et al.,* 1985) while Cubero (1974) suggested four subspecies, namely: *minor, equina, major* and *paucijuga*. Faba bean a large and economically important crop that is rich in protein and energy. It is widely considered as a good source of protein, starch, cellulose and minerals for humans in developing countries and for animals in industrialized countries (Haciseferogullari *et al*., 2003). In the Middle East and most parts of the Mediterranean, China and Ethiopia, faba bean constitutes one of the main dishes on the breakfast and dinner tables (Bond *et al*., 1985). Faba bean may by use as green manure or cover crop also; it has significant value in improving the fertility of soil by its rotation cultivation with cereal crops.

Drought stress is one of the most serious world-wide problems for agriculture. Four-tenths of the world's agricultural land located in arid or semi-arid regions and drought events are increasing (Wang and Hendon, 2007). Drought limits the growth and productivity of most crop species including faba bean. The reduction in faba bean seed yield was positively related to the amount of water reduction and reach up to 50% of seed yield (Musallam *et al*., 2004 and Ouda *et al.,* 2010 and Ammar *et al.,* 2014). Adaptationis a more complex process than just reduced growth and productivity (Conde *et al.,* 2011). Faba bean plants are sensitive to drought deficit (Ricciardi *et al*., 2001; Amede and Schubert 2003; Khan *et al.*, 2007 and 2010 and Ammar *et al.*, 2014). Understanding of the drought tolerance physiological mechanisms in faba bean is substantial to identify characters correlated with drought tolerance that can be selected in breeding programs.

Accumulating solutes is a wide spread plant response to environmental stresses such as drought, while carbohydrates are used for energy and maintaining metabolism under water deficit conditions (Khalid *et al.*, 2010). Proline is one of the most common compatible osmolytes in drought stressed plants. Proline has an important role in conferring osmotolerance (Mittler *et al*., 2004 and Verbruggen and Hermans, 2008). Compatible solutes are over produced under drought stress for facilitate osmotic adjustment (Hasegawa *et al*., 2000 and Shao *et al*., 2005). These compounds accumulated in high amounts mainly in cytoplasm of stressed cells without interfering with macromolecules and behaved as osmoprotectants (Yancey, 1994). Also proline has a key role in stabilizing cellular proteins and membranes in high concentrations of osmoticum (Yancey, 1994 and Errabii *et al.*, 2006). In the same orientation Vendruscolo *et al.* (2007) reported that proline accumulation in stressed plants is a tolerance mechanism against oxidative stress and it is the main strategy of plants to avoid harmful effects of drought stress. However Maggio *et al*. (2002) and Zlatev and Stoyanov (2005) suggested that proline accumulation in stressed plants is not stress tolerance mechanism, but it may be part of the stress signal influencing adaptive responses.

Consequently, the objectives of this study were to determine the differences between faba bean genotypes with different types for seed yield and its components in addition to assess the relationships of proline content and seed yield under three water regimes.

MATERIALS AND METHODS

To achieve the objective of the present study, nine faba bean genotypes belong to the three types (*minor, equina* and *major*) were collected from different geographical origins (Table 1). The nine genotypes were evaluated under three levels of water deficit in a field experiment during 2013/2014 and 2014/2015 seasons. Field experiments were conducted in sandy soil (76.1% sand, 12.0% silt and 11.9% clay) at Dirab Experimental and Agricultural Research Station (24°43′34″N, 46°37′15″E), King Saud University, Riyadh, Saudi Arabia. The experimental design was split plot with three replications keeping the water treatments in the main plots and genotypes in the subplots. Seeds of genotypes were planted in 50 and 20cm spaced rows and hills, respectively, during first week of November in both experimental years. Each experimental plot was represented by four rows with three meter long. Water treatments applied after 3 weeks of sowing by irrigations when the amount of evaporated water from the ‘class A pan’ evaporation reached 50 mm (control), 100 mm (mild drought stress) and 150 mm (severe drought).. At pod filling stage and before irrigation leaf samples from each plot were collected for determining proline content using method of Bates *et al*.,(1973). First, fresh leaf samples were homogenized in 3% sulfosalicylic acid, followed by the addition of 2 mL each of ninhydrin and glacial acetic acid and the samples were heated to 100 °C. The mixture was then extracted with toluene, and the free toluene was quantified spectrophotometrically at 520nm using L-proline as a standard. Proline concentration was determined using a calibration curve and expressed as µg/g leaf fresh weight. At maturing stage, five plants from each plot were selected from the middle rows to measure plant height, no. of branches/plant, no. of pods/plant, no. of seeds/plant, no. of seeds/pod, seed index (100-seed weight) and seed yield/plant.

The drought stress susceptibility index (SSI) was calculated according to Fischer and Maurer (1978):

$$SSI = \frac{1 - Y_{si}/Y_{pi}}{SI}$$

$$SI = 1 - \frac{Y_s}{Y_p}$$

Also drought tolerance efficiency (DTE) meanrelative performance ratio was estimated by using formula given by Fischer and Wood (1981).

$$DET = \frac{Y_{si}}{Y_{pi}} X100$$

Where Y_{si} is the yield/hectare of the genotype under stress conditions, Y_{pi} is the yield/hectare of the genotype under non-stress conditions, Y_s is the mean yield of all genotypes under stress conditions, and Y_p is the mean yield of all genotypes under non-stress conditions. A lower SSI and high DET indicate higher drought tolerance genotype. Yield/hectare was estimated according to the plot area harvested.

Statistical analysis: Data of the two seasons were submitted to analysis of variance (ANOVA) and after confirmation of errors compatibility; the combined analysis over the two seasons was applied following Gomez and Gomez (1984). The means of treatments were compared using Duncan’s multiple-range test (Duncan, 1955) at the level of 5% probability using Mstatc software (MSTATC 1990). Simple correlation coefficients between seed yield/plant and proline contents were computed according to Snedecor and Cochran (1981) using subprogram (correlation) in the same software.

Table 1.Type, name and origin of selected faba bean genotypes.

	Minor			*Equina*			*Major*	
No.	**Name**	**Origin**	**No.**	**Name**	**Origin**	**No.**	**Name**	**Origin**
1	Gazira 2	Sudan	**4**	Giza 2	Egypt	**7**	ILB 1814	Syria
2	Tribal White	Denmark	**5**	Giza 843	Egypt	**8**	Giza Blanka	Egypt
3	Kamline	Spain	**6**	Hassawi 2	Saudi Arabia	**9**	Gazira 1	Sudan

RESULTS AND DISCUSSION

Combined analysis of variance of the two seasons revealed significant differences among seasons and water treatments for all traits as well as their interactions in plant height, branches, seeds/pod and proline content. Genotypes and its interactions with seasons and water treatments exhibited highly significant differences for all traits except no. of branches in genotype by water treatments and seed yield/plant in genotype by water treatments by seasons (Table 2). All round improvement in growth and seed yield characters were found significantly maximum under well water irrigation treatment degraded with increase drought stress. The tallest genotypes Giza 843, Gazira 2 and Giza 2 under well irrigation treatment exhibited high reduction when grow under stress conditions as compare to the other genotypes (Table 3). The tallest genotypes over all treatments were Giza 843, Gazira 2, Gazira 1 and Giza 2 with mean values of 95.1, 93.9, 91.9 and 91.0cm, respectively. Faba bean genotypes *var., major* (ILB 1814, Giza Blanka and Gazira 1) had highest branches number under all conditions with mean values of 6.1, 5.5 and 5.0 under well irrigation and 4.7 4.7 and 4.3 mean of all treatments, respectively. The highest number of pods and seeds per plant showed by *minor* type followed by *equina* under well irrigation but *equina* genotypes were maintained numbers of pods in stress conditions (9.8, 7.1 and 6.8 for Hassawi 2, Giza 843 and Giza 2, respectively) but as mean of the water treatments suggested the superior of TW, Hassawi 2 and Gazira 2 with maximum number of pods (15.2, 13.8 and 13.5, respectively). Concerning no of seeds/plant, *minor* type genotypes produced highest number under well-watered conditions however, under drought stress Hassawi 2 from *equina* type shared Gazira 2 the first rank with mean number of 16.0 and 15.3, respectively (Table 3). These results are in agreement with these obtained by Khalafallah *et al*. (2008), Ouzounidou *et al.* (2014), Ammar *et al.* (2014) and Alghamdi *et al.* (2014) found that drought stress significantly influenced all faba bean characters.

Table 2. Combined analysis of variance of seed yield, its components and proline content traits of faba bean genotypes under three water regimes

S O V	df	Plant height	No. of branches	No. of pods/ plant	No. of seeds/ plant	No. of seeds/ pod	Seed index	Seed yield/ plant	Proline content
Season (S)	1	72483.2**	0.002ns	90.9**	1309.0**	2.49**	764.8*	314.4**	19120.9**
Treatment (T)	2	22493.6**	42.3**	1504.5**	6472.8**	0.37ns	1645.2**	3140.6**	203045.3**
S T	2	2130.1**	2.5*	2.18ns	91.4ns	0.7*	103.7ns	35.5ns	12153.2**
Error	8	55.9	0.4	7.4	46.7	0.1	110.6	12.7	251.3
Genotype (G)	8	2068.0**	19.8**	196.6**	412.7**	1.4**	8395.9**	165.7**	9602.8**
SG	8	356.9**	5.8**	34.8**	126.2**	0.52**	219.6**	39.3**	4372.9**
T G	16	140.6**	0.89ns	37.6**	108.8**	0.28*	236.4**	27.4**	5363.4**
S T G	16	111.9**	1.17*	16.9**	31.7*	0.34*	67.6**	7.79ns	1774.9**
Error	96	44.9	0.6	5.1	15.0	0.2	53.8	7.1	285.3

SOV, source of variation; d.f., degree of freedom; ns, non-significant; *Significant at P 0.05; **Significant at P 0.01.

Influence of water deficit on number of seeds/pod, seeds index, seed yield/plant and free proline content in leaves of the nine faba bean genotypes as mean of the two seasons are presented in Table 4. *Major* type's genotypes (Gazira 1, ILB 1814 and Giza Blanka) described by number of seeds per pod and seed index. In this study these genotypes maintained their number of seeds per pod under all water irrigation treatments and produced 2.9, 2.3 and 2.2, respectively as mean of the three treatments. Distinction between faba bean types was clear by seed index character, seed index of *major* genotypes were higher than other types which had values higher than of *equina* and almost double of weight of *minor* seed index under all conditions. The reduction in seed yield/plant was in linear with increase drought stress. The genotype Hassawi 2 exhibited maximum seed yield per plant under high level of water (T1) and less changes due to drought stress and maintained its rank over tested genotypes under all conditions. Hassawi 2 shared the first rank with ILB 1814 and Giza 843 under high water irrigation with mean values of 29.0, 27.1 and 27.0g, respectively while under low available water, Hassawi 2 was ranked first followed by Giza Blanka and Giza 843 with mean values of 12.1, 8.4 and 8.1g, respectively. The mean of the three water treatments indicated the superior of Hassawi 2 followed by Giza 843, ILB 1814 and Giza 2. Ammar *et al*. (2014) reported that drought stressed plants produced less number of branches, lower number of pods, seeds/pod, lighter seed weight which consequently led to a significantly lower seed yielddue to progressive water deficit. Estimates of proline contents of faba bean genotypes under different water treatments suggested that proline accumulation in faba bean leaves increased with progressive water deficit also the variations between genotypes under high water available were low and increased under mild and high drought stresses. The highest proline content values (264.0, 228.1 and 212.9µg) were measured under high drought stress in Gazira 1, Giza Blanka and Hassawi 2, respectively; these genotypes had higher seed yield under high drought stress conditions except Gazira 1. Ammar *et al.* (2014) found that the highest accumulation of leaf free proline in seedling of Gazira 2 and Hassawi 2 was under water deficit conditions. On the other side, the genotypes Gazira 2 and TW exhibited the lowest proline content (46.3 and 49.7µg, respectively) under well-watered treatment. These results suggested that proline accumulation in faba bean leaves under well water and increased with increasing the drought stress in faba bean genotypes not related to faba bean types however *major* type was higher in all treatments. In other field crops it was found that proline content was higher after drought in wheat (Vendruscolo *et al*., 2007 and Johari-Pireivatlou, 2009), Pea (Alexieva *et al*., 2001), Chickpea (Mafakheri *et al*., 2010), Sugar Beet (Putnik-Delic *et al*., 2013), Sesame (Kadkhodaie *et al*., 2015), Sunflower (Nazarli *et al*., 2011), upland Rice (Lum *et al*., 2014) and Cotton (Zhang *et al*., 2014). Over all water treatments proline content was in highly significant negative relationship with seed yield ($r= -0.65^{**}$, $P<0.01$) indicated that exposing faba bean plants to drought accumulation of proline in leaves increased and seed yield decreased. While the relationship was insignificant between proline content and seed yield/plant (r= 0.62 and 0.43) under well-watered and high drought stress, respectively. Ghiabi *et al.* (2013) noted that proline content showed significant positive correlation with yield of Chickpea under water deficit conditions and insignificant under irrigated environment. Siddiqui *et al.*(2015) suggested that heat-tolerant faba bean genotypes may have better osmotic adjustment by increasing the accumulation of proline content. On contrary with Parchin *et al.* (2014) observed that insignificant negative correlation between Wheat seed yield and proline content under drought stress. This indicated that proline accumulation in faba bean plants due to drought stress as drought tolerance mechanism of genotype but could not use as drought tolerance parameter. However, other authors suggested use accumulation of proline trait to select water stress-tolerant genotypes in Safflower (Amini *et al.*, 2014), Rosy periwinkle (Jaleel *et al*., 2007), Sesame (Hassanzadeh *et al.*, 2009 and Molaei *et al*., 2012 and Kadkhodaie *et al.*, 2015) and Wheat (Farshadfar *et al*., 2012).

Table 3. Influence of water deficit on plant height, number of branches, pods and seeds/plant of faba bean genotypes (combined of the two seasons)

Genotypes	Plant height (cm)			Mean	No. of branches/ plant			Mean
	T 1	T 2	T 3		T 1	T 2	T 3	
Gazira 2	114.9 A	96.6 EFG	70.2 JKL	**93.9 ab**	4.2 DEF	3.5 E-I	2.7 H-K	**3.5 cd**
TW	92.2GH	77.5JK	61.5 MN	**77.1 e**	3.1 F-K	2.8 H-K	2.0 KL	**2.6 e**
Kamline	106.1 BCD	90.1 GH	61.5 MN	**85.9 cd**	2.4 JKL	2.3 KL	1.6 L	**2.1 e**
Giza 2	117.2 A	89.3 GH	66.6 KLM	**91.0 ab**	3.2 F-K	2.7 H-K	2.2 KL	**2.7 de**
Hassawi 2	111.0 ABC	93.4 FGH	64.9 LMN	**89.8 bc**	4.8 CD	3.3 E-J	2.4 JKL	**3.5 cd**
Giza 843	113.8 AB	98.6 DEF	72.8 I-L	**95.1 a**	3.8 EFG	3.5 E-I	2.5 I-L	**3.3 dc**
ILB 1814	111.7 ABC	79.7 I	67.6 KLM	**86.3 cd**	6.1 AB	4.9 CD	3.0 G-K	**4.7 ab**
Giza Blanka	99.2 DEF	87.4 H	68.2 KLM	**84.9 d**	5.5 ABC	5.0 CD	3.7 E-H	**4.7 ab**
Gazira 1	104.8 CDE	96.8 EFG	74.0 IJK	**91.9 ab**	5.0 CD	4.4 DE	3.4 E-J	**4.3 bc**
Mean	**107.9**	**89.9**	**67.5**		**4.2**	**3.6**	**2.6**	
Genotypes	**No. of pods/plant**				**No. of seeds/plant**			
Gazira 2	20.1 BC	13.8 EF	7.3 JKL	**13.8 ab**	38.3 BC	21.3 FG	15.3 JKL	**25.0 ab**
TW	23.9 A	16.1 DE	5.7 LM	**15.2 a**	39.7 B	31.3 DE	11.0 LMN	**27.3 a**
Kamline	21.7 AB	10.8 GH	5.9 LM	**12.8 bc**	44.3 A	24.0 F	12.2LMN	**26.8 a**
Giza 2	19.1 BC	11.0 GH	6.8 KL	**12.3 bc**	34.6 CD	19.3 F-J	13.2 KLM	**22.3 b**
Hassawi 2	17.7 CD	13.0 FG	9.8 HIJ	**13.5 b**	36.6 BC	22.6 FG	16.0 H-L	**25.1 ab**
Giza 843	17.3 CD	10.4 GHI	7.1 JKL	**11.6 c**	38.0 BC	18.3 G-k	12.9 LM	**23.1 b**
ILB 1814	12.3 FGH	7.5 JKL	3.8 M	**7.9 d**	29.2 E	15.7 I-L	7.8 N	**17.5 c**
Giza Blanka	9.5 H-K	7.2 JKL	4.8 LM	**7.2 de**	20.8FGH	16.0H-L	9.8 MN	**15.6 c**
Gazira 1	7.7 I-L	6.8 JKL	3.2 M	**5.9 e**	20.5 F-I	15.2 JKL	9.2 MN	**14.9 c**
Mean	**16.6**	**10.7**	**6.0**		**33.6**	**20.4**	**11.9**	

T1, T2 and T3 mean water treatments (well-watered, mild and severe drought). Interaction and main effects sharing the same case letter, for a parameter, do not differ significantly at P 0.05.

Table 4. Influence of water deficit on number of seeds/pod, seeds index, seed yield/plant and free proline content in leaves of faba bean genotypes (combined of the two seasons)

Genotypes	No. of seeds/pod			Mean	Seeds index (g)			Mean
	T 1	T 2	T 3		T 1	T 2	T 3	
Gazira 2	1.9 C-F	1.6 F	1.6F	**1.7 c**	47.0 I	45.9 IJ	43.8 IJ	**45.5 e**
TW	1.7 EF	2.0 C-F	2.1 C-F	**1.9 c**	44 IJ	42.2 IJK	41 IJK	**42.2 e**
Kamline	2.1 C-F	2.0 C-F	2.1 C-F	**2.1bc**	46.4 I	48.3I	41.8 IJK	**45.5 e**
Giza 2	1.9 C-F	1.7 DEF	2.0 C-F	**1.9 c**	73.1 FG	68.1 GH	60.7 H	**67.3 d**
Hassawi 2	2.2 CDE	1.7 DEF	1.7 DEF	**1.9 c**	78.6 DEF	74.6 FG	75.7 EFG	**76.3 c**
Giza 843	2.1 C-F	1.8 DEF	1.8 DEF	**1.9 c**	78.0 DEF	84.6 CDE	66.7 GH	**76.4 c**
ILB 1814	2.4 BC	2.3 B-E	2.1 C-F	**2.3 b**	93.0 ABC	85.9 BCD	71.4 FG	**83.4 b**
Giza Blanka	2.2 B-E	2.3 B-E	2.2 CDE	**2.2 b**	102.2 A	94.7 AB	84.8 CDE	**93.9 a**
Gazira 1	3.0 A	2.8 AB	2.4 BCD	**2.9 a**	100.3 A	97.9 A	72.3 FG	**90.2 a**
Mean	**2.2**	**2.0**	**2.0**		**73.6**	**71.4**	**62.0**	
Genotypes	**Seed yield/plant (g)**				**Proline content µg/g fresh weight**			
Gazira 2	18.0 CDE	9.7 IJK	6.6 KLM	**11.4 d**	46.3 MN	105.7 GH	195.1 CD	**115.7 c**
TW	14.4 FGH	9.3 IJK	3.7 M	**9.1 e**	49.7 MN	86.8 HIJ	145.3 F	**90.3 e**
Kamline	18.5 CD	11.5 HIJ	5.7 LM	**11.9 d**	57.1 LMN	62.9 KLM	89.8 HI	**69.9 f**
Giza 2	25.2 B	12.7 GHI	7.7 KL	**15.2 bc**	58.8 LMN	112.7 G	124.2 G	**98.6 de**
Hassawi 2	29.0 A	16.8 DEF	12.1 GHI	**19.3 a**	55.6 LMN	80.8 IJK	212.9 BC	**116.4 c**
Giza 843	27.0 AB	15.1 EFG	8.1 JKL	**16.8 b**	65.7 J-M	82.1 IJK	176.5 DE	**108.1 cd**
ILB 1814	27.1 AB	13.5 FGH	5.6 LM	**15.4 bc**	69.7 I-L	105.5 GH	160.7 EF	**111.9 c**
Giza Blanka	21.2 C	14.8 E-H	8.4 JKL	**14.8 c**	57.3 LMN	113.7 G	228.1 B	**133.0 b**
Gazira 1	20.5 C	14.9 E-H	6.8 KLM	**14.0 c**	65.2 J-M	118.2 G	264.0 A	**149.1 a**
Mean	**22.7**	**13.6**	**7.3**		**57.1**	**96.5**	**177.4**	

T1, T2 and T3 mean water treatments (well-watered, mild and severe drought).Interaction and main effects sharing the same case letter, for a parameter, do not differ significantly at P 0.05.

Table 5 shows the seed yield (t/ha), percentage of reduction in seed yield, stress susceptibility index and drought tolerance efficiency of the nine faba bean genotypes. Two genotypes Hassawi 2 and Giza 843 exhibited maximum seed yield under both well irrigated conditions (5.2 and 4.9t/ha) as well as under stress (2.2 and 1.5t/ha, respectively) while the large seed genotype Giza Blanka was in the same rank with Giza 843 under drought stress conditions. High drought stress condition caused reduction in seed yield (67.9 %) across genotypes as compared to well irrigated treatment. The reduction in seed yield due to drought was ranged from 58.3% in Hassawi 2 to 79.4% in ILB 1814. Ouda *et al.*(2010) estimated that the reduction in faba bean seed yield by 50% if water deficit happen during podding stage. In Jordon Musallam *et al*. (2004) found that the difference between faba bean seed yield grow under irrigation and rainfed conditions more than double. The drought resistance parameters, stress susceptibly index (SSI) and drought tolerance efficiency (DTE) were ranged from 0.6 to 0.8 and from 20.4 to 42.3%, respectively. The cultivars which had the lowest SSI and highest DTE values were considered drought resistant. Three genotypes *i.e.*, Hassawi 2, Giza Blanka and Gazira 2 were recorded the lowest stress susceptibility index (0.6) and the highest drought tolerance efficiency (42.3, 39.5 and 37.5%, respectively). The minimum yield reduction was shown in a line with the highest DTE and the lowest SSI in chickpea genotypes (Parameshwarappa and Salimath 2008) and in spring bread wheat genotype (Bahar and Yildirim 2010). This revealed the superiority of local genotype Hassawi 2 in all conditions followed by Giza 843 and ILB 1814 under well irrigation and followed by Giza 843 and Giza Blanka under drought stress. These results are in agreement with Abdellatif *et al.* (2012) who found that Giza 843 gave medium seed yield mean over all water stresses treatments however it was drought tolerant variety and Ammar *et al.* (2014) they reported that Hassawi 2 and Giza Blanka were highly drought tolerant genotypes.

Table 5: Seed yield (t/ha), water deficit susceptibility index (SSI) and drought tolerance efficiency (DTE) of nine faba bean genotypes.

Genotypes	Seed yield (t/ha)		% reduction in yield	SSI	DTE
	T1	T3			
Gazira 2	3.2	1.2	63.3	0.6	37.5
TW	2.6	0.7	74.3	0.7	26.9
Kamline	3.3	1.0	69.2	0.7	30.3
Mean	**3.0**	**1.0**	**68.9**	**0.7**	**31.6**
Giza 2	4.5	1.4	69.4	0.7	31.1
Hassawi 2	5.2	2.2	58.3	0.6	42.3
Giza 843	4.9	1.5	70.0	0.7	30.6
Mean	**4.9**	**1.7**	**65.9**	**0.7**	**34.7**
ILB 1814	4.9	1.0	79.3	0.8	20.4
Giza Blanka	3.8	1.5	60.4	0.6	39.5
Gazira 1	3.7	1.2	66.8	0.7	32.4
Mean	**4.1**	**1.2**	**68.8**	**0.7**	**30.8**

T1 and T3 mean water treatments (well-watered, mild and severe drought).

Conclusions: Faba bean is considered a highly sensitive crop for drought, where yield reduction is positively related to the amount of water available. However this study underscores the need to give priority to select and develop drought tolerance faba bean genotypes. Since the seed yield reduction was great (79.3 %) in the ICARDA genotype ILB 1814 and low (58.3%) in the local cultivar Hassawi 2 under high water stress treatment. Also the variation between faba bean types was clear under both normal and drought conditions. Among the faba bean types, *equina* was more suitable to grow in Saudi Arabia conditions with less seed yield reduction due to drought. Hassawi 2 produced highest seed yield under all conditions with less reduction in seed yield. Three genotypes *i.e.*, Hassawi 2, Giza Blanka and Gazira 2 were recorded the lowest SSI and the highest DTE these genotypes belonged to the faba bean equina, major and minor types indicated that each type may had drought tolerant mechanism. Proline accumulation in faba bean leaves was found to be increased with progressive in drought. The high values of proline content were recorded under the highest drought treatment regardless to seed yield.

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