

## Sensitivity of Faba Bean Cultivars to Low Glyphosate Doses and the Efficiency of IAA as Indicator to Glyphosate Effects

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POT experiment was conducted during two successive seasons to evaluate the sensitivity of several field faba bean (*Vicia faba*, L.) cultivars, i.e. Giza 716, Giza 674, Giza 461, Misr 1, Noubaria 1 and Sakha 2 to glyphosate at 0,2,4 and 8mM. Most of tested cultivars were relatively tolerant to low glyphosate dose (2mM). This dose caused about 8% increases in the mean average of number and weight of kernels, relative to control. Faba bean cultivars appeared high sensitivity to 4 or 8mM of glyphosate. These doses resulted about 25 and 54% decreases in survival percentage corresponded by about 40 and 65% reduction in all vegetative characters, respectively, after 30 days from treatment. Sakha 2 was considered the most susceptible cultivar, particularly at high glyphosate doses. Treated plants tended to contain less indoles, phenols, free amino acids and protein than untreated ones. Determination of free IAA by HPLC appeared a remarkable variations among the studied cultivars. A great decrease in free IAA was observed after 3 or 6 days from glyphosate treatments. Such decrease was closely related to glyphosate levels for all studied cultivars being 11.7, 27.1 and 47.1% after 3 days from application 2, 4 or 8mM of glyphosate, respectively. Among the studied metabolites related to glyphosate effects, it can be indicated that endogenous free IAA was demonstrated as indicator to glyphosate effects, even after few days from a non injury dose treatments.

Glyphosate (N-[phosphono-methyl] glycine) is a broad-spectrum herbicide, capable of controlling annual and perennial plants (Franz *et al.*, 1997). Glyphosate has favourable environmental feature including rapid soil inactivation and degradation to harmless products and low toxicity to non-plant life (Hetherington *et al.*, 1999). Despite the general nonselectivity of glyphosate, a small margin of selectivity at low rates has been reported in certain crops, some of which are *Orobanche* hosts (Parker & Riches, 1993). Spraying faba bean plants with a low rate of glyphosate (27 g a.i./fed, twice) have been reported as an effective control of broomrape (*Orobanche spp.*) which is considered the main parasitic effecting faba bean in Egypt (Fayed *et al.*, 2002). After application to host foliage, glyphosate has been shown to translocate through the host phloem to broomrape attachments on the host roots (Jain & Foy, 1997). Low glyphosate concentrations exhibited varying degrees of phytotoxic symptoms and reduced faba bean growth (Shaban *et al.*, 1985). Petzold (1974) reported that faba bean toxicity after glyphosate was applied at 200-400 g/ha.

A major limitation for glyphosate usage has been its non selectivity. Tolerance of plant species to glyphosate has been studied by several workers. Yenne *et al.* (1988) mentioned that the cultivar Alaska was considered one of the most susceptible pea cultivars to glyphosate, whereas "Melrosa" was one of the most tolerant cultivars. Also, Degennaro & Weller (1984) cited that glyphosate (1.68 kg/ha) caused significant differences between susceptibility of 5 biotypes of *Convolvulus arvensis*.

The mode of action of glyphosate is by inhibition of 5-enolpyruvyl shikimate-3-phosphate synthase (EPSP synthase) a key enzyme of the shikimate pathway (Amrhein *et al.*, 1980). It causes a reduction in the synthesis of aromatic amino acids (phenylalanine, tyrosine, and tryptophan) and cinnamic acids accompanied by accumulation of high levels of shikimate and hydroxy benzoic acids in leaves and flowers (Lydon & Duke, 1988). The deregulation of the shikimic pathway by glyphosate led to an uncontrolled flow of carbon into the pathway, producing some disruptions in other essential metabolic pathways (Devine *et al.*, 1993). Many reports suggested that auxin (Indole acetic acid, IAA) levels were directly related to glyphosate mode of action, because the decrease of IAA levels in tobacco callus as well as in soybean and pea seedlings was associated with toxic and inhibitory effect of glyphosate (Lee, 1982 and 1984). Moreover, IAA reduced glyphosate inhibition of growth in soybean (Lee, 1980). On the contrary, Rajasekaran *et al.* (1987) mentioned that glyphosate treated plants contained 1.7 times more IAA in the basal portion of young *Pennisetum purpureum* Schum leaves than control.

Spraying faba bean plants with low glyphosate was introduced for controlling *Orobanche* in Egypt. The efficiency of this herbicide in this case is depending on the usage dose (Canal *et al.*, 1987). Sensitivity of faba bean is considered the major limitation factor for application a relatively high glyphosate dose. Hence, selection of faba bean cultivars with less glyphosate sensitivity can offer growers a safe and effective method to control *Orobanche* infestation. The objectives of this study were to evaluate the tolerance of six field faba bean cultivars to low glyphosate doses as well as to examine the relative efficiency of IAA as indicator of glyphosate effects.

### Material and Methods

Pot experiment was performed under green house conditions at National Research Centre, Cairo, Egypt during winter season of 2001/2002 and 2002/2003 seasons. Seeds of faba bean were obtained from the Agricultural Research Centre, Giza. Factorial experiment in randomized complete block design with 8 replicates conducted that included 24 treatments combination of six faba bean cultivars and four glyphosate levels. The tested faba bean cultivars were Giza, 716, Giza 674, Giza 461, Misr 1, Noubaria 1 and Sakha 2. Seeds of each cultivar

were sown in the pots (30 cm diameter and filled with clay loamy soil) at 11 November for the 1<sup>st</sup> season and at 1 November for the second one.

Seedlings were thinned to three plants per pot. Irrigation and other practices were done according to usual procedure. After 15 days from complete flowering (at 20, January in the 1<sup>st</sup> season and at 15 January in the 2<sup>nd</sup> one) plants were subjected to glyphosate treatments. Glyphosate as Round up (Mon 2139, 360g glyphosate (a.i.)/l as isopropylamine salt, Monsanto Co. was sprayed at 0 (control), 2mM (0.338 g a.i./l), 4mM (0.676 g a.i./l) and 8mM (1.352 g a.i./l). After 3 and 6 days, samples were taken to determine free IAA. Five plants were taken from each treatment after 15 days from glyphosate application and number of branches, number of leaves, fresh and dry weight of leaves, fresh and dry weight of whole plant were recorded. After 30 days from treatment, survival percentage was calculated and another sample was taken to determine the growth characters in addition to number of kernel and weight to of kernels.

#### *Biochemical analysis*

Some metabolic constituents related to glyphosate effects, *i.e.* free IAA, indoles, phenols, free amino acids and protein were determined in the plant samples. Endogenous levels of free IAA were extracted from the second leaf as described by Ding *et al.* (1999). Fresh sample (1g) was ground in a mortar with 4 ml/g of sample in 65% isopropanol with phosphate buffer pH 7.0. The solution was centrifuged at 10,000 xg for 15 min. The isopropanol was then evaporated under vacuo, and the aqueous layer was diluted with water and adjusted pH to 2.5 then passed through Strata C18-E. Sep-pak. Free IAA was eluted with 2ml acetonitrile. Extract was evaporated in vacuo and the residue resuspended in 0.5ml of 50% MeOH for HPLC analysis. Shimadzu HPLC with 250x4.6mm ODS column was used for IAA determination using solvent system: 30% MeOH/H<sub>2</sub>O containing 1% acetic acid, flow rate 1ml/min, detection at 282 nm.

Total indoles and total phenols in the ethanol extract were determined according to Larson *et al.* (1962) and Danial & George (1972), respectively.

Protein in the samples were precipitated with 10% trichloroacetic acid and free amino acids in the supernatant were determined by the method of Plummer (1978). Precipitated protein resuspended in 0.1N sodium hydroxide containing 0.2M sodium carbonate, and was determined by the method of Lowry *et al.* (1951).

#### *Statistical analysis*

All data were subjected to statistical analysis of variance according to Snedecor and Cochran (1981) using L.S.D. at 5% level of significance.

## Results

### *Effect of glyphosate on growth characters and chemical constituents*

#### *After 15 days from treatment*

##### *Growth characters*

Comparing the effect of glyphosate on the vegetative growth characters for six faba bean cultivars was illustrated in Fig. 1. Except the slight affect of number of branches, glyphosate tended to reduce all plant growth characters. Increasing glyphosate concentration to 4 or 8 mM resulted in a great reduction in number, fresh and dry weight of leaves as well as fresh and dry weight of whole plant.

Response of faba bean cultivars to low glyphosate level was varied. Giza 674, Giza 461, Misr 1 and Noubaria 1 showed a reduction effect on their growth characters, *i.e.* fresh and dry weight of both leaves and whole plant by such low dose, contrarily to the enhancement effect which exhibited cvs Giza 716 and Sakha 2. Meanwhile, plant growth characters of all evaluated cultivars were decreased as affected by high glyphosate doses (4 and 8 mM). Maximum reduction was achieved by Giza 716 when treated with high glyphosate dose (8 mM), since number and fresh weight of leaves and plant fresh weight were reduced by 71, 91 and 56%, as compare with control, respectively. The relatively sever effect of high glyphosate dose was exhibited cvs Sakha 2, Noubaria 1 and Giza 674, while, the less glyphosate effect was recorded for Misr 1 (Fig. 1).

##### *Chemical constituents*

Some metabolites related to glyphosate effects were analysed in the leaves, data illustrated in Fig. 2. With few exceptions, plants treated with glyphosate had lower indole contents than those of control.

Maximum decreases were produced by plants treated with 4mM of glyphosate, in most cases. As shown in Fig. 2, various cultivars varied in their response to glyphosate treatments. The lowest indole values were obtained from Misr 1 and Sakha 2 when treated with high glyphosate doses (4 and 8 mM). Whereas, spraying of Noubaria 1 plants with 2 or 8 mM produced more indoles in their leaves than those of control.

Total phenol contents did not appear a fixed trend in the response to glyphosate treatment for all studied cultivars. As shown in Fig. 2 phenols in the leaves of Giza 674, Noubaria 1 and Sakha 2 were responded positively to low and high glyphosate concentrations and negatively to the medium one. On the other side, a remarkable decreases in phenolics were exhibited cvs. Giza 461 and Misr 1 at all glyphosate doses, as compared with control.

Protein and free amino acids appeared a great variations as affected by glyphosate treatments. In most cases, plants treated with glyphosate tended to contain less protein and free amino acids than control. Moreover, medium

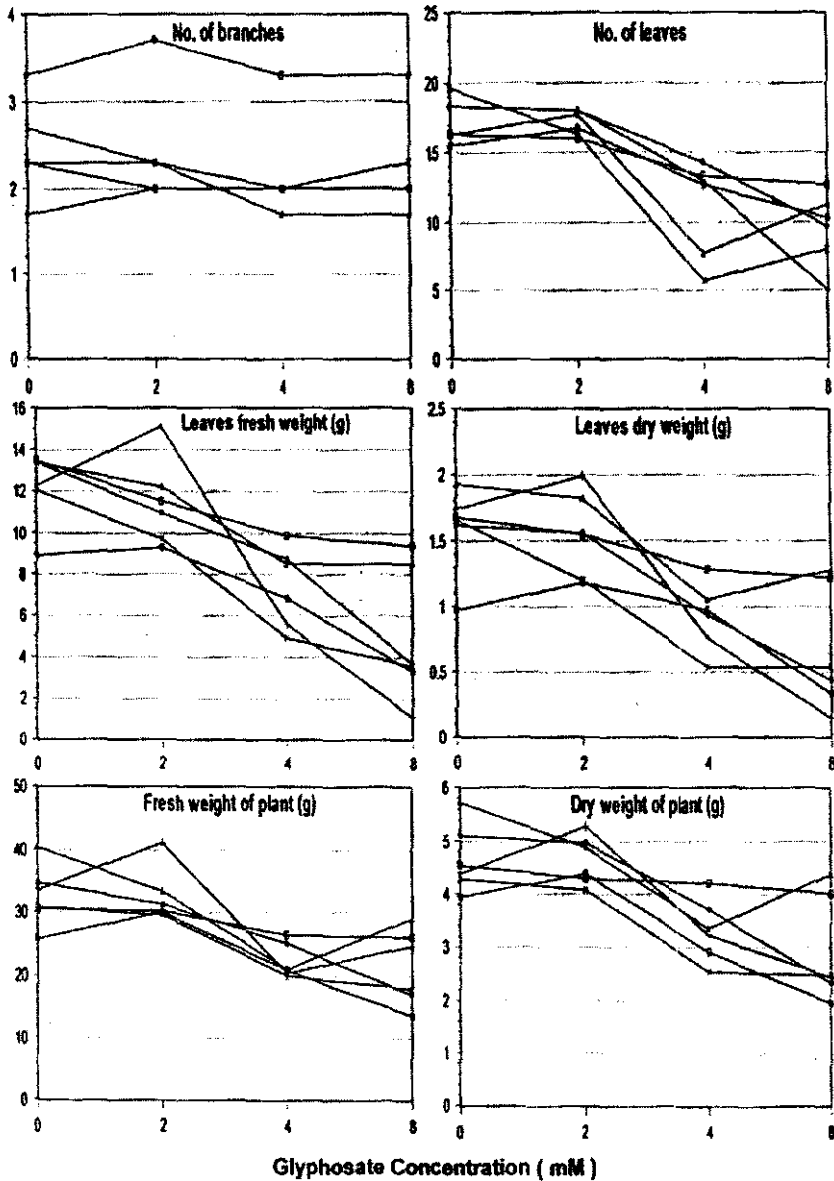


Fig. 1. Effect of glyphosate on growth characters of six faba bean cultivars after 15 days from treatments. (Average two seasons).

→ Giza 716 → Giza 674 → Giza 461 → Miser 1 → Noubaria 1 → Sakha 2

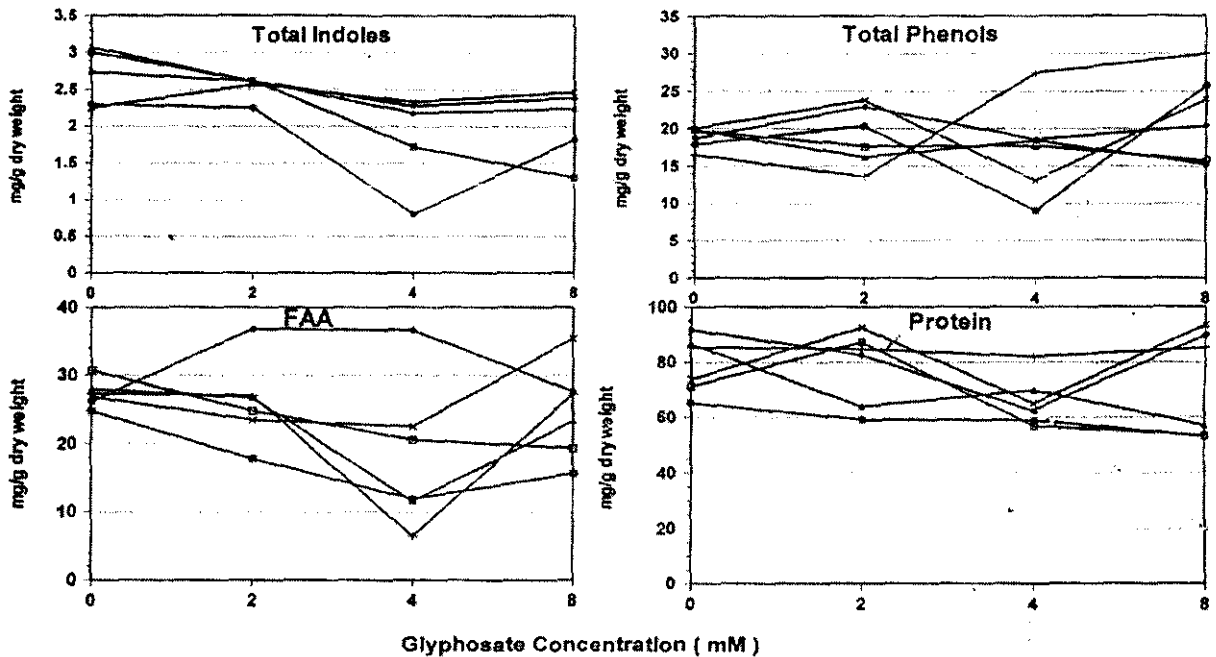


Fig. 2. Effect of glyphosate on chemical composition of six faba bean cultivars after 15 days from treatments. (Average two seasons).

+ Giza 716   → Giza 674   → Giza 461   ◊ Miser 1   + Noubaria 1   ◊ Sakha 2

glyphosate level was considered the most effective treatment on these constituents (Fig. 2). The great decrease in protein as affected by such medium dose was recorded for Giza 674 (32%) and Misr 1 (20%) for protein corresponded with Giza 716 (76%) and Giza 461 (40%) for free amino acids. But a great increase in free amino acid contents was noticed in the leaves of Giza 674 as affected by low and medium glyphosate concentrations.

#### *After 30 days from treatment*

##### *a- Growth characters*

Survival and growth characters were determined and calculated as percentage of control (Table 1). Results revealed that survival percentage was affected significantly by glyphosate treatments. The average percentages were reduced by 7.5, 25.0 and 54.2% relative to control, as affected by 2, 4 and 8 mM of glyphosate, respectively. As shown in Table 1 survival was differed among cultivars, the highest percentages were produced by Giza 674, Noubaria 1 and Giza 461, while the lowest one was exhibited Sakha 2 cultivar. In concern to interaction between glyphosate doses and cultivars, it can be noticed that the survival percentage of cvs Giza 716 and Giza 674 was not affected by low glyphosate dose, but application high dose (8mM) produced 33.3 and 62.5% survival, as compared with control, respectively.

The effect of glyphosate on growth characters of six faba bean cultivars expressed as percentage of control was presented in Table 1. Data indicated the significant effect of glyphosate on various growth characters. It can be noticed that most of these characters nearly had similar trend in the response to glyphosate treatments. Low rate reduced the mean average of number of leaves, fresh and dry weight of leaves and whole plants between 4.9 and 11.7% relative to control. A gradual significant decreases in growth characters were recorded by increasing glyphosate dose attained the maximum by high dose (More than 60% reduction in mean average).

Faba bean cultivars showed significant differences in their growth characters as affected by glyphosate treatment (Table 1). Comparing the mean percentage for number of leaves, fresh and dry weight of either leaves or whole plant indicated that cvs Giza 674 and Giza 461 exhibited the lowest glyphosate effect, as compared with the other cultivars. On the contrary to Sakha 2 which attained the maximum reduction affect, hence the mean percentage of different growth characters for treated plants accounted between 14.5% and 25.5% of those of control.

Concerning the interaction between glyphosate doses and cultivars, data in Table 1 revealed that treated G674 and Noubaria plants with 2mM of glyphosate resulted in more 10% increases in vegetative growth characters. Meanwhile, Sakha 2 plants treated with 8mM of glyphosate produced more than 95% decreases on number of leaves or fresh and dry weight of leaves, relative to control.

**TABLE 1. Effect of glyphosate on survival and growth characters of six faba bean cultivars after 30 days from treatment (Average two seasons).**

% of control

Characters	Survival				No. of leaves				Leaves fresh weight				Leaves dry weight				
	Glyphosate conc.	2mM	4mM	8mM	Mean	2mM	4mM	8mM	Mean	2mM	4mM	8mM	Mean	2mM	4mM	8mM	Mean
Giza 716		100.0	70.0	33.3	67.8	82.9	52.0	25.1	53.3	81.7	61.3	14.5	52.5	86.0	67.7	15.0	56.3
Giza 674		100.0	84.6	62.5	82.4	111.9	63.2	55.3	76.8	127.8	74.7	26.8	76.3	114.2	70.5	22.8	69.2
Giza 461		92.3	75.0	66.7	78.0	84.9	78.5	67.3	76.9	84.7	78.5	67.1	76.8	77.3	68.7	68.9	71.6
Misir 1		88.9	71.4	62.5	74.3	107.0	47.1	17.9	57.3	114.4	39.0	10.3	54.6	101.6	43.3	11.2	52.0
Noubaria 1		91.7	90.0	60.0	80.6	111.1	58.4	26.7	65.4	123.7	56.5	21.8	67.3	113.2	60.9	22.9	65.7
Sakha 2		81.8	58.9	50.0	63.6	66.5	5.0	3.8	25.1	35.7	12.6	4.3	17.5	37.6	1.4	4.4	14.5
Mean		92.5	75.0	45.8		94.1	50.7	32.7		94.7	53.7	24.1		88.3	52.1	24.2	
L.S.D5 % Cultivars		2.25				1.85				4.86				2.31			
Glyphosate		2.1				4.38				7.69				2.17			
Gly.xCult.		5.6				4.53				11.92				5.65			



TABLE 1. Cont.

Characters	No. of kernels				Weight of kernels				Fresh weight of whole plant				Dry weight of whole plant			
	2mM	4mM	8mM	Mean	2mM	4mM	8mM	Mean	2mM	4mM	8mM	Mean	2mM	4mM	8mM	Mean
Glyphosate conc. Cultivars																
Giza 716	114.3	76.7	0.0	63.7	119.2	21.8	0.0	47.0	97.4	60.8	33.8	64.0	96.8	68.5	34.2	66.5
Giza 674	100.0	62.2	27.0	63.1	106.8	14.6	8.5	43.3	119.7	72.5	38.5	76.9	118.8	78.4	34.7	77.3
Giza 461	108.1	54.0	0.0	54.0	108.7	8.1	0.0	38.9	87.7	80.6	68.7	79.0	80.4	79.3	69.4	76.4
Misc 1	114.0	54.0	14.0	60.7	101.3	10.9	12.4	41.5	95.8	34.0	29.6	53.1	95.9	36.1	32.4	54.8
Noubaria 1	110.0	10.0	0.0	40.0	118.0	10.0	0.0	42.7	117.8	52.8	24.3	65.0	113.3	52.7	25.7	63.9
Sakha 2	100.0	0.0	0.0	33.3	96.0	0.0	0.0	32.0	52.4	17.5	10.3	26.7	48.9	16.1	11.6	25.5
Mean	107.7	42.9	6.8		108.3	10.2	3.84		95.1	53.0	34.2		92.4	55.2	34.7	
L.S.D5 % Cultivars	1.9				2.2				2.4				1.9			
Glyphosate	2.0				2.5				1.5				1.4			
Gly.xCult.	4.6				5.5				5.9				4.6			

As for number and weight of kernels after 30 days from treatments, data in Table 1 indicated the great influence of glyphosate on these two characters. Low dose (2mM) increased mean percentages of number and weight of kernels to reach about 108% of control. Whereas increasing glyphosate dose produced a dramatic decrease in such two characters attained the maximum by high dose (average 93.2% and 69.5% decreases, relative to control, respectively).

Significant variations in number and weight of kernels were observed among faba bean cultivars due to glyphosate treatments. Mean relative percentage of two characters reached to the lowest value for Sakha 2 as compare with the other cultivars. Moreover, plants of such cultivar did not produce any kernels when sprayed either with 4 or 8 mM of glyphosate.

#### *Chemical constituents*

Total indoles, phenols, free amino acids and protein in the leaves of tested faba bean cultivars were analyzed, data presented in Tables 2 and 3. In concern to indoles and phenols, the mean concentrations of these constituents were found to be significantly less in the glyphosate treated plants than in the control ones. It can be observed that the degree of decreases was associated with the glyphosate increases, hence the highest reduction effect (average 43% for indoles and 26% for phenols) was recorded for plants received high glyphosate dose.

As shown in Table 2, concentrations of indoles and phenols were varied significantly between the investigated cultivars. Average mean as percentage of control for each cultivar, revealed that the less reduction affected by glyphosate treatments was recorded by cvs Giza 674 and Giza 461 for indoles and by Giza 716 and Giza 461 for phenols. While the relatively high effect exhibited Misr 1 and Noubaria 1 for either indole or phenol contents, when compared with other cultivars.

As for protein and free amino acids, it can be observed a gradual decreases in their mean values by increasing glyphosate level from 2 to 4 to 8 mM, being 6.4%, 20.1% and 22.5% for protein corresponded by 0.4%, 22.7% and 27.9% for free amino acid as compared with control, respectively. Levels of these essential constituents appeared significant variations between the studied cultivars, as affected by glyphosate treatments. Depending on the mean average as percentage of control, protein in leaves of Giza 461 and Giza 674 had the lowest effect by glyphosate (96.3 and 93% of control, respectively), but the highest effect was recorded by Sakha 2 (77% of control). Except the enhancement effect on free amino acid contents for cv Giza 716, all evaluated cultivars responded negatively to glyphosate treatments. It can be observed that Noubaria 1 achieved the highest decrease effect (average 25% of control). On the other side, treated Giza 716, Giza 674 and Giza 461 plants with low glyphosate dose increased free amino acid contents, as compared with control.

TABLE 2. Effect of glyphosate on protein and free amino acids (g/100g dry matter) of six faba bean cultivars after 30 days from treatments (first season).

Characters	Protein						Free amino acids					
	0mM (Control)	2mM	4mM	8mM	Mean	Mean % of control	0mM (Control)	2mM	4mM	8mM	Mean	Mean % of control
Giza 716	10.00	8.95	8.30	9.05	9.10	91	1.68	2.17	1.75	1.62	1.81	108
Giza 674	9.60	9.90	6.95	9.15	8.90	93	1.89	2.25	1.23	1.42	1.70	90
Giza 461	9.50	9.50	9.25	8.40	9.15	96	2.67	2.97	1.83	2.41	2.47	93
Misr1	10.35	9.10	8.10	7.75	8.85	86	1.90	1.50	1.51	1.17	1.52	80
Noubaria 1	10.90	10.05	9.85	6.75	9.40	86	3.67	2.90	2.69	1.79	2.76	75
Sakha 2	10.85	9.90	6.45	6.25	8.35	77	2.15	2.10	1.78	1.68	1.93	90
Mean	10.20	9.55	8.15	7.90			2.33	2.32	1.80	1.68		
L.S.D5 % Cultivars	0.4						0.09					
Glyphosate	0.5						0.27					
Gly.xCult.	1.0						0.21					

**TABLE 3. Effect of glyphosate on total indoles and total phenols of six faba bean cultivars after 30 days from treatments (first season).**

Characters	Total indoles (mg/g dry matter)						Total phenols (mg/g dry matter)						
	Glyphosate conc. Cultivars	0mM (Control)	2mM	4mM	8mM	Mean	Mean % of control	0mM (Control)	2mM	4mM	8mM	Mean	Mean % of control
Giza 716		2.90	2.09	2.16	1.29	2.11	73	15.4	16.0	11.9	15.5	14.7	95
Giza 674		3.04	2.64	2.10	2.21	2.50	82	18.5	15.5	11.0	14.2	14.8	80
Giza 461		2.63	2.30	1.89	1.64	2.12	81	19.4	18.5	16.1	15.4	17.4	90
Misr 1		3.13	2.44	1.56	1.66	2.20	70	21.4	16.0	13.4	15.4	16.6	78
Noubaria 1		2.87	2.26	1.63	1.49	2.06	72	35.5	24.4	26.3	22.0	27.1	76
Sakha 2		3.30	2.19	2.00	1.89	2.35	71	25.6	21.2	19.5	17.8	21.0	76
Mean		2.98	2.32	1.89	1.70			22.8	18.6	16.4	16.7		
L.S.D5 % Cultivars	0.12						0.7						
Glyphosate	0.12						0.6						
Gly.xCult.	0.31						1.4						

### *Effect of glyphosate on free indole acetic acid*

Endogenous levels of free indole acetic acid (IAA) in the leaves of six field faba bean cultivars were determined at flowering stage using HPLC. Data in Table 3 showed that the levels of IAA differed greatly among the studied cultivars. The highest concentrations (14400 ng/g fresh weight) exhibited Noubaria 1 cultivar, followed by Giza 674 (13600 ng/g). The lowest IAA level (8720 ng/g) was recorded by Giza 461.

To study the effect of glyphosate on IAA, leaves subjected to analysis by using HPLC and IAA content in glyphosate treated plants was calculated as percentage of control as shown in Table 4. It can be noticed a great decrease in IAA contents due to glyphosate application either after 3 or 6 days from treatments. A gradual decrease in IAA as the glyphosate level increase, since decreases in mean average accounted 11.7% and 20.5% after 3 and 6 days as affected by low dose (2mM) corresponded with 47.1% and 45% for high dose (8mM), respectively.

Variations in the IAA reduction between tested cultivars as affected by glyphosate treatments were observed. The less glyphosate effect was recorded by Giza 716 either after 3 or 6 days, since the mean percentage reached to 87.2 and 85% of control, respectively. Whereas, the highest reduction effect was obtained by Giza 674 (43.4% of control) after 3 days and by Misr 1 (42.9% of control) after 6 days as compared with the other cultivars.

### **Discussion**

The obtained results indicated that, except Sakha 2, all tested cultivars were relatively tolerant to low glyphosate dose (2mM). Since the noticeable reduction effect on growth characters exhibited cvs Giza 674, Misr 1 and Noubaria 1 after 15 days were recovered after 30 days from treatment. Moreover, this treatment caused about 8% increases in average number and weight of kernels, as compared with control. The low injury of faba bean plants as affected by low glyphosate dose was reported before by Zahran *et al.* (1980).

A sharp drop in survival and in all vegetative growth characters except number of branches was obtained by increasing glyphosate concentration to 4 or 8 mM (Fig. 1 and Table 2). Since survival percentage achieved about 25 and 54% decrease due to application glyphosate at 4 and 8 mM accompanied by more than 40 and 65% decreases in all vegetative growth characters, respectively. Meanwhile number of branches did not appear a clear effect by all treatments. In agree with these results, Shaban *et al.* (1985) mentioned that glyphosate 130 and 195 g/fed exhibited varying degrees of phytotoxic symptoms and reduced all the faba bean plant characters-except number of branches/plant. The results indicated the high sensitivity of all cultivars to two high glyphosate doses. Sakha, 2, was considered the most susceptible cultivar. Since plants of this cultivar failed to produce any kernels when treated with 4 or 8mM of glyphosate. In this concern, many investigators observed the diversity of

TABLE 4 . Concentration of free indole acetic acid (IAA) in the leaves of six faba bean cultivars at flowering stage and its effect by glyphosate after 3 and 6 days from treatment (first season).

cultivars	G716	G674	G461	Misr 1	Nubaria1	Sakha 2
Free IAA(ng/g fresh matter) (control)	12000	13600	8720	10220	14400	10030

## Free IAA% of control

Time	After 3 days				After 6 days			
	2mM	4mM	8mM	Mean	2mM	4mM	8mM	Mean
Glyphosate conc.								
Cultivars								
Giza 716	90.8	121.7	49.2	87.2	102.1	85.6	68.1	85.3
Giza 674	61.0	56.0	52.8	56.6	77.8	69.2	48.2	65.1
Giza 461	86.2	61.0	46.9	64.7	69.0	74.6	52.3	65.1
Misr 1	123.7	50.8	55.5	76.7	62.9	55.9	52.8	57.2
Noubaria 1	89.4	73.8	61.2	74.8	86.0	77.6	67.7	77.1
Sakha 2	78.4	74.3	51.8	68.2	79.1	69.9	40.3	63.1
Mean	88.3	72.9	52.9		79.5	72.1	54.9	

sensitivity among species, cultivars and biotypes (Degennaro & Weller, 1984 and Yenne *et al.*, 1988). Such diversity was suggested to be related to changes in glyphosate absorption (Green *et al.*, 1992) or to the specific activity of EPSP synthase enzyme (target site of glyphosate effect) (Dyer *et al.*, 1988) or to genetic inheritance (Frascaroli *et al.*, 1992). Pinto *et al.* (1988) mentioned that glyphosate inhibits plant growth by reducing the production of 5-enol-pyruvyl shikimate-3 phosphate synthase enzyme an intermediate in the biosynthesis of the three aromatic amino acids (protein units) and cinnamate derived phenolics. Supporting to this explanation, data in Table 2 illustrated the reduction effect in total indoles, total phenols, free amino acids and protein contents due to glyphosate treatments.

Glyphosate treatments tended to decrease free IAA after 3 and 6 days as well as, total indole contents after 15 and 30 days from treatments. Such decreases were closely related with glyphosate concentration for all studied cultivars. Since glyphosate at 2 or 4 or 8 mM reduced mean average of endogenous IAA levels by 11.7, 27.1 and 47.1% after 3 days, corresponded with 20.5, 27.9 and 45.1% after 6 days from treatment, respectively. Similar findings were observed by many investigators (Westwood & Biesboer, 1986 and Kudoyarova *et al.*, 1992). Reduction in IAA may be attributed to increase in oxidation process due promotion IAA-oxidase by glyphosate (Lee, 1982) or to conjugation IAA with other moiety as reported by Lee & Dumas (1985).

The sensitivity of free IAA to glyphosate varied among the cultivars tested (Table 3). Giza 716 exhibited the lowest IAA affect by glyphosate eafter 3 and 6 days, while the maximum affect was recorded by Giza 674 after 3 days and by Misr 1 after 6 days from treatments. In this respect, Lee & Dumas (1985) found that glyphosate promoted IAA metabolism more in buckwheat, Alska pea and mungbean than American germander, Little Marvel pea or soybean under the same condition.

Soon after glyphosate treatments, effects on free IAA are much dramatic even at low glyphosate level (Table 3). Moreover, total indole effects were much more great than affects on other metabolites related to glyphosate effects (protein, free amino acids and phenolics). These findings supported the hypothesis that the occurrence of free IAA in bean leaves can be associated with toxic and inhibitory effect of glyphosate as suggested by Lee & Dumas (1985). Such effects on the size of free IAA of faba bean plants was an indicator of the degree of regulation to which this pool was subjected and they demonstrated the relative efficiency of free IAA as indicator of glyphosate effects at various time even after a injury dose of herbicide.

It can be concluded that, most of faba bean cultivars were tolerant to 2mM of glyphosate. A high sensitivity was exhibited all tested cultivars by increasing glyphosate level to 4 or 8 mM. However, Sakha 2 was the most susceptible cultivar, particularly at high glyphosate doses. Treated plants tended to attain less

free IAA, total indole, total phenols, free amino acids and protein than untreated ones. Endogenous free IAA level was demonstrated as indicator to glyphosate effects even after few days from a non injury dose of herbicide treatments.

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## حساسية أصناف الفول البلدى للجرعات المنخفضة من الجليفوسيت وكفاءة استخدام اندول حمض الخليك كدلالة لتأثيرات الجليفوسيت

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قسم النبات - المركز القومى للبحوث - القاهرة - مصر .

أجريت تجربة أصص خلال موسمين متتاليين لدراسة حساسية أصناف الفول البلدى جيزة ٧١٦ وجيزة ٦٧٤ وجيزة ٤٦١ ومصر ١ ونوبارية ١ وسخا ٢ للجليفوسيت المستخدم بجرعات صفر، ٢، ٤، ٨ ملليمولر. أظهرت معظم الأصناف تحملا للجرعة المنخفضة من الجليفوسيت. كما أحدثت تلك الجرعة زيادة فى متوسط عدد ووزن الحبوب بنسبة ٨%. بينت النتائج الحساسية العالية لأصناف الفول المختلفة لتركيزات ٤ و ٨ ملليمولر. وأحدثت تلك التركيزات نقصا فى نسبة البقاء بلغ ٢٥% و ٥٤% مقابل نقص ٤٠% و ٦٥% على التوالى فى قراءات النمو المختلفة بعد شهر من المعاملة. يعتبر صنف سخا ٢ أكثر أصناف الفول البلدى حساسية وخاصة عند استخدام التركيزات العالية من الجليفوسيت. احتوت أوراق النباتات المعاملة على نسبة أقل من كل من الاندولات - الفينولات - الأحماض الأمينية الحرة والبروتين مقارنة بالنباتات غير المعاملة. تم تقدير هرمون اندول حمض الخليك فى أوراق الأصناف المختلفة أثناء الأزهار باستخدام جهاز HPLC ، وأظهرت النتائج اختلافات كبيرة فى محتوى الأصناف من ذلك الهرمون. لوحظ نقص كبير فى إندول حمض الخليك بعد ٣-٦ يوم من المعاملة بالجليفوسيت. ارتبط الانخفاض فى إندول حمض الخليك بزيادة تركيز الجليفوسيت حيث وصلت نسبة الانخفاض إلى ١١,٧% و ٢٧,١% و ٤٧,١% بعد ثلاثة أيام من المعاملة بتركيزات ٢ و ٤ و ٨ ملليمولر. أثبتت النتائج إمكانية استخدام محتوى الأوراق من إندول حمض الخليك كدلالة لتأثير الجليفوسيت حتى بالنسبة للجرعات المنخفضة غير المؤثرة على نمو نبات الفول.