ARTICLE / INVESTIGACIÓN

Allelopathic effect of sunflower residues on some soil properties and growth parameters of wheat, bean and flax crops

Taisir M. Flayyih, Ahmed A. Almarie*

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Field Crops Department, College Of Agriculture, University Of Anbar- Anbar, Iraq.
Corresponding author: ag.ahmed.abdalwahed@uoanbar.edu.iq

Abstract: Allelopathic effects of the sunflower verities *Helianthus annuus* residues were evaluated on some soil properties and their potential against growth parameters of the proposed successive crops Wheat *Triticum aestivum* L., Broad Bean *Vicia fabe* L. and Flax *Linum Ustatissmim* L. Sunflower plants were chopped and incorporated with field soil after getting seed, and then successive crops were cultivated. The sunflower residues have reinforced the soil with the macronutrients considered essential for the germination of any crop. The soil organic matter content and the percentage of organic carbon in the ground were increased. Significant suppression of broad bean and flax crops was observed, while the sunflower residues did not affect wheat growth. The results obtained showed that broad bean and flax crops are not recommended to grow after the sunflower crop to avoid losses due to the negative allelopathic potential of these crops. Sunflower residue incorporation may provide multidimensional benefits for better weed control, enhanced soil health, and higher seed yield of wheat.

Key words: Allelopathic effect, Sunflower residues, Succssesive crops, Crop injury symptoms.

Introduction

Allelopathy is the chemical interaction between plants or plants with microorganisms that lead to either positive or negative effects on the performance of neighboring organisms. Allelopathy plays a significant role in natural ecosystems by determining vegetation patterning, plant dominance, plant succession, and plant biodiversity, preventing seed decay, and causing seed dormancy[1]. Allelopathy plays an essential role in the study of suitable agricultural systems as well as in weed control[2]. Also, allelopathy has a significant role in agricultural ecosystems. It plays a substantial role in weed-crop, crop-weed, crop-crop, forestry and nutrient cycling[3]. Sunflower is an annual dicotyledonous plant that can be grown throughout the year in subtropical and tropical regions for its seeds. The allelopathic potential of sunflowers is presented to inhibit the growth and development of other plants. The allelopathic effects of sunflower plants on successive crops and soil properties vary from stimulation to inhibition depending on the quantity and quality of the bioactive compounds in this plant and their residues.

Over 200 natural bioactive compounds include allelopathic compounds characterized in sunflower plants. Most of these compounds inhibit or stimulate the germination and growth of organisms. Heliannuols, terpenoids, flavonoids, chlorogenic acid, chlorogenic acid, and scopoletin were the most bioactive compounds found in sunflower plants[4]. Moreover, sunflower residues contribute to increasing the soil's organic matter, and thus becoming a natural organic fertilizer provides the soil with the necessary elements without the need for chemical fertilizers. The demeanor of sunflower residues towards successive crops is unclear and needs more in-depth studies. Hence, the current study aims to screen the allelopathic effect of three sunflower varieties on the growth parameters of successive crops and their content from essential nutrients in trying to minimize the use of conventional chemical fertilizers. Purvis *et al.*, 1990[5] reported that sunflower crop residues reduced wheat germination and growth by 4-33%. As for the remaining sunflower residues on the surface of the soil and leaving them without plowing, it often reduced the development of the crops that were planted after them compared to the removal of residues or traditional plowing. At the same time, wheat productivity increased in the non-cultivated treatments, reaching 5.2 tons. ha^{-1} When mixed with soil and plowing, the productivity decreased to 4.9 tons/ha. The sunflower crop residue in the soil reduced harmful weed growth early and, when mixed with soil, reduced the yield of later crops[6].

Materials and methods

The field experiment was conducted in the agro-station belonging to the college of Agriculture- University of Anbar-Iraq, which is located at 43.39 latitudes and 33.44 longitudes. In brief, three varieties of sunflowers, Sakha, Akmar and Ishaki, were grown in plots with a 70 cm distance between rows and 20 cm between plants inside the row. When plants reached the maturity stages, plans were chopped after getting the seeds and mixed well with the field soil. The proposed successive crops, Wheat *Triticum aestivum*, Broad bean *Vicia fabe* and Flax *Linum Ustatissmim*, were cultivated in the same plots of sunflower plants parts were mixed. Seeds of the Ibaa 99 wheat variety were grown in 3m rows with 20 cm between each other.

Regarding flax plants, using local variety with 3m row length and 25 cm between each other. Broad bean seeds

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were cultivated in 3 m rows with 25 cm in between holes. Weedy check and free weed treatments of successive crops are used as controls. Weed plants were continuously removed from treatments throughout the growing season to ensure that just the sunflower's allelopathic potential affected the consecutive crops.

Soil Nutrient Analysis

Samples were taken from the field's soil from a depth of 0 to 30 cm after mixing the sunflower crop for four weeks to evaluate the changes in the soil nutrients compared to the control treatment. The analysis was conducted in the central laboratory belonging to the college of Agriculture- at the University of Anbar.

Successive crops growth parameters

The injury score of successive crops was estimated beginning from cultivation until the fifth week from germination by eye observation using a numerical scale from (0–5) as 0: no harm, 1: slight yellowing, 2: yellowing or burning, or visible dwarfing, 3: yellowing, burning or severe spotting, 4: semi-dead plants and 5: complete plant death. When successive crops reached maturity, growth parameters were taken.

Experimantal analysis

Experimental data were subjected to one analysis of variance (ANOVA) using the SASS system, version (9). The experiment was conducted in (RCBD) design with four replications. The differences between mean values were determined using Dunkin's range test ($P \leq 0.05$)[7].

Results

Soil Nutrient Analysis

Data is presented in Table 1. Showed some soil properties for the experimental field according to the samples taken at 2, 4 and 6 weeks after mixing sunflower residues compared with the controls. As can be seen, most treatments have differed significantly compared to the management. The sunflower residues enhanced soil properties by increasing the essential nutrients, NPK. Moreover, organic matter increased in soil and growing ranges from 44 to 143%. The same is true for the organic carbon and C/ N ratio, which witnessed a significant increase in all treatments.

Crop Injury Score

The injury score of the proposed successive field crops is presented in Figure1. Wheat plants were represented by changing the green color to a pale green color due to the damage that occurred to the plant due to sunflower residues. Regarding the Broad bean crop, the injury score in this plant affected by sunflower residues behaved the same as wheat plants except for slight dwarfing, but the general condition of the plant is rather good. Regarding flax crops, plants showed more sensitivity to the sunflower residues in all three varieties.

Crop Growth Parameters

As can be seen from the data presented in table 2., most of the study growth parameters of the wheat crop were enhanced by the residues of the three sunflower varieties. Although plant high and flag leaf area treats of wheat crop did not show a significant difference within the studies treatments, the weedy check recorded the highest value of plant high, which was 91.6 cm and the most negligible value of flag leaf area, which was only 29.36 cm. Also, the weedy check treatment recorded the lowest values compared to the other studied traits.

Table 3 shows the negative effect of all studies' treatments regarding the broad bean crop. The wide bean plant cultivated after mixing sunflower residues suffers from these treatments. The high of broad bean plants did not reach significant variations in all treatments. However, the plants growing in the weedy check treatment recorded the highest value of plant high, which was 85.33 cm. The other studied traits presented in Table 3. appeared that the free weed treatment was the highest in terms of the superiority of the studied features, which differed significantly from the sunflower residues treatment, which came less than expected as a result of the negative effect of sunflower residues on this crop.

As for the flax plants grown after the sunflower resi-

Treatments	Duration	K mg.kg^{-1}	p mg.kg^{-1}	N mg.kg^{-1}	Organic Matter	Organic Carbon	C/N Ratio
Sakha	2 Weeks	434	50.0	1843	1.11	5.16	19.1
Akmar		343	50.0	2396	1.16	4.53	18.5
Ishaqi		401	64.6	2796	1.40	6.1	39.5
Sakha	4 Weeks	521	49.7	1256	1.19	5.6	39.8
Akmar		405	26.5	1555	2.00	5.0	32.0
Ishaqi		394	29.0	1549	2.10	8.3	31.3
Sakha	6 Weeks	432	43.0	2422	1.30	5.6	31.0
Akmar		419	70.0	1430	1.54	7.9	35.0
Ishaqi		418	71.0	1177	1.61	6.2	37.3
Control		17.6	16.2	92	0.67	2.42	14.5
L.S.D. : 0.05		174	24.2	361	0.38	1.48	14.3

Table 1. Soil properties of the field according to the samples taken at 2, 4 and 6 weeks after mixing sunflower residues compared with the controls.

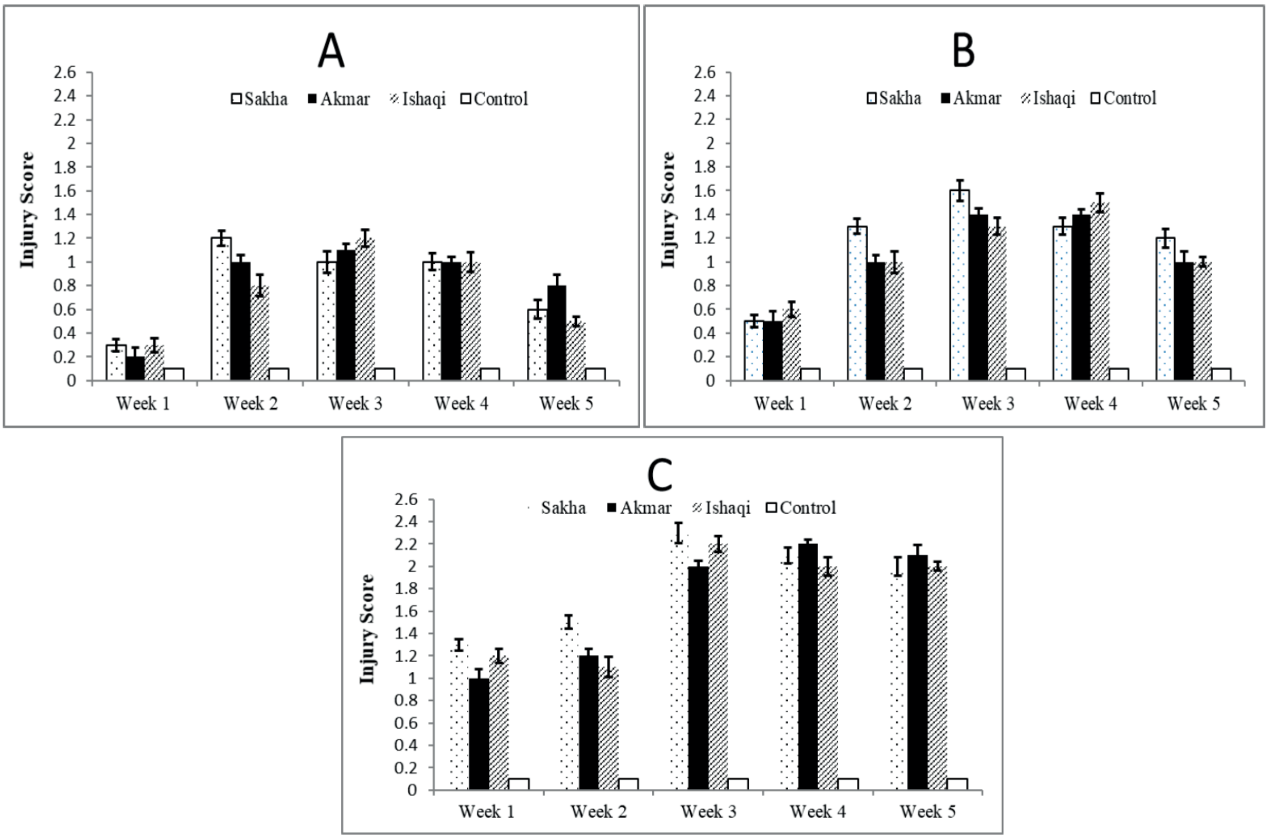

Figure 1. Injury symptoms of proposed successive crops affected by three varieties of sunflower residues mixed with soil field A: Wheat, B: Broad bean, C: Flax. Scale from (0–5) 0: no harm, 1: slight yellowing, 2: yellowing or burning, or visible dwarfing, 3: yellowing, burning or severe spotting, 4: semi-dead plants and 5: complete plant death.

Treatment	Plant High cm	Flag leaf Area cm^2	Dry matter of vegetative part (g)	Total yield Ton.ha^{-1}
Sakha	76.70	31.43	10.81	5.32
Akmar	74.17	33.23	10.75	5.31
Ishaki	80.43	31.73	11.86	5.07
Weedy Check	91.60	29.36	7.98	4.11
Free Weed	79.49	34.03	12.57	4.97
L.S.D: 0.05	N.S.	N.S.	2.1	0.823

Table 2. Allelopathic effects of sunflower residues on growth parameters of wheat.

Treatment	Plant High cm	leaf Area cm^2	Dry matter of vegetative part (g)	Total yield Ton.ha^{-1}
Sakha	62.33	2277	11.98	2.95
Akmar	57.80	2390	7.75	3.86
Ishaki	76.26	2328	7.01	4.63
Weedy Check	85.33	2162	6.44	4.20
Free Weed	76.86	2669	7.62	5.30
L.S.D: 0.05	N.S.	218.6	1.32	1.20

Table 3. Allelopathic effects of sunflower residues on growth parameters of Broad bean.

Treatment	Plant High cm	Number of leaves per plant	Dry matter of vegetative part (g)	Total yield Ton.ha^{-1}
Sakha	62.3	85.0	2.35	0.837
Akmar	58.1	94.0	2.40	0.979
Ishaki	55.8	84.3	2.47	0.843
Weedy Check	96.0	114.0	3.73	0.754
Free Weed	104.3	166.7	11.33	1.380
L.S.D: 0.05	13.65	20.94	0.70	0.406

Table 4. Allelopathic effects of sunflower residues on growth parameters of Flax.

dues, the same trend of the broad bean plants was sculpted regarding the negative impact of these residues in all the studied traits. The results shown in Table 4 showed that the treatments were significantly different from the free weed treatment, which come in the highest values of characteristics.

Discussion

Soil Nutrient Analysis

The sunflower residues increased the amount of the essential nutrients for plant growth (NPK) and those necessary nutrients beneficial for the activity of microorganisms and their proportions. The results align with the results of Ullah *et al.*, 2018[9] which confirmed that sunflower residue incorporation at 6 ton ha^{-1} improved soil health, suppressed weeds and resulted in better seed yield of spring-planted mung bean. Returning soil fertility naturally is desirable as it is one of the promising strategic solutions to provide it naturally without using chemical fertilizers, which negatively affect the properties of the soil[10]. The extreme extravagance in adding chemical fertilizers to the soil in quantities that exceed the needs of the plant and at unsuitable dates for the growth stage of the crop leads to the destruction of the balance in the soil between the elements of the plant's food and creates an unbalanced environment for the growing plants in addition to the possibility of an imbalance that harms the biological diversity in the soil.

Crop Injury Score

Various crop sensitivity to the sunflower residues is due to genetic factors related to genetic variation. Many researchers concluded that the field crops grown after sunflowers were affected diversely, and the degree of the effect depended upon the extract's concentration and the sunflower biomass in the field soil[11].

Crop Growth Parameters

The results in Table 2. indicated the positive effect of sunflower residues on growth characteristics and seed yield of the wheat crop as a result of the positive response to those residues. This comes as an expected result of the response to improving the soil with the necessary elements needed by the wheat crop, which helped in its healthy development and growth, thus improving yield and quality. The current results are consistent with (12,13), who mentioned that the wheat crop is suitable for cultivation under sunflower allelopathic stress. The results of the broad bean and flax crop response came to the exact opposite of the results achieved in the wheat crop, as shown in Tables 3 and 4. Despite the revitalization of the soil with the necessary elements by the sunflower residues, the allelopathic effect was negative by reducing the growth parameters, which affected the reduction of seed yield. Over 200 natural bioactive compounds include allelopathic compounds characterized in sunflower plants. Most of these compounds are involved in inhibiting or stimulating germination and growth of organisms, such as heliannuols, terpenoids, flavonoids, chlorogenic acid, chlorogenic acid, and scopoletin, most bioactive compounds found in the sunflower plants[14].

Conclusions

Sunflower residues are a valuable source of nutrition and play an efficient role in sustainable crop production. Not all successive crop shows a positive response to sunflower residues because the allelopathic substances which secrete them, in turn, play a positive or negative role on the subsequent crops. The improvement in soil properties and suppression resulted in better wheat yield. On the contrary, it negatively affected the growth parameters and yield of bean and flax crops. In short, sunflower residue incorporation may provide multidimensional benefits for better weed control, enhanced soil health and higher seed yield of wheat. More studies are needed to determine the allelopathic effects of sunflower residues on different successive crops.

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