Journal of Research in Ecology

An International Scientific Research Journal

ISSN No: Print: 2319 –1546; Online: 2319– 1554

Original Research

Effects of foliar application with fulvic acid on the growth, yield and protein content of three genotypes of faba bean (*Vicia faba* L.)

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ABSTRACT:

A field experiment was conducted at the second Agricultural Research Station (Al-Bander), during 2017/2018 winter seasons, to study the effects of foliar application using fulvic acid on the growth, yield and protein content of three genotypes of Faba bean. The experiment was arranged in a factorial design with three replicates. The genotypes used in this experiment were koualaji, primato and zinnia with the foliar application spraying of fulvic acid at the concentration of 0, 1.5 and 3 g/L. Results indicated that genotype zinia increased number of branches per plant 8.92 branch/plant, chlorophyll content 541.8 mg.m^2, number of pods per plant 22.60 pods/plant, weight of 100 seeds 106.70 g, as well as total yield per hectare 3559 kg/ha. The foliar application of sprayed fulvic acid at the concentration 3 g/L was superior in plant height 86.51 cm, number of branches per plant 11.33 branch/plant, chlorophyll content 575.1 mg.m^2, number of pods per plant 22.87 pods/plant, weight of 100 seeds 108.82 g as well as total yield 4092 kg/ha. The interaction between genotypes and foliar application of fulvic acid (zinia × 3.0 g/L) was superior in chlorophyll content 649.3 mg.m^2, no. pods per plant 27.00 pods as well as the weight of 100 seeds 120.33 g, while the combinations (koalaji × 3.0 g/L) and (primato × 3.0 g/L) were superior in plant height 91.67 and 85.67 cm respectively, and protein content 33.67 %. Finally the combination (primato × 1.5 g/L) was significantly superior with the number of seeds per pod 5.27 seeds/pod.

Keywords:

Genotypes of faba bean, Fulvic acid application, Growth, Yield and protein content.

Article Citation:
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Effects of foliar application with fulvic acid on the growth, yield and protein content of three genotypes of faba bean (*Vicia faba* L.)
Journal of Research in Ecology (2018) 6(2): 1965-1975

Dates:
Received: 19 July 2018 **Accepted:** 12 Aug 2018 **Published:** 18 Sep 2018

Web Address:
http://ecologyresearch.info/documents/EC0601.pdf

Journal of Research in Ecology

INTRODUCTION

Faba bean (*Vicia faba* L.) is a species from the family Fabaceae (Leguminosae), subfamily Faboideae, tribe Fabeae. It is one of the most important winter crops of high nutritive value in the world known for its great potential for yield and high protein contents (25-40%) Matthews and Marcellos (2003). Legumes, in general, provide a high proportion of dietary fiber in the diet and they have been used successfully as a part of the dietary treatment of diabetes. The crude fiber content in faba beans ranged from 5.0 % to 8.5% (Pearson, 1975; Chavan *et al.*, 1986). Faba beans seeds contain substantial amounts of minerals of high nutritional values for instance K, Ca, S and Fe. Where calcium ranges from 120 up to 260 $mg.l^{-1}$ on dry basis. Its seed not only provide a cheap source of protein but also food of high nutritive value especially in the diet of low income people it is a good alternative to expensive meat and fish protein Chavan *et al.* (1989). The protein of faba bean are similar qualitatively to those of soybean, so it provides an alternative to soy bean meal for animal feed, it is also grown for green manure which can be used to considerably enhance yields of other crops, faba bean which provides nitrogen in agricultural systems through the unique process of biological fixation of atmospheric nitrogen by symbiosis with *Rhizobium.* Nitrogen fixation bacteria in the root system of the faba bean makes more soil nitrogen available to the crop. This substantially reduces the need for nitrogen fertilizers Jensen *et al.* (2010). One of the problems facing the productivity of this crop is the failure of the branches and fall flowers that fail to form mature pods Attiya *et al*. (1998). Humic and fulvic acids are utilized in crop productions, particularly with vegetable produced under protected environment, for example plastic houses and greenhouses, since they profoundly improve crop growths and yields, owing to their positive effects on plant height, dry and fresh weights besides nutrient uptake increments of treated plants. These improvements can be attributed to their capabilities in mineral chelating, holding water and nontoxic properties (Malan, 2015). Xudan (1987) found yield increases of 7.3-18.0%, as compared to check treatments in fulvic acid treated plants, additionally he reported water stress resistance generated by hot and windy weather.

These effects seem to depend on the concentration (2, 3, and 5) and source of the substance and on the plant species Wright and Lenssen, (2013). Fulvic acid wheat treated plants revealed yield increases (7 to 18%), as compared to untreated (Xudan, 1986). Moreover, foliar fulvic acid of rice and radish at rates of 1,2 and 4% apparently improved plant height Khang (2011). It was found that soaking cowpea seeds with humic and fulvic acid resulted in significant increases in seed germination and further lengths of shoots and roots, when compared to control (Abbas *et al.,* 2015). Therefore, this study was conducted to elucidate the effects of foliar application of fulvic acid on plant growth, yield and protein content of three genotype of faba bean.

MATERIALS AND METHODS

A field experiment was conducted in the second experimental station (Al Bander) at departments of field crops, College of Agriculture, University of Al- Muthanna, during winter (2017-2018). The experiment was arranged in a factorial design based on Completely Randomized Block Design (CRBD) with three replicates. The seed genotypes used in this experiment (koualaji, primato and zinia) were obtained from the General Authority for Agricultural Research, Ministry of Agriculture, Iraq, with the foliar application spraying of fulvic acid at the concentration of 0, 1.5 and 3 g/L. On 15th October 2017, seeds were so want rate of three seeds per hole after two weeks of emergence reduced the number of plants per hole to one plant with 0.7m interplant and 0.3 m intra plant. Phosphorous pentoxide (P_2O_5) 20% at rate of 80 $kg.ha^{-1}$, urea N 46% at rate of 50 $kg.ha^{-1}$ were applied before the first irrigation

(Aguilera-Diaz and Recald, 1995; Mady, 2009). Also, necessary monitoring was conducted during growth stage in order to control pest and plant diseases in accordance with the technical advices. The midline plants of each experimental unit were harvested in order to determine the seed yield at the end of cropping season and after physiologic maturity of plants. This was carried out in 10 April 2018 at each experimental unit.

Soil properties

To determine some of the physical and chemical properties according to the method given by Ryan *et al*. (2001). Analyzing soil was done in the facilities of soil and water department laboratories, college of Agriculture, Al-Muthana University. Table 1 presents a view of soil properties.

The studied traits

Ten random plants were selected from the intermediate lines to calculate the following characteristics.

Plant height (cm)

Plant height was measured on a week before harvest, it was measured from the tip to the ground level of the plant Al-Isawi, (2010).

Chlorophyll content (mg/m^2)

The total chlorophyll content of the leaves was evaluated by chlorophyll meter (Spad 502) for ten plants randomly taken from the midline of each experimental unit, and by the following formula of Monje and Bugbee, (1992)

Ch= -80.05+10.40*(SPAD-502)

The following was also recorded during the experimental period:

1. Number of branches /plant
2. Number of pods/plant
3. Number of seeds/pod

Weight of 100 seeds (g)

100 seeds were randomly counted and weighted.

Total yield (kg/ha)

Ten plants were harvested from each experimental unit and the weight of pods were taken, on the basis of the experimental unit area the total yield was converted to kilogram per hectare**.**

Protein content of seeds (%)

Total nitrogen percentage of (*Vicia faba* L.) seeds was determined by Kjeldahl method, the percentage of protein in the seeds was calculated by multiplying total nitrogen by factor 6.25 (Scheffelen *et al.,* 1961).

Statistical analysis

The data were given in mean ±SD. The statistical analysis were done in SPSS software package (SPSS, 1998).

Table 1. Some physical and chemical properties of the experimental soil

S. No	Properties	Results
1	ECE (Ds.m^{-1})	2.8
2	pH	7.6
3	TDS (ppm)	1.4
4	OM (%)	0.9
5	N (mg kg^{-1})	16.10
6	P (mg kg^{-1})	1.40
7	K (mg kg^{-1})	12.10
8	Sand (g kg^{-1})	490
9	Silt (g kg^{-1})	200
10	Clay (g kg^{-1})	310
11	Soil texture	Silty clay loam

RESULT AND DISCUSSION

Plant height (cm)

Plant height was significantly enhanced by the spray of fulvic acid and interaction over control (Table 2) but showed non-significant in genotypes. Maximum plant height (86.51 cm) was recorded at the concentration 3.0 g/L of fulvic acid compared with the control treatment at 0.0 g/L concentration which was 65.04 cm. This is due to the positive effect of humic compound on plant growth by increasing the permeability of cellular membranes, stimulating enzymatic reactions, improving cell division, elongation of cells, increasing plant enzyme production and stimulating intracellular vitamins

Table 2. Effect of genotype and foliar spray of fulvic acid and their interaction in plant height for *Vicia faba* L.

S. No	Genotype	Spray of fulvic acid (g/L)			Mean of genotype
		0.0	1.5	3	
1	Koalaji	60.67	71.67	91.67	74.67
2	Primato	67.23	74.57	82.20	74.67
3	Zinia	67.23	76.43	85.67	76.44
4	Mean of spray fulvic acid	65.04	74.22	86.51	
5	L.S.D (0.05)	Genotype	Fulvic acid	Fulvic acid × Genotype	
		N.S	3.71	6.42	
6	± SD	1.75	1.75	3.03	

(Kaya *et al*., 2005) and these activities are working to increase the vegetative growth of the plant and thus increase the carbohydrates manufactured in the leaves and transfer of any fruit parts leads to increase the occurrence.

The result of interaction between genotype and fulvic acid concentrations showed significant effect for this trait, the highest values of plant height was recorded in the combination (koalaji×3.0 g/L) which was 91.67 cm, while the lowest values were recorded in the combination (koalaji×0.0 g/L) which was 60.67 cm.

Number of branches /plant

Fulvic acid treated faba beans Table 3 gave significantly higher branches number per plant, particularly with zinia genotype (8.92). However, insignificant difference was detected, in relation to primato genotype (8.2). The lowest branches number per plant (6.72) was observed koalaji cultivar Table 3. 3 g/L fulvic acid treated faba beans manifested substantially higher branches per plant (11.33), as compared to control (5.96) this finding was due to the role of humic and fulvic acids on vegetative growth, which was brought up to its role on positive effects of permeability of cellular membranes (Kaya *et al*., 2005). However, insignificant differences were detected in genotypes treated with foliar application of fulvic acid.

Chlorophyll content (mg/m^2)

The results in Table 4 showed significant differences in the genotype, foliar application sprayed of fulvic acid and their interaction for chlorophyll content. The genotype zinia showed the highest value (541.8 mg/m^2) over all the other. While the lowest value was seen in the genotype primate (397.2 mg/m^2). This is dependent on the genetic makeup and environmental conditions of the genotypes. These results are in concordance with Harby (2018) and Jbara (2018) who showed that differ-

Table 3. Effect of genotype and foliar spray of fulvic acid and their interaction in number of branches / plant for *Vicia faba* L.

S. No	Genotype	Spray of fulvic acid (g/L)			Mean of genotype
		0.0	1.5	3	
1	Koalaji	5.07	5.77	9.33	6.72
2	Primato	6.37	7.20	12.00	8.52
3	Zinia	6.43	7.67	12.67	8.92
4	Mean of spray fulvic acid	5.96	6.88	11.33	
5	L.S.D (0.05)	Genotype	Fulvic acid	Genotype ×Fulvic acid	
		0.99	0.99	N.S	
6	±SD	0.47	0.47	0.81	

Table 4. Effect of genotype and foliar spray of fulvic acid and their interaction in chlorophyll content (mg/m^2) for *Vicia faba* L.

S. No	Genotype	Spray of fulvic acid (g/L)			Mean of genotype
		0.0	1.5	3	
1	Koalaji	333.5	374.8	588.3	432.2
2	Primato	337.0	358.5	496.0	397.2
3	Zinia	454.9	521.4	649.3	541.8
4	Mean of spray fulvic acid	375.1	418.2	575.1	
5	L.S.D (0.05)	Genotype	Fulvic acid	Genotype ×Fulvic acid	
		16.58	16.58	28.72	
6	±SD	7.82	7.82	13.55	

ent genotypes were among them in chlorophyll content traits.

The results revealed that chlorophyll content was affected significantly by the foliar application of fulvic acid. The high concentration 3.0 g/L showed a highest value (575.1 mg/m^2) compared with the control treatment which showed lowest value (375.1 mg/m^2). This is due to the role of the nitrogen which is present in fulvic acids that enters to the building of loop porphyrins which was basic in the chlorophyll structure. Fulvic acid substantially increases chlorophyll, moisture content of leaf and assimilation production Anjum *et al*. (2011).

Interaction between genotypes and foliar application of fulvic acid showed highly significant differences for this trait, the highest mean observed in combination (zinia × 3.0 g/L) (649.3 mg/m^2), while the lowest mean was observed in the combination (koalaji × 0.0 g/ L) (333.5 mg/m^2).

Number of pods/plant

The obtained results in Table 5 mentioned that genotypes, foliar application sprayed of fulvic acid and their interaction showed significant differences for the number of pods per plant.

The genotype zinia showed highest mean which was 22.60 pods/plant, while the lowest mean was 18.11 pods /plant represented by the prima to genotype. This is due to superior zinia genotype with increased chlorophyll content Table 4 that increased the rate of photosynthesis which led to produce the dry matter to have the increased number of pods per plant. Among yield components, number of pods per plant, one of the most

Table 5. Effect of genotype and foliar spray of fulvic acid and their interaction in the number of pods/plant for *Vicia faba* L.

S. No	Genotype	Spray of fulvic acid (g/L)			Mean of genotype
		0.0	1.5	3	
1	Koalaji	17.17	19.43	21.60	19.40
2	Primato	16.17	18.17	20.00	18.11
3	Zinia	20.30	20.50	27.00	22.60
4	Mean of spray fulvic acid	17.88	19.37	22.87	
5	L.S.D (0.05)	Genotype	Fulvic acid	Genotype×Fulvic acid	
		0.89	0.89	1.53	
6	±SD	0.42	0.42	0.72	

Table 6. Effect of genotype and foliar spray of fulvic acid and their interaction in the number of seeds /pod for *Vicia faba* L.

S. No	Genotype	Spray of fulvic acid (g/L)			Mean of genotype
		0.0	1.5	3	
1	Koalaji	3.73	4.50	4.07	4.10
2	Primato	4.37	5.27	4.73	4.79
3	Zinia	3.47	4.77	4.37	4.20
4	Mean of spray fulvic acid	3.86	4.84	4.39	
5	L.S.D (0.05)	Genotype	Fulvic acid	Genotype ×Fulvic acid	
		0.27	0.27	N.S	
6	±SD	0.13	0.13	0.22	

important yield components and grain yield. Ability of the flowers and pods of beans in the actual production potential is high, but this is dependent on the genetic makeup and environmental condition are perfect, and because changes in the yield is very high Simin *et al*. (2011). Similar results were obtained by El-Refaey *et al*. (2012) and found significant differences between genotype involved in their research.

As for the foliar application of fulvic acid, the concentration 3 0.g/L showed that the highest mean was 22.87 pods/plant, compared with the control treatment which was 17.88 pods/plant. This is due to the role of humic and fulvic acids to improve vegetative growth and decrease the competition of nutrients between the pods. Thus increased number of pods per plant, or due to the positive effect of humic and fulvic acids which encourage absorption of nutrients, stimulate enzymatic activities and bio processes and had major role in the carbohydrate and protein synthesis inside the plant and then transferred to the plant parts including pods Abbas (2013). Similar results were obtained by El-Hak *et al*. (2012).

Interaction between genotypes and foliar application of fulvic acid showed highly significant differences for this trait, the highest mean observed in combination (zinia× 3.0 g/L) was 27 pods/plant, while the lowest mean observed in combination (prima to × 0.0 g/ L) was 16.17 pods / plant. Results suggested that cultivar positively responded to fulvic acid and thus they showed profound increases in terms of pod number per plant, owing to photosynthesis improvement, materials and their. Similarly results reported on red bean was done by Shadisadat *et al*. (2016).

Number of seeds/pod

The results in Table 6 showed significant differences in the genotype and fulvic acid concentrations for

Table 7. Effect of genotype and foliar spray of fulvic acid and their interaction in weight of 100 seed (g) for *Vicia faba* L.

S. No	Genotype	Spray of fulvic acid (g/L)			Mean of genotype
		0.0	1.5	3	
1	Koalaji	85.00	90.67	95.80	90.49
2	Primato	85.00	93.43	110.33	96.26
3	Zinia	90.49	109.27	120.33	106.70
4	Mean of spray fulvic acid	86.83	97.79	108.82	
5	L.S.D (0.05)	Genotype	Fulvic acid	Genotype ×Fulvic acid	
		1.49	1.49	2.59	
6	±SD	0.70	0.70	1.22	

Table 8. Effect of genotype and foliar spray of fulvic acid and their interaction in seeds yield (kg/ha) for *Vicia faba* L.

S. No	Genotype	Spray of fulvic acid (g/L)			Mean of genotype
		0.0	1.5	3	
1	Koalaji	1722	2582	3655	2653
2	Primato	1995	3016	4017	3010
3	Zinia	2179	3897	4602	3559
4	Mean of spray fulvic acid	1965	3165	4092	
5	L.S.D (0.05)	Genotype	Fulvic acid	Genotype ×Fulvic acid	
		313.0	313.0	N.S	
6	±SD	147.7	147.7	255.8	

number of seeds per pod. The genotype prima to showed highest mean value (4.79 seeds/pod) over all the other. While the lowest mean value was seen in the genotype koalaji (4.10 seeds/pod). This is due to the genetic variances between the genotypes or may be due to the formed sufficient amount of dry matter during composition of stage pod sand development which increase fertility of flowers and decrease sterility of flowers. This led to the increase in the number of seeds per pod. Similar results were obtained by Al-Tamimi, (2018).

The number of seeds per pod was significantly increased by foliar application with fulvic acid during the growing season compared with the control treatment. The highest mean value was obtained from the plants with foliar application of fulvic acid at the concentration of 1.5 g/L was 5.27 seeds/pod. While the lowest mean value was 3.47 seeds/pod that were obtained with the sprayed concentration of 0.0 g/L. This could be explained as humic compounds that are rich in both organic and mineral substances which are essential to plant growth and consequently increase yield quality and quantity Zaky *et al*. (2006). These results were in agreement with Jbara (2018). Interaction between genotypes and foliar application sprayed of fulvic acid showed non-significant differences for the number of seeds per pod.

Weight of 100 seed (g)

The obtained results in Table 7 mentioned that genotypes, foliar application sprayed of fulvic acid and their interaction showed significant differences for the weight of 100 seed (g). The genotype zinia showed that highest mean value which was 106.70 g for this trait, while the lowest mean value was 90.49 g represented by the genotype koalaji. This is due to the nature and ability of the genotype on usefulness, outputs of photosynthesis from the source, increased number branches per

Table 9. Effect of genotype and foliar spray of fulvic acid and their interaction in protein percentage (%) for *Vicia faba* L.

S. No	Genotype	Spray of fulvic acid (g/L)			Mean of genotype
		0.0	1.5	3	
1	Koalaji	21.00	27.33	31.00	26.44
2	Primato	20.67	24.00	33.67	26.11
3	Zinia	21.00	26.67	28.67	25.44
4	Mean of spray fulvic acid	20.89	26.00	31.11	
5	L.S.D (0.05)	Genotype	Fulvic acid	Genotype ×fulvic acid	
		N.S	1.41	2.44	
6	±SD	0.67	0.67	1.15	

plant and decreased number of seeds per pod (Table 3 and 6) which gave positive effects on the weight of 100 seeds (g) El-Refaey (2012). Similar results were obtained by Shadisadat *et al*. (2016).

Weight of 100 seeds (g) was significantly increased by foliar application with fulvic acid compared with the control treatment. The highest mean value were obtained from the plants (foliar) sprayed with fulvic acid at the concentration of 3.0 g/L was (108.82 g). While the lowest mean value was (86.83 g) that were obtained with the sprayed concentration of 0.0 g/L. The results of this study are consistent with results of El-Galad (2013) and Jbara (2018) when they studied on faba bean. Further, using humic compounds also increased leaf area and provided more photosynthetic material which helps in the filling of grains that can increase yield through seed weight Yildirim (2007). Interaction between genotypes and foliar application sprayed with fulvic acid showed highly significant differences for this trait. The highest mean observed in the combination of (zinia × 3.0 g/L) (120.33 g), while the lowest mean was observed in the combination of (koalaji × 0.0 g/L) (85.00 g). This is due to the genetic variances between the genotypes and their response to foliar application sprayed in the fulvic acid.

Total yield (kg/ha)

The obtained results in Table 8 mentioned that genotypes, foliar application sprayed of fulvic acid showed significant differences for the total yield (kg/ha). However, the interaction between genotypes and foliar application sprayed of fulvic acid showed non-significant for this trait. The genotype zinia recorded the highest mean value of 3559 kg/ha, while the lowest mean value recorded the genotype koalaji which amounted to 2653 kg/ha. This is due to the superiority of genotype zinia in the number of pods per plant and weight of 100 seed (Table 5 and 7). Sharif *et al.* (2002) reported the improvement in maize yield by foliar application of 4 g/L and Al-Tamimi (2018) on faba bean.

Total yield (kg/ha) was significantly increased by foliar application with fulvic acid that are compared with the control treatment. The highest mean value were obtained from the plants foliar sprayed with fulvic acid at the concentration of 3.0 g/L with the value of (4092 kg/ha). While the lowest mean value was (1965 kg/ha) obtained with the concentration of 0.0 g/L that increased the yield per hectare which may be due to the role of humic and fulvic acids that improved the quality of yield through many of the enzymes and increased photosynthesis which led to the improved growth, yield and its components. All these factors helped the plant to give high yield. That is accepted with the finding of Safeek *et al.* (2013) and Jbara (2018) on faba bean. Interaction between genotypes and foliar application sprayed of fulvic acid showed non-significant differences for total yield per hectare.

Protein content of seeds (%)

The results in Table 9 showed non-significant differences in the genotypes. The protein content was significantly increased by foliar application with fulvic acid compared with the control treatment. The highest mean value were obtained from plants that are foliar sprayed with fulvic acid at the concentration of 3.0 g /L was (31.11%), while the lowest mean value was 20.89 % at the concentration of 0.0 g/L. Hendawy *et al*. (2015) stated that phosphorous possesses an activation effects on coenzymes required for amino acid synthesis, photosynthesis, glycolysis, respiration, protein and fatty acid synthesis. The obtained increases in potassium absorption as result of fulvic acid application may have a positive role on metabolism of nitrogen, carbohydrates, lipid, starch and protein synthesis (Zahra *et al*., 1984).

Interaction between genotypes and foliar application sprayed of fulvic acid showed highly significant differences for protein content (%). The highest mean observed in combination (primato × 3.0 g/L) was (33.67 %), while the lowest mean observed in combination (primato × 0.0 g/L) was (20.67 %). The obtained results

may be due to the direct effect of humic on cell wall, membrane and/or in the cytoplasm, which was reflected on photosynthesis, respiration rates, enhanced protein synthesis and plant hormone like activity (Chen and Aviad, 1990).

CONCLUSION

The obtained results revealed that foliar application sprayed of fulvic acid on faba bean is very beneficial to crop growth, yield and protein content. Hence, it could be suggested that genotypes of faba bean grown under the experiment and similar condition. The foliar sprayed at 4.0 g/L for the genotype (zinia) produced high yield and good quality of green pods, with good weight of 100 seeds and high protein content which is suitable for marketing.

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