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Aqueous Extract of (*Eruca sativa* Mill) as Growth Stimulant in Enhancing Growth and Yield of Faba Bean (*Vicia faba* L)

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Abstract: A field study was conducted in the fall of 2019 to investigate the potential of Arugula (*Eruca sativa* Mill) aqueous extract as a growth stimulant in enhancing the growth and yield of Faba Bean (*Vicia faba* L*)*. The study was conducted using sandy soil at a farm in Abo Esaa town in a plot size of 3X5 m^2 with a row spacing of 25cm,which based on a complete randomized design (RCD) with four replications, three treatments were carried out, including no foliar spray with *E. sativa* extracts (control) and foliar sprayed with 20% and 40% aqueous extracts of *E. sativa*. Accordingly, Faba Bean (*Vicia faba* L) plants were foliar sprayed six times with the aqueous extracts of *E. sativa* at rates of 20 and 40% at vegetative and reproductive stages. The result showed that among these concentrations, the foliar spray of faba bean plants with 40% of *E. sativa* extracts potentially were increased all measured growth and yield traits. The results pointed out that plant height increased by 32%, number of branches by 73%, number of leaves by 95%, number of seeds plant by 89%, leaves, stems, pods and roots dry weight by 92%, 80%, 74%, and 89%, respectively. Thus, the study concluded that *E. sativa* aqueous extracts could potentially be used efficiently by crop producers as a growth enhancer for faba bean crops because of their productivity, great nutritive value, low cost, and environmentally friendly nature.

Keywords*:* *Vicia faba* L; *Eruca sativa* Mill; Aqueous Extracts; Growth; Yield.

INTRODUCTION

Faba bean (*Vicia faba L)* is a main legume crop grown in Libya due to its high nutritional value of the seeds. Humans in all over the world consume Faba been seeds as a substantial source of vegetable protein (El-Dabaa et al., 2019). Also, some faba bean varieties make significant livestock feed for animal feeding (Crépon et al., 2010; Cherif et al.,2018). Likewise, growing this legume is valuable to other crops as it increases soil fertility by biological nitrogen fixation and increases the soil content of nitrogen (El-Dabaa et al., 2019). In Libya, soil fertility is one of the principal production limitations, especially nitrogen deficiency. Hence, immense quantities of chemical fertilizers are applied for crop production. However, artificial chemical fertilizers are potentially toxic and may harm the environment (Khanh et al., 2004; Macı´as et al., 2006). In addition, over-applying of chemicals may cause human health problems, ground water contamination, and may lead to toxicity in foods (Hong et al., 2004).

Eruca sativa is an herb vegetable and a perennial plant belonging to the Brassicaceae family (Koubaa et al., 2015). Arugula (*Eruca sativa* Mill) is a highly valued plant distributed in many countries worldwide. It has an impressive range of medicinal uses and high nutritional value. The health benefits of *E. sativa* leaves and seeds were widely investigated, however, considering to the literature available, little information is currently available about the biostimulants effect of *E. sativa* on plant growth in general, and on faba bean specifically. Biostimulants are plant extracts that contain some kinds of bioactive compounds that able to im-

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prove some physiological processes that stimulate growth and development of crops with increasing nutrient use efficiency, and reducing synthetic chemical fertilizers without affecting the quality and crop yield (Bulgari et al., 2015; Elzaawely et al., 2017). Biostimulants possibly offer a new approach for the regulation of physiological processes in plants to stimulate growth, alleviate stress, and increase yield (Yakhin et al., 2017). Foliar application of biostimulants and micronutrients could be a better way of fast action in improving plant growth and yield (Khan et al..,2021). Another work, investigated the effect of some natural plant extracts include garlic, moringa, and licorice extracts on the yield and fruit quality of pear trees. The work is reported that extracts of these plants could be recommended to be used effectively as natural plant extracts for improving the growth of various crops due to its high nutritive value, antioxidant effect, easy preparation, and environmentally friendly (Abd El–Hamied and El-Amary, 2015). To reduce dependence on synthetic chemical fertilizers, an alternative source for nutritional components is required for improving crops and faba bean production that minimizes environmental pollution. Therefore, this study aimed to highlight the potential of arugula (*Eruca sativa* Mill) aqueous extract as a green fertilizer in enhancing the growth and yield of faba bean (*vicia faba* L).

MATERIAL AND METHODS

Plant Materials: Faba bean (*Vicia faba L)* seeds and Arugula (*Eruca sativa* Mill) obtained from the local market**.**

Experimental and treatment conditions: A field experiment was conducted in sandy soil at a farm in abo Esaa town based on a randomized complete design (RCD) with four replications in a plot size of 3X5 m^2 with a row spacing of 25 cm. Seeds of faba bean were sown in sandy soils in November 2019. Di-Ammonium phosphates ($(NH_4)_2HPO_4$) 46P, 18N were applied twice, the first application was around the vegetative stage, and the second application was around the flowering stage of plant growth. The plants were irrigated as needed and were under monitoring.

***Eruca sativa* extract:** Plant materials were obtained from the local market, and the leaves of the plant were first washed and left to dry. *Eruca sativa* aqueous extract was prepared following modified methods of (Phiri, 2010). Briefly, 100 g of fresh leaves of *E. sativa* were mixed with 100 ml of distilled water in a household blender for 15 minutes. The solution was filtered through filter paper Whatman No. 1 and stored at 4C° until used the next day.

Application of *Eruca sativa* extract: At the spray time, 20% and 40% of plant extract were prepared by taking 20 and 40 ml of plant extract and diluted by adding fresh water to make 100 ml of plant extract, which almost immediately was foliar sprayed to growing faba bean plants. The same procedure was repeated every ten days with a total of six times. The control plants were sprayed with tap water, and plants were harvested after 150 days of sowing.

Data collection: At harvesting, a random sample of four plants were randomly taken from each treatment and the following data were recorded:

1. Plant height (cm)
2. Number of branches / plant.
3. Number of leaves / plant.
4. Number of pods / plant.
5. Number of seeds / pod.
6. Number of seeds / plant.

Subsequently, plants were dried and the following data were recorded:

1. Leave dry weight / plant (g)
2. Stem dry weight / plant (g)
3. Root dry weight / plant (g)
4. Pods dry weight / plant (g)
5. Weight of 10 seeds (g).
6. Yield of seeds (g) / plant.

The 10 seed weight was recorded in g of the weight of 10 randomly selected seeds from

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each replication after threshing, and seed yield was calculated. Seeds yield was estimated in g per plant with total weight of seeds after threshing.

Statistical Analysis: The experimental design was a randomized complete design (RCD) with four replications. Analysis of variance performed using generalized linear model (GLM) procedure in SAS 9.4 (SAS Institute Inc., Cary, NC, USA) for growth and yield-related traits. Separation of means was carried out using the least significant differences (LSD; $P < 0.05$). The means were compared using Duncan's multiple range test.

RESULTS

The P-values for growth and yield-related traits obtained with SAS PROC GLM are presented in table 1. The effects of the application of *E. sativa* aqueous extract were significant ($P < 0.05$) on plant height, number of branches, number of leaves, number of pods, number of seeds, leaves, stems, pods, and roots dry weight, dry weight of 10 seeds and yield of seeds (Table 1). Data presented in Table 2 shows the effect of the application of *E. sativa* extract at different concentrations on the growth and yield of faba bean plants.

Table:1. Probability values of the effect of *Eruca sativa* aqueous extract on the growth and yield of faba bean (*Vicia faba* L) Plants

Traits	Treatments
Plant height (cm)	0.0420
Number of branches plant^{-1}	0.0395
Number of leaves plant^{-1}	0.0372
Number of pods plant^{-1}	0.0376
Number of seeds pod^{-1}	0.0467
Number of seeds plant^{-1}	0.0245
Leave dry weight plant^{-1} (g)	0.0460
Stem dry weight plant^{-1} (g)	0.0443
Root dry weight plant^{-1} (g)	0.0478
Pods dry weight plant^{-1} (g)	0.0309
Weight of 10 seeds (g)	0.0455
Yield of seeds plant^{-1}. (g)	0.0013

Table:2. The effect of *(Eruca sativa* Mill*)* aqueous extract on the growth and yield of faba bean (*Vicia faba* L) Plants.

Traits	Treatments		
	Control	20%	40%
Plant height (cm)	55^{b}	56^{b}	73^{a}
Number of branches plant^{-1}	3.7^{b}	5.5^{ab}	6.5^{a}
Number of leaves plant^{-1}	69^{b}	117^{ab}	135^{a}
Number of pods plant^{-1}	9^{b}	10.5^{ab}	14^{a}
Number of seeds pod^{-1}	3.4^{b}	4^{ab}	4.2^{a}
Number of seeds plant^{-1}	31.7^{b}	42^{ab}	60^{a}
Leave dry weight plant^{-1} (g)	5.5^{b}	7.9^{ab}	10.6^{a}
Stem dry weight plant^{-1} (g)	10^{b}	13^{ab}	18^{a}
Root dry weight plant^{-1} (g)	4^{b}	5.6^{ab}	7^{a}
Pods dry weight plant^{-1} (g)	25^{b}	31^{ab}	47^{a}
Weight of 10 seeds (g)	9.7^{b}	13.8^{ab}	16.8^{a}
Yield of seeds plant^{-1}. (g)	32.6^{b}	57.5^{b}	97.8^{a}

* Individual value is the mean of 4 plants under different salinity levels. Values followed by different letters are significantly different according to Duncan's multiple range test ($P < 0.05$

The results were showed that the low concentrations (20%) of *E. sativa* extract did not have a significant effect on the plant height of faba beans. Whereas the high concentrations (40%) of *E. sativa* extract exhibit a significant effect on the plant height of faba bean, which

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increased plant height by 32% compared to control plants (Fig. 1A). Concurrently, the number of branches plant-1 increased under both concentrations of *E. sativa* extract. The result indicated that the application of 20% of *E. sativa* extract increased the number of branches plant-1 by 47%, and the application of 40% of *E. sativa* extract increased the number of branches plant-1 was by 73% (Fig. 1B). Likewise, the number of leaves plant-1 was increased by the application of *E. sativa* extract at both concentrations. Figure 1C showed that the number of leaves plant-1 increased by the application of 20% and 40% of *E. sativa* extract by 69% and 95% respectively.

Also, the result indicated that both concentrations of *E. sativa* extract induced a significant increase in the number of pods plant-1 of faba beans. The highest values of the number of pods plant-1 were noted at a concentration of 40% of *E. sativa* extract, which increased plant height by 54% compared to control plants (Fig. 2A). The same trend is found in the number of seeds pod-1 and the number of seeds plant-1. The application of 20% and 40% of *E. sativa* extract increased the number of seeds pod-1 by 19% and 24% respectively Fig. 2B. The number of seeds plant-1 was increased by 33% and 89% as a result of the application of 20% and 40% of *E. sativa* extract respectively Fig 2C.

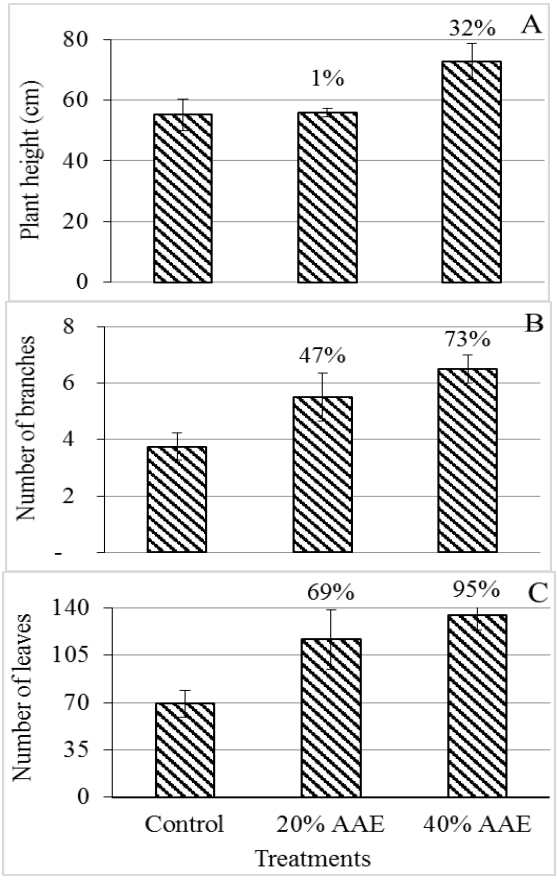

Figure 1. The effect of *Eruca sativa* aqueous extract treatments on (A) plant height (cm), (B) number of branches and (C) number of leaves / plant of faba bean plant. Each datum indicates mean value and vertical lines on top of bars indicate standard error of means (n = 4). Values in parenthesis indicate the percent increase from control.

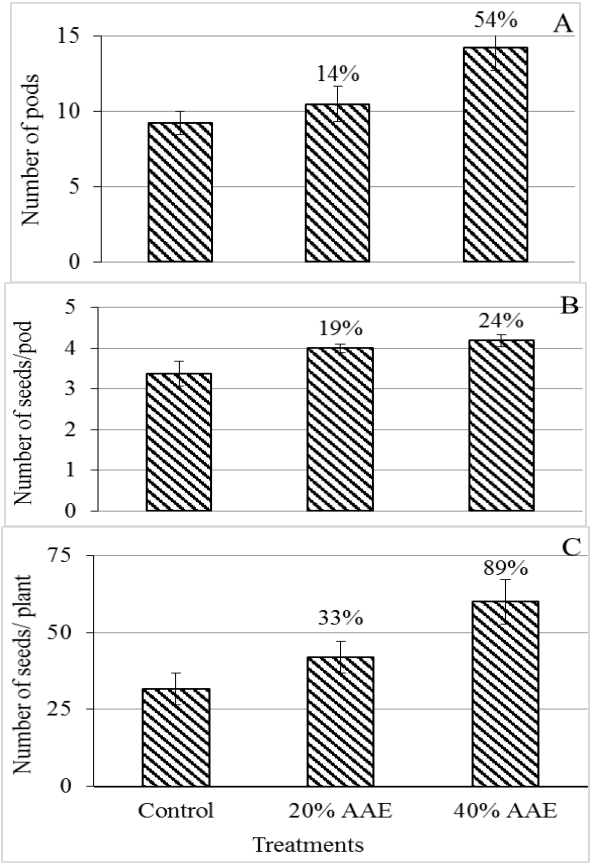

Figure 2. The effect of *Eruca sativa* aqueous extract treatments on (A) Number of pods^{-1} plant, (B) number of seeds pod-1 (C) number of seeds plant^{-1} of faba bean plant. Each datum indicates mean value and vertical lines on top of bars indicate standard error of means (n = 4). Values in parenthesis indicate the percent increase from control.

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In addition, *Eruca sativa* aqueous extract treatments created significant stimulation in biomass accumulations plant-1. This stimulation was displayed by an increase in dry weight of the plant's stem, leaves, and roots. Leaves dry weight was increased by 43% and 92% due to the application of 20% and 40% of *Eruca sativa* aqueous extract respectively Fig. 3A. The 20% of *Eruca sativa* aqueous extract treatments increased stems dry weight by 29% and 40% of *Eruca sativa* aqueous extract treatments increased stem dry weight by 80% Fig. 3B. Similarly, the 20% of *Eruca sativa* aqueous extract treatments increased plant roots dry weight by 40% and 74% of *Eruca sativa* aqueous extract treatments Fig. 3C.

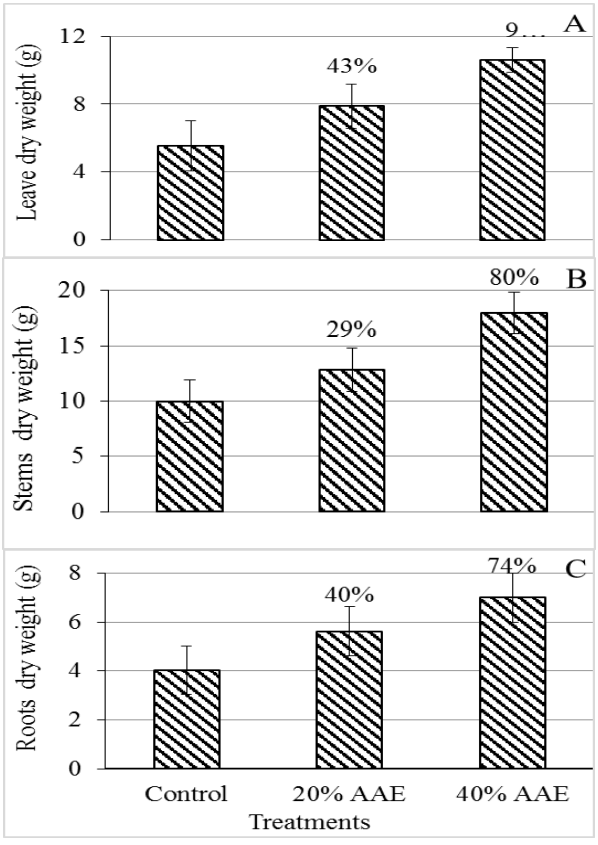

Figure 3. The effect of *Eruca sativa* aqueous extract treatments on (A) leave dry weight (g), (B) stem dry weight (g) (C) roots dry weight (g) of faba bean plant. Each datum indicates mean value and vertical lines on top of bars indicate standard error of means (n = 4). Values in parenthesis indicate the percent increase from control.

Moreover, spraying of faba bean plants with 20% and 40% of *Eruca sativa* aqueous extract resulted in a significant increase in pods dry weight plant-1 (g), weight of 10 seeds, (g) and yield of seeds plant-1 (g) Fig 4.

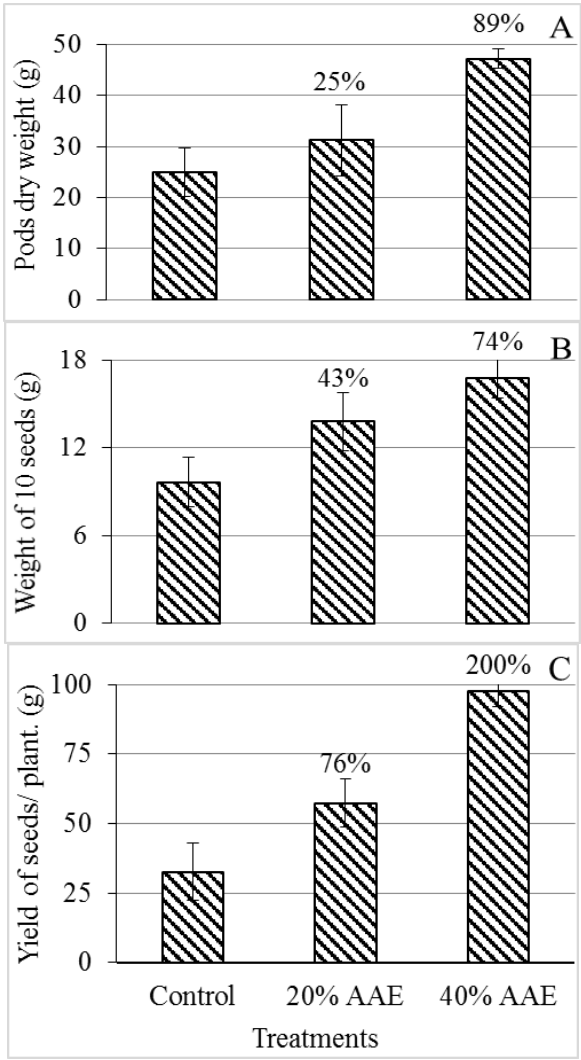

Figure 4. The effect of *Eruca sativa* aqueous extract treatments on (A) pods dry weight plant^{-1} (g), (B) weight of 10 seeds (g) and (C) yield of seeds plant^{-1} (g) of faba bean plant. Each datum indicates mean value and vertical lines on top of bars indicate standard error of means (n = 4). Values in parenthesis indicate the percent increase from control.

The result illustrated that both concentrations of *Eruca sativa* aqueous extract increased pods dry weight plant-1 (g), which was increased by 25% and 89% when plants of faba bean were sprayed by 20% and 40% respectively of *E. sativa* aqueous extract Fig.4A. At

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the same time, the weight of 10 seeds (g) as increased by 43% and 74% as a result of the application of 20% and 40% of *E. sativa* aqueous extract respectively Fig.4B. The highest increase was found in the yield of seeds plant-1 (g), which increased by 76% and 200% when faba bean plants were treated with 20% and 40% respectively of *E. sativa* aqueous extract Fig 4C.

DISCUSSION

This work was conducted to study the effect of foliar spray with aqueous extract of *Eruca sativa* Mill plant at concentrations of 20% and 40 % on the growth and yield of faba bean (*Vicia faba* L). The results showed that foliar application with 20 % *Eruca sativa* Mill aqueous extract showed significant effects on vegetative growth and yield components of faba bean. However, foliar application with 40% *Eruca sativa* aqueous extract showed highly significant improvement effects on vegetative growth and yield of faba bean, as shown in table 2. This may be due to the phytochemical properties of *Eruca sativa* aqueous extract and their biostimulate and antioxidant potential (Sadiq et al., 2014). It is noticeable from the results that all implemented concentrations of *Eruca sativa* aqueous extract (20% and 40%) concentrations significantly stimulated the growth and yield components of faba beans.

Currently, concerns are growing about human safety and the environmental impact of conventional synthetic fertilizer commonly used to improve plant growth. Some plant aqueous extracts may enhance plant growth, increase plants' tolerance against biotic and abiotic stresses and improve nutrient use efficiency (Posmyk and Szafrańska, 2016). An increase in growth and yield components of faba bean was achieved when faba bean plants were sprayed with 40% of *Eruca sativa* aqueous extract. This observation is comparable to that reported on the effect of moringa plant extracts on enhancing growth, yield, biochemical, hormonal contents of snap bean plants (Elzaawely et al., 2017). Data also showed that high concentrations of *Eruca sativa* aqueous extract are directly proportional to increased shoot growth. This agree with an early study that concluded the irrigating basil plants with Moringa leaf extracts resulted in an increase of shoot length, shoot fresh weight, and shoot dry weight and recommended Moringa as bio-organic fertilizer for various crops (Abdalla, 2013; Hassanein et al., 2019). According to the results obtained herein, the number of seeds pod-1 was the least affected trait and followed by plant height. Whereas the number of leaves plant-1, leave dry weight, and seed yield plant-1 were the most affected traits.

This finding is in agreement with a study which indicated that *Croton macrostachyus* and *Plectranthus barbatus* leaf extracts increased shoot length and leaf number per plant, and these two plant species were a source of cheap soil nutrients and may substitute the use of inorganic fertilizers (Odhiambo et al., 2019).

In the current study almost all growth and yield traits investigated were significantly improved with the application of *E. sativa* aqueous extract. This outcome was similar to other studies including: Moringa extract improving growth and yield of tomato plants (Culver et al., 2012), *Moringa oleifera* leaf extract improving growth and yield components of snap beans (Emongor, 2015), and foliar application of Moringa leaf extract enhancing growth, yield and nutritional quality of cabbage (Hoque et al., 2020).

The same result was reported in a previous study that showed that the application of mulberry, brassica, and sorghum leaf extracts improved growth and enhanced biochemical and antioxidant activities of radish plants (Ashraf et al., 2016). This improvement of faba bean growth after foliar sprayed with *E. sativa* extracts was because *Eruca sativa* plants have

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been reported a rich source of important nutrient elements such as (N, P, K, Ca, Mg, Na, Fe, Cu, Mn, and Zn (Bukhsh et al., 2007; Barlas et al., 2011), that may have benefits in enhancing plant growth. *Eruca sativa* plant may increase plants to uptake more and more valuable elements, which increased the nutrient status and ultimately accomplish optimum growth and yield of faba beans.

CONCLUSIONS

With regard to yield parameters: seed yields^{-1} compared to control were significantly increased, especially that obtained from 40% of *E. sativa*. The study indicated that to improve faba bean production, the application of 40% of *E. sativa* showed the best plant performance. Therefore, using *E. sativa* aqueous extract as commercial fertilizer is recommended for improving the production of faba beans. Plant fertilizers that degrade quickly are safer than persistent synthetic chemical fertilizers, less harmful to the environment, decrease production costs, and are not causing chemical resistance in the environment.

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المستخلص المائي لنبات الجرجير (*Eruca sativa Mill*) كمحفز للنمو في تعزيز نمو وإنتاجية نبات الفول (*Vicia faba L*)

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المستخلص:. لمعرفة قدرة المستخلص المائي لنبات الجرجير (*Eruca sativa* Mill) كونه محفزا للنمو في تعزيز نمو وإنتاجية نبات الفول (*Vicia faba* L)، تم إجراء دراسة حقلية خريف 2019. أجريت الدراسة باستخدام تربة رملية في إحدى مزارع منطقة أبوعيسى، وقد اتبعت الدراسة نظام التصميم العشوائي الكامل (RCD) بأربعة مكررات وبمساحة 3x5م^2 وبمسافة 25سم بين الأسطر. وفقا لذلك، تمت معاملة نباتات الفول بثلاث معاملات وتشمل: عدم الرش بالمستخلص المائي لنبات الجرجير (الشاهد)، رش الأوراق بنسبة 20٪، و40٪ من المستخلص المائي لنبات الجرجير *E.sativa*. تم رش اوراق نباتات الفول (*Vicia faba* (L) ست مرات بالمستخلص المائي لنبات الجرجير *E.sativa* بنسبة 20٪، و40٪ في المرحلتين الخضرية والزهرية. أظهرت النتائج أن الرش الورقي لنبات الفول بالمستخلص النباتي لنبات الجرجير بتركيز 40٪ أدى إلى الزيادة في ارتفاع النبات بنسبة 32٪، وعدد الأفرع بنسبة 73٪، وعدد الأوراق بنسبة 95٪، وعدد البذور لكل نبات بنسبة 89٪، ووزن الأوراق والسيقان والقرون والجذور الجافة بمقدار 92٪ ، 80٪ ، 74٪ ، 89٪ على التوالي. واستنتجت الدراسة إمكانية استعمال المستخلص المائي لنبات الجرجير *E. sativa* بكفاءة من قبل منتجي المحاصيل بوصفه محسنا لنمو محاصيل الفول؛ بسبب إنتاجيته الكبيرة، القيمة الغذائية للنبات، وانخفاض التكلفة إضافة إلى كونه مركبا صديقا للبيئة.

الكلمات المفتاحية: الفول *Vicia faba* L، المستخلص المائي، نبات الجرجير *Eruca sativa* Mill ، النمو، إنتاجية المحصول.

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