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The Effects of Foliar Spraying of Folic Acid and Cysteine on Growth, Chemical Composition of Leaves and Green Yield of Faba Bean (*Vicia faba* L.)

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Abstract: An experiment was conducted during winter growing season of 2018 /2019 at *Al-Qurnah* sub-district, Basrah Governorate to study the effect of foliar spraying of folic acid and amino acid cysteine at different concentrations on growth, Minerals, chlorophyll contents and green yield faba bean (*Vicia faba* cv. Luz de otono). The study included sixteen treatments Consist of four concentration of folic acid (o,10,20 and 30) mg.L^{-1} in combination with four concentrations of Cysteine (0,10,20 and 30) mg.L^{-1}. The results indicated that spraying with folic acid or cysteine significantly increased all vegetative growth characteristics (shoot height, branch number, leaflet number and fresh and dry weight of shoot system per plant), N, P, K, chlorophyll content of leaves and green pod yield/plant and fresh seed yields /plant. Spraying with folic acid at 30 mg.L^{-1} and cysteine at 30 mg.L^{-1} gave the greatest values of growth parameters, chlorophyll and yield, whereas 20 mg.L^{-1} folic acid with 30 mg.L^{-1} Cysteine was produced the highest values of N, P and K in faba bean leaves as compared with other combination treatments. Control treatment gave the lowest values for growth parameters, chlorophyll, N, P, K and yield.

Keywords : Faba bean, folic acid, Cysteine , Growth, yield.

Introduction

Faba bean (*Vicia faba* L.) is the fourth most important pulse crop in the world after dry bean, dry peas, and chickpeas. It is considered as the major crop in many countries. This importance is due to its rich protein content of 24-33% and good source energy (Winch, 2006). In addition, it contributes to soil fertility through biological nitrogen fixation (Igwilo,1982).

Due to the importance of this crop, the need to increase its productivity was one of the main (spur) motives for the use of bio-stimulants such as vitamins and amino acids, including folic acid and amino acid cysteine. Folic acid (vitamin B9) is a central cofactor for one-carbon transfer reactions which are involved in many cellular reactions such as synthesis of purines, metabolism of amino acids, a glycine to serine conversion, synthesis of methionine and the formation of lignin, chlorophyll and choline and also in the photorespiration cycle (Hanson & Roje, 2001; Jabrin *et al.*, 2003). Folic acid has become the most prominent of B complex vitamins despite its essential biochemical function in

amino acid metabolism and nucleic acid synthesis (Andrew *et al*., 2000). Folic acid natural antioxidant (Asensi-Fabado & Munné-Bosch, 2010) and folic acid treatment increases growth and productivity (Stakhova *et al.*, 2000). Farouk *et al*. (2018) recommended that foliar application of 20 $mg.L^{-1}$ folic acid can be used to induce the plant growth, yield and seed quality of pea (*Pisum sativum* L.) plants. Heo *et al*. (2019) showed that *treated Antirrhinum majus* plants with folic acid at 25 $mg.L^{-1}$ promoted growth early and also promoted early flowering.

Cysteine is an α-amino acid occupies a central position in plant metabolism because it is a reduced sulfur donor molecule involved in the synthesis of essential biomolecules such as vitamins and co-factors, defense compounds such as glucosinolates and thionins and antioxidants, such as glutathione which plays an important role in plant stress responses (Alvarez *et al.,* 2012) the thiol side chain in cysteine often participates in enzymatic reactions (Romero *et al*., 2014). El-Awadi & Abd El Wahed (2012) showed that foliar spraying of the cystiene at 25 $mg.L^{-1}$ significantly promoted the growth, quality and Leaf photosynthetic pigment contents of green onion (*Alluim cepa* L.).

The objective of this study was to evaluate the effect of folic acid and amino acid cysteine as foliar applications on the growth, chemical composition and yield of faba bean.

Material & Methods

The field experiments were carried out during the Winter seasons of 2018/2019 at Al-Qurnah sub-district / Basrah Governorate to investigate the effect of different levels of folic acid and cysteine and the interaction between them on growth, chemical constituents of leaves and yield of faba bean plants. Physical and chemical proprieties of the soil used in the experiment and water irrigation are presented in table (1). Diammonium phosphate DAP (NP (46: 18) was added before sowing at 140 kg. Ha^{-1}. Faba bean seeds cv. Luz de otono (secured from FITO *seed* Co., Spanish) were sown at

Table (1): The Soil physic-chemical proprieties and irrigation water in the field.

Soil characteristics	
Character	Value
E.C. ($dS.m^{-1)}$	6.16
pH	7.55
Total nitrogen ($mg.kg^{-1}$)	56
Phosphorus ($mg.kg^{-1}$).	20.14
Potassium ($mg.kg^{-1}$)	18.00
Organic matter (%)	1.8
Soil Texture	
Sand (%)	2
Silt (%)	79
Clay (%)	19
Texture Class	silty *clay*
Irrigation water	
E.C. ($dS.m^{-1)}$	3.22
pH	7.57

4th October /2018 at one side of the ridge. The experimental land is divided into 48 plots each plot contained one treatment. Plot contained 3 ridges, each 2.4 meters long with 75 cm wide and hills were spaced at 30 cm distance, and four seeds were sown in each hill. The plants were thinned to two plants per hill at 20 days after sowing. .All treatment plots received the same amount of total fertilizer urea 46% N at the rate of 120 kg. Ha^{-1} was added after 30 days from sowing.

The experiment consists of 16 treatments, including of folic acid produced by Actavis company and amino acid cysteine produced by Thomas Baker (Chemicals) each of them were used at four level (control, sprayed with distilled water), 10, 20 and 30) $mg.L^{-1}$, applied after 20, 30 and 40 days from sowing as foliar application. The experiment was made in a randomized complete block design in a factorial experiment with three replicates. Treatments means were compared by using Least Significant Differences (L.S.D.) at the probability of 0.05.

A random sample of 10 plants was assigned for investigation in each plot, to study the morphological characters at 55 days after sowing.

After 55 days from sowing samples of six random plants were taken from experimental plots to estimate the following characteristics: shoot height (cm), number of Leaflet and branches/ plant, shoot fresh and dry weight/ plant (g), chlorophyll ($mg.g^{-1}$) in fresh leaves according to Zaehringer *et al*. (1974), the mineral percentage determined in dried leaves, nitrogen and potassium estimated according to Page *et al*. (1982). Phosphorus estimated according to Murphy & Riley (1962).The harvests started at 4/2/2019 and lasted until 24/3/2019. At harvest determination green pod and fresh seed yield.$plant^{-1}$ (g).

Results & Discussion

Data presented in table (2) revealed that foliar application of folic acid caused a significant increase on plant height, branches/plant, number of the leaflets and as well as fresh weight and dry weight of plants compared to the control treatment. The maximum increase was obtained in response to 30 $mg.L^{-1}$ folic acid. The improvement of Plant growth characters as a result of folic acid foliar spray may be due to the positive role of folic in regulating the synthesis of proteins and nucleic acids (Andrew *et al*., 2000), increasing cell division and expansion, synthesis of natural hormones and chlorophyll (Jabrin *et al*., 2003) and increases nutrient uptake (Kilic & Ace, 2016). As well as increasing tolerance against abiotic stress (Poudineh *et al*., 2015). The contribution of folic in these processes reflected by an increase in the size of the total vegetative growth, which was reflected by an increase of plant weight and accumulation of dry matter.

Foliar application of cysteine resulted in a significant increase in shoot height, number of leaves and branches/plant as well as fresh weight and dry weight of plants compared to the control treatment. The application of cysteine at the rate of 30 $mg.L^{-1}$ gave the greatest values of growth parameter. The increase of growth characters as a result of cysteine foliar spray may be due to the role of cysteine as a source a source of nitrogen and sulfur major macronutrients essential for plant growth and development or to the vital role of cysteine as an amino acid may play an important role in plant metabolism and protein assimilation which is necessary for cell formation (Rai, 2002) and consequently increase the fresh and dry matter or the sulfur

Table (2): Effect of foliar application of folic acid and cysteine on some vegetative growth characters of faba bean after 55 days from sowing.

Treatments		Shoot Height (cm)	No. of branches/plant	Number of leaflet /plant	fresh weight of shoot (g)	dry weight of shoot (g)
Folic acid ($mg.L^{-1}$)						
0		33.22	3.75	87.33	131.8	30.46
10		33.38	4.25	101.00	181.1	41.85
20		34.73	4.57	107.50	154.8	40.25
30		35.30	4.77	112.59	197.2	45.18
LSD 0.05		1.65	0.61	4.79	10.5	5.04
Cysteine ($mg.L^{-1}$)						
0		31.79	3.68	91.25	137.0	29.48
10		33.17	4.14	105.08	168.7	40.83
20		35.42	4.55	100.83	161.1	40.95
30		36.23	4.97	111.25	198.1	46.58
LSD 0.05		1.65	0.61	4.79	10.5	5.04
Folic acid	Cysteine	Folic acid × Cysteine				
0	0	27.53	2.55	60.67	109.0	22.83
	10	32.63	3.75	97.33	132.9	37.17
	20	35.63	4.10	92.00	122.3	26.50
	30	37.07	4.61	99.33	163.0	35.33
10	0	32.43	4.00	97.00	166.8	35.00
	10	32.67	4.10	97.67	181.2	39.58
	20	33.97	4.22	95.33	195.0	38.83
	30	34.43	4.05	114.00	181.2	54.00
20	0	33.53	4.11	101.67	130.8	27.00
	10	33.75	4.33	11.33	145.8	46.00
	20	35.90	4.55	102.33	153.8	47.33
	30	35.90	5.28	114.67	188.7	40.67
30	0	33.70	4.05	105.67	141.2	32.67
	10	33.80	4.39	114.00	245.0	40.57
	20	36.17	5.31	113.67	173.1	51.17
	30	37.53	5.33	117.00	259.4	56.33
LSD 0.05		3.29	1.22	9.58	20.1	10.08

derived from this amino acid is present in the electron transport system may have increased the rate of photosynthetic metabolism (Romero *et al*., 2014) thus the use of cysteine may have increased the rate of photosynthesis (Jobe *et al*., 2019), thereby providing a large amount of photoassimilate for growth.

The interaction between the foliar application of folic acid and Cysteine indicated that plants subjected to foliar application of 30 $mg.L^{-1}$ folic acid with 30 $mg.L^{-1}$ cysteine showed the highest plant height, $branches.plant^{-1}$, number of leaflet and as well as fresh weight and dry weight of shoots than the other combination treatments. Data presented in table (3) showed that foliar application of folic acid significantly increased nitrogen, potassium and

Table (3): Effect of foliar application of folic acid and Cysteine on NPK, chlorophyll in leaves and yield of faba bean.

Treatments		Microelements			Total chlorophyll (mg.g^{-1} Fw)	Green pod yield/ plant (g)	Fresh seed yield / plant (g)
		N%	P%	K%			
Folic acid (mg.L^{-1})							
0		2.534	0.240	2.470	9.19	339.3	165.5
10		3.800	0.298	2.676	9.58	418.8	200.0
20		4.522	0.426	2.810	10.14	453.6	251.7
30		3.961	0.416	2.744	10.38	608.8	291.0
LSD 0.05		0.059	0.002	0.024	1.14	13.5	11.3
Cysteine (mg.L^{-1})							
0		3.530	0.322	2.568	8.72	358.5	185.9
10		3.610	0.334	2.628	9.91	396.5	202.9
20		3.812	0.342	2.706	10.01	492.9	233.7
30		3.864	0.384	2.798	10.64	572.5	286.0
LSD 0.05		0.059	0.002	0.024	1.14	13.5	11.3
Folic acid	Cysteine	Folic acid × Cysteine					
0	0	2.183	0.222	2.400	7.66	225.7	117.0
	10	2.653	0.242	2.474	9.33	321.7	145.5
	20	2.523	0.248	2.480	9.17	363.3	169.8
	30	2.777	0.248	2.526	10.05	446.7	229.5
10	0	3.770	0.254	2.560	8.22	360.0	156.9
	10	3.533	0.268	2.634	9.59	381.7	169.8
	20	4.273	0.270	2.686	9.84	453.3	210.7
	30	3.623	0.404	2.826	10.66	480.0	262.6
20	0	4.330	0.41	2.680	9.37	381.7	223.3
	10	4.367	0.416	2.720	10.09	394.3	242.1
	20	4.550	0.432	2.860	10.25	508.3	252.6
	30	4.840	0.448	2.980	10.86	530.0	288.9
30	0	3.836	0.402	2.634	9.64	466.7	245.1
	10	3.887	0.412	2.686	10.64	488.3	254.2
	20	3.903	0.418	2.794	10.24	646.7	301.8
	30	4.217	0.432	2.860	11.00	833.3	362.9
LSD 0.05		0.112	0.004	0.048	2.27	26.9	22.5

phosphorous percentage in a faba bean leaves as compared with control treatments. 20 mg.L^{-1} folic acid gave the highest values of N, P and K. Increase in nitrogen, phosphorus and potassium in leaves treated with folic acid due to the effect of folic acid on enhancing root development and the uptake of water and nutrients **(**Farouk & EL-Saidy, 2013; Poudineh *et al.*, 2015). Application of cysteine induced a significant increase of N, P, K contents of faba bean leaves compared to untreated controls. 30 mg.L^{-1} gave the highest values of N, P and K. increases in N, P and K treated with cysteine due to cysteine is a source of nitrogen and sulfur which are major macronutrients essential for plant growth and development.

The interaction between the foliar application of folic acid and cysteine indicated that plants subjected to foliar application of 20 mg.L^{-1} folic acid in combination with 30 mg.L^{-1} cysteine produced the highest values of N, P and K in faba bean leaves than the other combination treatments.

Foliar application of folic acid on bean plants induced a significant increase in total chlorophyll contents of faba bean leaves (Table 3) compared with untreated control. The folic acid increased the chlorophyll content in leaves and this may be due to that folic acid induced activation of the biosynthesis of glycine, which is involved in the synthesis of porphyrins and chlorophyll in chloroplast membranes (Stakhova *et al*., 2000).

Foliar application of cysteine on bean plants induced significant increase in chlorophyll contents of faba bean leaves (Table 3) compared with untreated control. The role of cysteine in increasing total chlorophyll could be due to cysteine is a reduced sulfur donor molecule involved in the synthetic of essential biomolecules such as chlorophyll (Romero *et al*., 2014).

The interaction between folic acid treatments and cysteine significantly affected by chlorophyll (Table 3) 20 mg.L^{-1} of folic acid with 30 mg.L^{-1} cysteine gave the highest values than the other combination treatments.

Data presented in (Table 3) showed that foliar application with folic acid significantly increased green pod yield per plant and fresh seed yield per plant compared to the control treatment. The maximum increase was obtained in response to 30 mg. L^{-1} folic acid.

Foliar application of cysteine results in significant increase of green pod and fresh seed yield per plant compared to the control treatment. 30 mg.L^{-1} cysteine acid gave the highest values. The improvement of faba bean green pod yield and fresh seed yield by applying folic acid or cysteine could be a reflection of vegetative growth, minerals and chlorophyll which in turn leads to an increase of photosynthetic assimilates production that translocate to the reproductive organs during the maturation stage of the pods and seeds.

The interaction between foliar application folic acid and cysteine indicated that plants subjected to foliar application of 30 mg.L^{-1} folic acid with 30 mg. L^{-1} Cysteine showed the highest green pod and fresh seed yield per plant than the other combination treatments.

Conclusion

This study can showed the enhanced effect of folic acid and cysteine on growth, the chemical composition of leaves as well as green yield and the fresh seed of faba bean. 30 mg. L^{-1} of folic acid combined with 30 mg.L^{-1} of cysteine could effectively improve the growth and yield of faba bean.

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