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The Allelopathic Potential Effect of Winter Crops on Biochemical Constituents and Productivity of Cotton

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Allelopathy is an important mechanism of plant interference mediated by the release of plant-produced secondary metabolites or decomposition products of microbes to the aerial or soil environment. Its potential effect (promote or inhibit) of onion, clover, barley and garlic soil residues on germination percentage, seedling growth, leaves chemical constituents, yield components and fiber properties of cotton Giza 97 cultivar was studied by using seed-after-seed protocol. The allelopathic potential winter crop residues significantly affected all study parameters. Sowing cotton after onion, clover and garlic residues enhanced seed germination, seedling growth, metabolic activities yield components and fiber properties in 2021 and 2022 seasons compared with control. These might be related to the presence of promoter substances (allelochemicals) improving cotton germination, growth and development. Conversely, cotton planted after barley residues showed a reduction in germination, seedling growth, leaves chemical constituents and yield in both seasons compared to control. These might be attributed to the high concentration of phenols and flavonoids in barley residues causing repression of germination, growth and development of cotton. Onion residues achieved the best positive effect (above the control) on cotton germination (4.99 and 3.98%), seedling fresh weight (18.21 and 16.68%), boll weight (14.01 and 19.59%) and seed cotton yield (32.26 and 43.01%), respectively, in both seasons compared to fallow plants. Barley residues achieved the lowest negative results (below the control) for cotton germination (9.42 and 13.34%), seedling fresh weight (13.6 and 16.46%), boll weight (8.28 and 6.75%) and seed cotton yield (13.73 and 13.22%), respectively, in both seasons compared to fallow plants.

Keywords: Allelopathic potential; Cotton; seedling growth; leaves chemical constituents; yield

1. Introduction

Allelopathy is any process including secondary metabolites produced via plants, bacteria, algae, fungi and viruses that can influence plant growth, development and a biological system (Galon *et al.,* 2021). Also, allelopathy is also defined as the direct or indirect harmful or useful effects of a plant on another. These effects can occur by releasing chemical compounds (allelochemicals) into the soil via root exudation, residual decomposition of plants, leaching and stem flow into the environment (Abbas *et al.,* 2021). Allelochemicals are a mechanism of plant-soil feedback by releasing secondary metabolites into the soil to modify its properties such as maintaining soil moisture, enhancing soil organic matters, C/N ratio and decreasing soil erosion to impact on seedling growth (Kamran *et al.,* 2019 and Ming *et al.,* 2020). The main groups of plants' allelochemical compounds are flavonoids, phenolic compounds, alkaloids, coumarins, glucosinolates, quinones, benzoxazinoids, terpenes and amino acids (Koehler-Cole *et al.,* 2020). Nevertheless, allelochemicals were found to be cytotoxic in high concentrations. The cytotoxic effects can occur through a spectrum of mechanisms such as reduction of ion uptake, mineral nutrients, water absorption, shoot turgor pressure, dry matter production, leaf area expansion, photosynthesis, protein synthesis, enzymes activity and plant’s overall growth (Aslam *et al.,* 2016). Plants' response to cover crops' allelopathic potential depends on the source of allelochemicals (i.e., plant part), allelochemicals concentration and the growth stage of the plant. Allelochemicals can inhibit the growth of some plant

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species at certain concentrations and promote the growth of the same or different species at different concentrations (Ebrahimi *et al.*, 2017).

Onion (*Allium cepa* L.) and garlic (*Allium sativum* L.) extracts have been recorded to possess allelopathic activity (Cheng *et al.,* 2016; Ding *et al.*, 2016). El-Rokiek *et al.* (2018) stated that garlic cloves water extract at lower concentrations improved sunflower growth and yield, but it gave complete inhibition at high concentrations. Zhou *et al.* (2011) observed that garlic root extract at high concentrations inhibited seedling germination and growth of pepper, tomato, lettuce and of cucumber. Abou El-Ghit (2016) noticed that onion and garlic seed and clove extracts at high concentration had significant harmful allelopathic effects on seed germination, metabolic activities and growth parameters of pea seedlings. The inhibition by allelochemical compounds is due to negative effects on iron concentration equilibrium and amino acid metabolism. Xu *et al.* (2013) cited that the decomposed stalk garlic has allelopathic inhibitory effects on lettuce and carrot, whereas improved Chinese cabbage growth. Yuan *et al.* (2012) revealed that garlic root exudates at a high concentration significantly inhibited seed germination and seedling growth of radishes and lettuce.

Clover (*Trifolium alexandrinum* L.) has been documented to process an allelopathic activity because it improves nitrogen (N) availability (direct effect) and biologically controls nematodes in the soil system (indirect effect). Clover could be adopted by farmers to enhance soil fertility and repress weeds in traditional agricultural systems. Kazerooni *et al.* (2013) studied the effect of *T. alexandrinum* extract on some plant species' seed germination and unveiled that the germination percentage decreased with increasing the extract concentration. Ebrahimi *et al.* (2017) deduced that the low concentration of *T. alexandrinum* extracts improved plant seeds' germination and growth of *Peganum harmala*, whereas the high concentration of *T. alexandrinum* extract harmed plant seeds' germination and growth.

Barley (*Hordeum vulgare* L.) is also known for its allelopathic activity because of its allelocemical compounds such as phenols (43%) and terpenes (Ashrafi *et al.,* 2009). The same variety of barley was also found to be autotoxic to other varieties of barley, but not to itself. Leaves and roots were the most phytotoxic parts of barley plant for other plants, which contain the highest source of allelocemical compounds. Maver *et al.* (2020) demonstrated that barley has allelopathic compounds in seeds, residues, or root exudates. These compounds include 44 allelochemical compounds that belong to different chemical classes (alkaloids, cyano-glucosides, phenolics, polyamines) and have been specified as potential allelochemicals that contribute to the allelopathic effectiveness of barley. Bouhaouel *et al.* (2015) reported that the allelopathic potential of Tunisian barley root compounds was tested according to two experimental protocols, namely the ‘seed-to-seed’ where seeds of the allelochemical-donor species were grown together with the receiver species, and a new bioassay named ‘seed-after-seed’ where the donor and the receiver species of allelochemicals were grown sequentially, minimizing resource competition. The inhibitory effect of the compounds emitted by germinating barley seeds was higher in ‘seed-to-seed’ than in ‘seed-after-seed’ experimental protocols. Yet, the allelopathic effect of the ‘seed-after-seed’ method is two-fold.

Therefore, the objectives of this study were to assess the soil content of allelochemical compounds produced by some winter crops residues such as onion, clover, barley, and garlic as well as to investigate the impact of these compounds on cotton plant seedling growth, leaves chemical constituents, seed cotton yield and fiber quality using a seed-after-seed protocol.

2. Material and methods

Experimental design and treatment

This study was carried out to assess the allelopathic potential of some winter crop residues in the soil on cotton plant seeds germination, seedling growth characteristics, leaves chemical constituents, yield components and fiber properties. The study was carried out using the Giza 97cotton cultivar (*Gossypium barbadense* L.) during the 2021 and 2022 seasons. A seed-after-seed protocol was used, where the donor and received crops of allelochemicals were grown sequentially.

Two pot experiments were carried out during the 2021 and 2022 seasons in Giza Station, Agricultural Research Center, Egypt. The seeds of winter cover crops of onion (*Allium cepa* L.), clover (*Trifolium alexandrinum* L.), barley (*Hordeum vulgare* L.) and garlic (*Allium sativum* L.) were sown in pots of 40 cm in diameter, filled with about 20 kg of clay loam soil on November 20th in both seasons. The pots of all winter crops were irrigated regularly once a week.

The all pots of winter cover crops (onion, clover, barley, and garlic) received an adequate amount of

fertilizer (50 units of nitrogen, 30 units of P_2O_5 and 46 units of K_2O), Where the fertilizer equations and the dates of their addition were standardized on all winter crops (to avoid their impact on the allelopathic effect of winter crops on the growth and productivity of cotton). The date of harvesting winter crops is April 11 in both seasons. The plants of such crops were harvested leaving their root systems in the soil (15 days) for decomposition, before cotton sowing to study the allelopathic effects of such roots.
Cotton Giza 97 cultivar seeds were sown in all pots on April 16th in the 2021 and 2022 seasons. Plants were thinned leaving two plants per pot (after 20 days), all pots received an adequate amount of fertilizer (75 units of nitrogen, 24 units of P_2O_5 and 24 units of K_2O) to produce a sound, healthy plants and irrigation were applied regularly at the plant needs. A complete randomized block design with ten replicates was used.

Soil samples

Fallow soil samples were prepared for all experiment treatments and separated for two groups. The first group for winter cover crops' and the second group the control samples (soil left without planting winter cover crops "Fallow soil"). After harvesting the winter cover crops, the soil samples were taken from winter cover crops' pots 15 days after their harvesting before sowing cotton as well as from the fallow sample (control). For soil analysis before planting winter crops is the same as fallow treatment (control) analysis where the sample was taken from the unified soil before being placed in the ground. The soil analysis was conducted according to Rebecca (2004). The chemical composition of such soils is shown in Table (1).

Table 1: Chemical properties of experimental soil after planting some winter cover crops.

Soil after	pH	EC (dS m^{-1})	Available nutrients (mg/kg soil)			Soluble anions (cmolc/kg soil)				Soluble cations (cmolc/kg soil)			
			N	P	K	CO_3^{2-}	HCO_3^-	Cl^-	SO_4^{2-}	Ca^{2+}	Mg^{2+}	Na^+	K^+
2021													
Control	7.73	1.57	45.23	9.46	481.5	--	3.84	5.46	6.69	6.17	3.05	6.27	0.38
Onion	7.92	1.61	49.02	9.85	493.2	--	3.64	5.72	6.58	4.65	2.43	5.24	0.26
Clover	7.84	1.36	52.14	5.63	405.7	--	3.28	4.73	6.16	4.32	1.86	4.51	0.19
Barley	7.63	1.32	31.58	5.16	342.6	--	3.19	4.68	5.87	4.06	1.81	4.38	0.19
Garlic	7.87	1.59	47.53	9.74	486.5	--	3.87	5.77	6.61	4.22	2.11	5.18	0.24
2022													
Control	7.68	1.52	44.89	9.37	477.9	--	3.57	5.13	6.45	5.94	2.87	6.17	0.35
Onion	7.96	1.62	49.57	9.88	494.1	--	3.69	5.81	6.62	4.67	2.48	5.29	0.28
Clover	7.87	1.38	52.36	5.81	406.3	--	3.31	4.79	6.22	4.38	1.91	4.57	0.23
Barley	7.66	1.35	31.32	5.11	340.9	--	3.23	4.72	5.91	4.12	1.86	4.43	0.24
Garlic	7.89	1.60	47.82	9.81	485.2	--	3.92	5.83	6.64	4.25	2.20	5.22	0.25

The soil quality depends on the availability of elements for absorption. The availability of water, nitrogen (N), phosphorus (P) and potassium (K) are the main qualification for cotton production. Consequently, results showed that the allelopathic potential effect of the winter crops residues affected in the soil the content of N, P, K.
Soil analysis after planting winter cover crops and pre-planting of cotton plants indicated that clover and barley planting led to a considerable loss in available phosphorus and potassium in the soil. Therefore, this loss should be recovered by phosphorus fertilizer to produce a balance between vegetative and fruiting growth and prevent excessive growth for the cotton plant.

Seedling growth characters

After 20 days from planting cotton seeds; emergence percentage and seedling growth characters, including seedling length (cm), root length (cm), fresh weight/10 seedling (g) and dry weight/10 seedling (g) were recorded.

Leaves chemical constituents

Leaves from the top apex (third or fourth leaves) were taken (at the start of flowering) with random from cotton plants, for chemical analysis as follow:

- Total chlorophyll and carotenoid content

The total chlorophyll and carotenoid content were estimated by the spectrophotometric method recommended by Arnon (1949) and Robbelen (1957), respectively. Leaf samples (0.3g from each replicate were homogenized in 50ml 80% (v/v) acetone and centrifuged at 10,000 × g for 10min. The absorbance of each acetone extract was measured at 665, 649, and 440nm using a UV-visible spectrophotometer.

-Total soluble sugars content

The total soluble sugar content was determined in leaf ethanol extracts by the phenol-sulfuric acid method according to Cerning (1975). A stranded curve was prepared using different concentrations (10–100 mg/ml) of pure glucose.

- Total phenols content

The total phenols were determined in ethanol of leaves using the Folin-Ciocalteau method according to Simons & Ross (1971). One milliliter of sample was mixed with 1ml of Folin and Ciocalten's phenol reagent, after 3min, 1ml of saturated Na_2CO_3 (14%) was added to the mixture and completed to 10ml by adding distilled water. The reaction was kept in the dark for 90 min, after which the absorbance was read at 725 nm. A calibration curve was constructed with different concentrations of Gallic acid (0.01–1 mM) as the standard.

- Total free amino acids content

The total free amino acid content was determined in the ethanol extract of cotton leaves by the ninhydrin method according to Rosen (1957).

- Total antioxidant capacity

Total antioxidant capacity was determined in ethanol extract of cotton leaves using the phospho-molybdenum method of Prieto *et al.* (1999) as follows: A known volume (0.01 ml) of the extract was added to a test tube then completed to a constant volume (0.3 ml) with DW. 3.0 ml of reagent solution (0.6 M Sulfuric acid, 28.0 mM Sodium phosphate and 4.0 mM Ammonium molybdate) were added to each tube and mixed well then incubated at 95°C for 90 min. Blank was prepared by the same procedure without extract. After cooling to the room, the absorbance of the solution was measured at 695 nm using a spectrophotometer against blank. Increased absorbance of the reaction mixture indicated increased total antioxidant capacity.

Growth characters and yield components

Three samples were taken from four pots at the harvest stage to record growth characters of plant height (cm) and number of fruiting branches/plant and yield components of number of open boll/pot, seed index (g), boll weight (g), lint percentage and seed cotton yield (g/plant).

Fiber technology properties

According to A.S.T.M. (2012) fiber length, micronaire reading and fiber strength were recorded during data collection.

Statistical Analysis

The measured variables were analyzed by variance (ANOVA) and Duncan test at 0.05 probability level by using M Stat-C statistical package (Freed, 1991).

3. Results

Emergence and seedling growth characters

The results in Table (2) revealed that the allelopathic potential of winter crops residues (onion, clover, barley and garlic) significantly affected on emergence percentage and seedling growth characters (seedling length, root length, fresh weight/10 seedling and dry weight/10 seedling) of cotton in 2021 and 2022 seasons.

Data is clear that allelochemical compounds of onion and clover residues in the soil significantly increased cotton seeds germination percentage (promotion effect). However, allelochemicals of barley soil residues caused a significant reduction (inhibition effect) in the cotton seeds germination percentage. Garlic residues did not affect cotton seeds germination percentage in both seasons compared to fallow (control) plants.

The highest cotton seeds germination percentage was registered by allelochemicals of onion residues that exceeded by (4.99 and 3.98%) followed by allelochemicals of clover residues by (3.62 and 2.92%), while allelochemicals of barley residues registered the lowest seeds germination percentage by (9.42 and 13.34%) in both seasons compared to control plants.

The allelochemical compounds of onion, clover and garlic residues in soil improved significantly (stimulating effect) cotton seedling characters (seedling length, root length, fresh weight/10 seedling and dry weight/10 seedling), while allelochemical compounds of barley residues in the soil reduced significantly (inhibit effect) cotton seedling characters in both seasons compared with the control plants.

The allelopathic potential of onion residues gave the maximum positive effect on cotton seedling characters such as seedling length by (13.16 and 10.46%), root length by (14.08 and 24.4%), fresh weight/10 seedlings by (18.21 and 16.68%) and dry weight/10 seedlings by (13.73 and 11.18%), respectively, in both seasons compared to control plants. Conversely, barley allelopathic potential gave the lowest negative percentages for cotton seedling characters such as seedling length by (4.32 and 7.12%), root length by (17.39 and 14.2%), fresh weight/10 seedling by (13.6 and 16.46%) and dry weight/10 seedling by (8.94 and 13.15%), respectively, in both seasons, compared to control cotton plants.

Table 2: Allelopathic effect of winter crops on emergence % and seedling growth of cotton during 2021 and 2022.

Winter crops	Emergence (%)	Seedling length (cm)	Root length (cm)	Fresh weight/10 seedlings (g)	Dry weight/10 seedlings (g)
			2021		
Control	88.72c	16.86c	5.75b	18.23d	3.13ab
Onion	93.15 (+4.99)*a	19.08 (+13.16)*a	6.56 (+14.08)*a	21.55 (+18.21)*a	3.56 (+13.73)*a
Clover	91.94 (+3.62)b	18.54 (+9.96)b	6.25 (+8.69)a	20.15 (+10.53)b	3.42 (+9.26)ab
Barley	80.36 (-9.42)d	16.13 (-4.32)d	4.75 (-17.39)c	15.75 (-13.60)e	2.85 (-8.94)b
Garlic	89.35 (+0.71)c	18.25 (+8.24)b	6.23 (+8.34)a	18.91 (+3.73)c	3.28 (+4.79)ab
L.S.D 0.05	**0.547**	**0.334**	**0.335**	**0.606**	**0.599**
			2022		
Control	89.02c	16.43c	4.22c	17.86c	3.04b
Onion	92.57 (+3.98)a	18.15 (+10.46)a	5.25 (+24.40)a	20.84 (+16.68)a	3.38 (+11.18)a
Clover	91.62 (+2.92)b	17.57 (+6.93)b	5.04 (+19.43)a	19.63 (+9.91)b	3.16 (+3.94)ab
Barley	77.14 (-13.34)d	15.26 (-7.12)d	3.62 (-14.21)d	14.92 (-16.46)d	2.64 (-13.15)c
Garlic	89.86 (+0.94)c	17.24 (+4.93)b	4.75 (+12.55)b	18.25 (+2.18)c	3.11 (+2.30)ab
L.S.D 0.05	**0.514**	**0.403**	**0.269**	**0.500**	**0.318**

*Parentheses show the percentage of promotion or inhibition.

Leaves chemical constituents

The significant allelopathic potential effect of winter crops residues (onion, clover, barley and garlic) on cotton leaves chemical constituents (total chlorophyll, carotenoids, total soluble sugars, total phenolic compounds, total free amino acids and total antioxidant capacity) compared with fallow (control) cotton plants were recorded in Table (3).

The obtained results in Table (3) indicated that a positive allelopathic effect of onion, clover and garlic soil residues on cotton leaves chemical constituents. Whereas the allelopathic effect of barley residues tended to decrease all cotton leaves chemical constituents compared to the control.

Allelopathic potential of onion achieved the highest positive percentage values for cotton leaves cotton chemical constituents; total chlorophyll by 46.98%, carotenoids by 31.46%, total soluble sugars by 14.78%, total phenolic compounds by 15.18%, total free amino acids by 25.6% and total antioxidant capacity by 7.25% compared to control plant. However, barley allelopathic potential displayed the lowest values for cotton leaves chemical constituents; total chlorophyll by 23.36%, carotenoids by 44.72%, total soluble sugars by 6.5%, total phenolic compounds by 19.93%, total free amino acids by 10.37% and total antioxidant capacity by 27.31% compared with control cotton plant.

Yield and yield components

Data in Table (4) deduced that the allelopathic potential of winter crops had a significant effect on growth characters (plant height and number of fruiting branches/plant), yield and its components (number of opened bolls/plant, boll weight, seed index, lint % and seed cotton yield) in both seasons compared to control plant.

The healthy cotton plants were sown after onion, clover and garlic gave high emergence percentages, seedling growth characteristics and leaves chemical constituents. These plants also recorded an increase in growth characteristics, yield and its components compared with control plants in both seasons. On the contrary, sowing barley before cotton resulted in lower growth and yield as compared to control plants in both seasons.

Onion allelopathic potential recorded the best means of growth characters and yield component. The recorded growth characteristics and yield component of onion were exceeded plant height by (25.12% and 16.69%), number of fruiting branches/plant by (32.97 and 28.57%), number of opened bolls/plant by (16.01 and 19.57%), boll weight by (14.01 and 19.59%) and the seed cotton yield by (32.26 and 43.01%) in both seasons, respectively, compared to control plant.

On other hand, the allelopathic barley potential recorded the lowest means of growth characters decreased plant height by (3.05% and 5.75%) and number of fruiting branches/plant by (10.23 and 10.4%), and also yield component of number of opened bolls/plant by (5.91 and 6.93%), boll weight by (8.28 and 6.75%), seed index by (5.34 and 1.81%) and seed cotton yield by (13.73 and 13.22%) in both seasons, respectively, compared to control plant.

Fiber properties

The finding in Table (4) demonstrated that the allelopathic potential of winter crop residues has a significant effect only on micronaire reading, whereas fiber length and fiber strength were not affected significantly in both seasons compared to the fallow (control) plant.

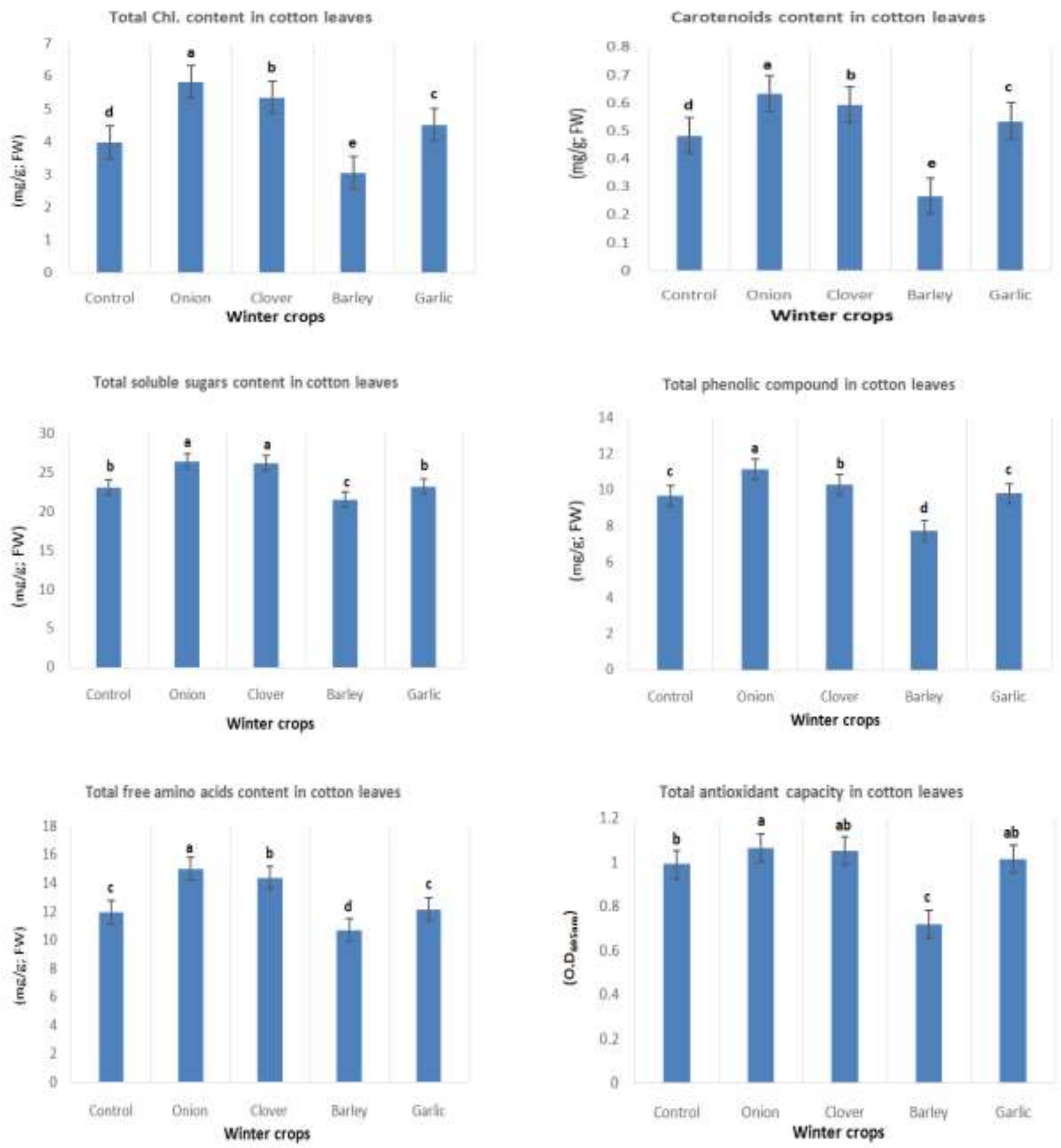

Fig. 1. Allelopathic effect of winter crops on total chlorophyll, carotenoids, total soluble sugars, total phenolic, total free amino acids and total antioxidant capacity contents of cotton leaves.

Emergence and seedling growth characters

Seeds germination stage is the most sensitive stage in cotton growth compared to other stages. Furthermore, cotton plant roots are the first plant part that absorbs allelochemical compounds directly from the soil. Thus, roots are the most affected part of the plant by allelochemicals. Moreover, the allelochemicals' effects depend on their concentration and type of residue. The present results are in accordance with Ebrahimi *et al.* (2017) and Kazerooni *et al.* (2013), who concluded that the corruption of previous plants residues in the soil might harm plant seeds germination and seedling growth by impeding plants' root's ability to absorb water-soluble materials from the soil. This might be related to the release of allelochemical compounds like phenolic acids by plants after their harvesting, these compounds can have harmful effects on plants' germination and growth. Allelochemical compounds of onion, garlic and clover residues in soil showed a positive effect on germination percentage and morphological characteristics of cotton seedlings (seedling length, root length, fresh weight/10 seedlings and dry weight/10 seedlings). Allelochemical compounds and their concentration in the soil might have promoted the metabolic activities and growth regulators content of cotton seedlings resulting in an increase in fresh and dry weights, roots and seedling length. Besides that, onion and garlic have a high degree of stabilization, which elevates their acidity in compared to similar phenolic acids. This acidity affected on plant-microbe interactions that play serious roles in several vital ecosystem processes such as nutrient cycling. Additionally, Legume crops such as clover were found to increase soil fertility, particularly nitrogen content and subsequently the productivity of the following crops. In the present study, clover allelochemical residues showed a positive effect on cotton seed germination and seedling growth. Clover residues might have provided cotton growth with a fixed nitrogen supply produced by nodule bacteria on clover roots. This in turn could have stimulated the vegetative growth of cotton and produced healthy plants. These findings in agreed with Namish (2002), Kazerooni *et al*. (2013), Abou El-Ghit (2016), Koehler-Cole *et al.* (2020). El-Rokiek et al. (2018) illustrated that the reduction in plant growth might be attributed to the high concentration of phenolic and flavonoids (allelochemical compounds) in garlic extract. Ebrahimi *et al.* (2017), documented allelopathic effects of the *T. alexandrinum* extract where an increase in plant dry weight was found with increasing the extract concentration.

Table 4: Allelopathic effect of winter crops on growth characters, yield components and fiber properties on cotton during 2021 and 2022.

Winter crops	Growth characters		Yield components					Fiber properties		
	Plant height (cm)	No. of fruiting branches/ plant	No. of opened boll/pot	Boll weight (g)	Seed index (g)	Lint (%)	Seed cotton yield (g/plant)	Fiber length (mm)	Fiber strength	Micronaire reading
2021										
Control	66.75c	9.28d	16.23c	1.57b	9.17b	39.1ab	25.48d	33.74a	4.41a	10.45ab
Onion	83.52a	12.34a	18.83a	1.79a	9.55a	38.24b	33.70a	34.13a	4.68a	10.84a
Clover	73.18b	11.67b	18.62a	1.64b	9.43a	38.9ab	30.53b	33.96a	4.52a	10.69a
Barley	64.71c	8.33e	15.27d	1.44c	8.68c	39.84a	21.98e	33.15a	4.37a	10.23b
Garlic	67.06c	9.84c	17.16b	1.59b	9.30b	39.0ab	27.28c	33.82a	4.49a	10.57ab
L.S.D 0.05	**5.272**	**0.494**	**0.402**	**0.087**	**0.241**	**1.378**	**1.299**	**N.S**	**N.S**	**0.464**
2022										
Control	65.29cd	8.75d	15.43d	1.48d	8.82bc	39.4ab	22.83d	33.47a	4.08a	10.30ab
Onion	76.19a	11.25a	18.45a	1.77a	9.35a	38.76b	32.65a	34.05a	4.57a	10.72a
Clover	69.35b	10.33b	17.34b	1.63b	9.19a	39.3ab	28.26b	33.82a	4.51a	10.55a
Barley	61.53d	7.84e	14.36e	1.38e	8.66c	40.26a	19.81e	33.10a	4.32a	10.18b
Garlic	66.43bc	9.23c	16.47c	1.54c	8.95b	39.2ab	25.36c	33.64a	4.26a	10.39ab
L.S.D 0.05	**3.985**	**0.475**	**0.555**	**0.052**	**0.228**	**1.337**	**1.536**	**N.S**	**N.S**	**0.432**

4. Discussion

In contrast, our results showed that allelochemical compounds of barley residues caused a reduction in plant germination. This finding may be related to barely residues' influence on hormones that are important in germination like gibberellins. Barely residues may also have altered amylase and proteinase activity affecting the transfer of stored compounds during the germination stage. Also, water-soluble allelochemical compounds of barley residues (phenols and terpenes) in soil were found to prevent mineral uptake by roots plant. This can disrupt plants' cell membrane normal actions which can negatively affect seeds germination and seedling growth of cotton. Bouhaouel *et al.* (2015) deduced that the higher growth inhibition observed in the 'seed-to-seed' protocol, compared with the 'seed-after-seed' one, could be related to the inability of seed-to-seed protocol to reduce the concentration and toxicity of the released barley allelochemicals in soil over time. Allelopathic effects of barley could be altered by the metabolization of allelochemicals by soil microbes into new products with enhanced or reduced toxicity. So, the phytotoxicity of allelochemical molecules could be influenced by both abiotic (physical and chemical) and biotic (microbial) factors (Maver *et al.,* 2020). Price *et al.* (2008) and Shekoofa *et al.* (2020) stated that cover crop extracts reduced cotton radical elongation by 49% reliant on species. The cotton radicle elongation was inhibited by 'wheat' (23%), 'crimson clover' (30%), 'rye' (26%), 'black oat' (34%), 'white lupin'

(40%), black medic' (33%), 'sunn hemp' (35%), 'hairy vetch' (45%) and 'triticale' (28%), which indicates that cover crops can differ in their allelopathic potential.

Leaves chemical constituents

Allelochemicals of winter crop residues can influence on cotton plants' physiological and biochemical processes such as cell wall expansion, cell division, photosynthesis, antioxidant enzymatic activities, protein synthesis and nucleic acids level. Allelopathic effects of onion, clover and garlic were found to promote the photosynthetic pigments at low concentrations. This positive effect of allelochemicals might be attributed to the activation of enzyme synthesis, cofactors required for protein and chlorophyll synthesis, thus increasing the photosynthesis rate, as well as carbohydrates and phenols biosynthesis of the cotton leaves. Allelochemicals can improve plant growth via increasing chlorophyll which might be a secondary effect of allelochemicals (Ebrahimi *et al.*, 2017). A similar trend was reported by Namish (2002), who pointed out that the improvement in sugar content in cotton leaves sown after onion and clover might be due to an increase in hydrolytic enzyme activity which promotes the breakdown of polysaccharides to soluble carbohydrates. Abou El-Ghit (2016) stated that the allelopathic potential of onion and garlic seed extracts at high concentrations caused a gradual reduction of the metabolism of pea seedlings in terms of total chlorophylls, total carbohydrates, soluble proteins, and nucleic acids contents.

Conversely, the reduction in chlorophyll content in cotton leaves via barley residues allelochemicals might be related to the decomposition of chlorophyll and carotenoid pigments or reduction in their synthesis. Reactions and processes like cell division, cell membrane stability and permeability, hormone production, respiration and photosynthesis could be affected by the allelopathic substance. The reduction in total soluble sugar content might be related to the inhibition of carbohydrate formation because of the reduction of the photosynthesis rate. This, in turn, decreases the total phenols content soluble carbohydrate the main precursor for phenol synthesis in plant tissues. Koehler-Cole *et al.* (2020) concluded that phenolic compounds and benzoic acid produced by barley have negative allelopathic effect on plants as they inhibited germination and seedling growth via altering membrane permeability and transport of ions. They also reduced chlorophyll contents by damaging the thylakoid membrane. Phenolic compounds (e.g. ferulic acid) inhibited protein synthesis and photosynthesis by reducing the assimilation of certain amino acids into proteins. Allelopathic compounds also acted as an intermediate in some plant hormones synthesis and degradation, for example, a phenolic compound (ferulic acid) was found to activate abscisic acid synthesis and dihydroflavononenaringenin degraded the indole-3-acetic acid (Maver *et al.,* 2020).The obtained results are in line with those of Abou El-Ghit (2016), Singh and Sunaina (2014), who deduced that allelochemicals could reduce cellular ATP content through inhibition of electron transport and oxidative phosphorylation, as well as change membrane permeability property compared to inorganic ions uptake.

Yield components and fiber quality

Results showed that the allelopathic potential of winter crop residues of onion, clover, barley and garlic affected on cotton yield component and fiber quality properties. The results illustrated that the improvement of cotton yield components after onion, clover and garlic might be related to the allelochemical compounds produced from the residues of their roots promoted cotton seedling growth, development, photosynthesis and carbohydrates contents. However, the negative effect of allelopathic barley soil residues on cotton yield components and fiber quality might be linked to the reduction of photosynthesis rate, and thus plant growth caused by the allelochemical compounds ending in impairment of seedling growth and leaves chemical constituents. Sun and Liu (2019) deducted that low concentrations of onion residues did not have any adverse effect on cotton seedling growth. Moreover, they improved cotton plant growth and increased its yield in intercropping. Cotton intercropped with onion could decrease the accumulation of phenolic allelochemicals in the soil. Phenolic compounds are important allelochemicals that can affect plant growth and yield. Baber *et al.* (2009) stated that different plant extracts had mutable allelopathic effects on different organs of the same plant. This might be attributed to the quantities and types of allelochemicals existing in different crop extracts, for example, the wheat seedling was found to be inhibited by the high concentration of wild onion extract. Allen *et al.* (2012) mentioned that using wheat and rye as cover crops in the rotation decreased cotton growth, seed yield and cotton lint due to rye and wheat allelopathic potential on cotton plant growth and yield.

5. Conclusion

Conservational agriculture systems that use high residue cover crops offer many advantages, including enhanced water leakage, decreased soil water evaporation, improved soil organic matter and increased soil biodiversity. The allelopathic effects are selective, depending upon the concentrations and residue type, either inhibitory or stimulatory to the growth of companion or subsequent crops. The allelochemicals released from crop residues in the soil are likely to cause positive or harmful effects on the proceeding crops, and thus stimulate or inhibit seed germination, seedling growth, leaves chemical constituents and yield components. Onion, clover and garlic allelopathic potential affected positively in cotton germination%, seedling growth, chemical constituents, yield components and fiber quality in both seasons. Conversely, barely allelopathic potential had negative effects on cotton germination%, seedling growth, chemical constituents, yield components and fiber quality it might be related to the effect of high concentrations of allelochemical compounds such as phenols and flavonoids that decreased seed germination, growth and photosynthesis rate of cotton and thus reduced yield and fiber quality.

6. References

A.S.T.M. (1975). American society for testing and materials. Standard on textile materials (D 1448-59 and D 1445-67). The society, Washington, Philadelphia, U.S.A.

Abbas, A., Huang, P., Hussain, S., Saqib, M., He, L., Shen, F. and DU, D. (2021). Application of allelopathic phenomena to enhance growth and production of *camelina* (*Camelina sativa* L.). *Applied Ecology and Environmental Research*, 19(1), 453-469.

Abou El-Ghit, H.M. (2016). Physiological Allelopathic Effect of Aqueous Extracts of Cucumber, Carrot, Onion, and Garlic Seeds on Germination and Growth of Pea. *Journal of Pharmaceutical, Chemical and Biological Sciences*, 4(1), 13-19.

Allen, V.G., Brown, C.P., Kellison, R., Green, P., Zilverberg, C.J. and Johnson, C.J. (2012). Integrating cotton and beef production in the Texas southern high plains: I. Water use and measures of productivity. *Agron. J.*, 104, 1625–1642.

Arnon, D.I. (1949) Copper enzymes in isolated chloroplasts: polyphenol oxidase in Beta vulgaris, *Plant Physiology*, 24(1), 1-15.

Ashrafi, Z.Y., Mashhadi, H.R., Sadeghi, S. and Alizade, H.M. (2009). Inhibitive effects of barley (*Hordeumvulgare*) on germination and growth of seedling quack grass (*Agropyrumrepens*).*Icelandic Agricultural Sciences*, 22, 37-43.

Aslam, F., Khaliq, A., Matloob, A., Tanveer, A., Hussain, S. and Zahir, Z.A. (2016). Allelopathy in agro-ecosystems: a critical review of wheat allelopathy-concepts and implications.*Chmoecology*, DOI 10.1007/s00049-016-0225-x.

Baber, B.H., Aziz, A.T., Javaid, M.M., Tahir, M., Sibtatn, M., Khaliq, A. and Pacanoski, Z. (2009). Phytotoxic influences of *Asphodelustenuifolius* Cav (wild onion) on germination and seedling growth of wheat. *Allelopathy Journal*, 2, 341-350.

Bouhaouel, I., Gfeller, A.L., Fauconnier, M., Rezgui, S., Amara, H. S., Jardin, P. (2015). Allelopathic and autotoxicity effects of barley (*Hordeumvulgare* L. ssp. *vulgare*) root exudates. *Bio Control*, 60,425–436.

Cerning, B.J. (1975) A note on sugar determination by the anthrone method. *Cereal Chemistry*, 52, 857-860.

Cheng, F., Cheng, Z.H. and Meng, H.W. (2016). Transcriptomic insights into the allelopathic effects of the garlic allelochemical diallyl disulfide on tomato roots.*Sci. Rep*. 6, 38-49.

Ding, H., Cheng,Z., Menglong, L., Hayat, S. and Feng, H. (2016). Garlic exerts allelopathic effects on pepper physiology in a hydroponic co-culture system. *Biology Open*, 5(5),631–637.

Ebrahimi, M., Maryshany, A.R., Shirmohammadi, E. (2017). Allelopathy Effects of *Trifolium alexandrinum* L. on Germination and Nutrient Uptake in Medicinal Plant *Peganumharmala* L. *Journal of Medicinal Plants and By-products*,1,71-79

El-Rokiek, K. G., El-Masry, R.R., Ahmed, S.A.A., Mohamed, S. A. and Messiha, N.K. (2018). Allelopathic effects of *Allium sativum* cloves on growth and yield of *Helianthus annuus* plants associated *Cyperusrotundus*. *International Journal of Environment*, 7(3), 78-86.

Freed, R.D. (1991). M Stat-C microcomputer statistical program. *Michigan State Univ.*, East Lansing, Michigan, USA.

Galon, L., Rossetto, E. R., Zanella, A. C. E., Brandler, D., Favretto, E. L., Dill, j. M., Forte, C. T. and Müller, C. (2021). Allelopathic potential of winter and summer cover crops on the germination and seedling growth of *Solanumamericanum*. *International Journal of Pest Management*, 1, 33-41.

Kamran, M., Cheema, Z.A., Farooq, M., Ali, Q., Anjum, M.Z., Raza, A. (2019). Allelopathic influence of *sorghum* aqueous extract on growth, physiology and photosynthetic activity of maize (*Zea mays* L.) seedling. *Philipp Agric Sci*., 102, 33-41.

Kazerooni, M.S., Tokasi, M., Banayan, A.M. (2013). Study of allelopathic effects of berseem clover (*Trifolium alexandrinum*) shoots aqueous extract on germination and initial seedling growth of some weed species.*J Plant Prot.*;27,509-512.

Koehler-Cole, k., Everhart, S.E., Gu, Y., Proctor, C.A., Marroquin-Guzman, M., Redfearn, D.D. and Elmore, R.W. (2020). Is allelopathy from winter cover crops affecting row crops? Agric. Environ. Lett. https://doi.org/10.1002/ael2.20015, 6P

Maver, M., Miras-Moreno, B., Lucini, L., Trevisan, M., Pii, Y., Cesco, S., (2020). New insights in the allelopathic traits of different barley genotypes: Middle Eastern and Tibetan wild-relative accessions vs. cultivated modern barley. *PLo. SONE*; 15(4), e0231976.

Ming, Y., Zhu, Z. J., Li, J., Hu, G. X., Fan, X. M. and Yuan, D. Y. (2020). Allelopathic Effects of *Castaneahenryi* aqueous extracts on the growth and physiology of *Brassica pekinensis* and *Zea mays*. *ChemBiodiv.*, DOI: 10.1002/cbdv.202000135.

Namish, A.A. (2002). The allelopathic effect of some winter crops on some endogenous compounds and its relation to cotton growth characters and yield. *Minufya J. Agric. Res*., 27(3), 436-474.

Price, A.J., Stoll, M.E., Bergtold, J.S., Arriaga, F.J., Balkcom, K.S. and Kornecki, T.S., Raper, R.L. (2008). Effect of cover crop extracts on cotton and radish radicle elongation. *Commun. Biom. Crop Sci*., 3, 60–66.

Rebecca, B. (2004). Soil survey methods manual. *Soil Survey Investigations Report*. No.42 Natural resources conservation services.

Robbelen, G. (1957). Ztscnrunter suchungenan strahleninduzierten blalttarbumtaten von *Arahidopsis thaliana* (L.) Heynt. Z. *Indutet Absbanm u Verbungaleherett*, 88, 189-202.

Rosen, H. (1957). A modified ninhydrincolormetric analysis for amino acid nitrogen.*Archives of Biochemistry and Biophysics*, 67(1), 10-15.

Shekoofa, A., Safikhan, S., Raper, T. B. and Butler, S.A. (2020). Allelopathic impacts of cover crop species and termination timing on cotton germination and seedling growth. *Agronomy*, 10, 638-648.

Simons, T.J., Ross, A.F. (1971). Change in phenol metabolism associated with enclosed systemic resistance to tobacco mosaic Virus Samson NN tobacco. *Phytopathology*, 61, 1261- 1265.

Singh, N.B, Sunaina, A. (2014). Allelopathic Stress produced by bitter gourd (*Momordicacharantia* L.). *J. Stress Physiol. Biochem*; 10(2), 5-14.

Sun, X.Z. and Liu, J.G. (2019).Allelopathic effects of onion and cumin on cotton growth and soil phenolicscontent. *Allelopathy Journal*, 47 (1), 137-148.

Xu, H., Cheng, Z., Meng, H., Yang, X. and Ahmad, I. (2013). Allelopathic effect of decomposed garlic (*Allium sativum*) stalk on lettuce (*L. sativa* var.*crispa* L.). *Pak. J. Bot.*, 45(1),225-233.

Yuan, J., Junshan, Q., Zhang, B., Zhang, Y., Feng, K., Qu, Z. and Li, C. (2012). Allelopathic effects of garlic root exudates on germination and seedling growth of some crops and to control *Pythium* species. *Allelopathy Journal*, 29(2), 242-249.

Zhou, Y., Wang, Y., Li, J. and Xue, Y.J. (2011). Allelopathy of garlic root exudates. *Yingyong Shengtai Xuebao*, 22(5), 1368-1372.

التأثير الأليلوباثي المحتمل للمحاصيل الشتوية على المكونات البيوكيميائية وإنتاجية القطن

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يعتبر الأليلوباثي آلية مهمة لتداخل النباتات بواسطة إطلاق مركبات ثانوية من النباتات المنتجة أو نواتج التحلل الميكروبي للبيئة الهوائية أو التربة. تم دراسة تأثير القدرةا لأليلوباثي (يعزز أو يمنع) لبقايا محاصيل البصل، البرسيم، الشعير والثوم فيا لتربة باستخدام بروتوكول البذور – بعد –البذور علي نسبة الإنبات، ونموا لشتلات، والمكونات الكيميائية للأوراق، ومكونات المحصول وخصائص ألياف القطن لصنف جيزة ٩٧. حيث أثرت القدرةا لأليلوباثية لبقايا المحاصيل الشتوية بشكل معنوي علي جميع الصفات تحت الدراسة. أشارت النتائج إلى أن زراعة القطن بعد بقايا البصل والبرسيم والثوم أدي إإلي تحسين نسبة إنبات البذور ونمو البادرات والأنشطة الأيضية ومكونات المحصول وخواصا لألياف في موسمي ٢٠٢١ و ٢٠٢٢ مقارنة بالنباتات الكنترول. وذلك يرجع إلي إحتواء بقايا النباتات الشتوية علي المزيد من المواد المحفزة (الأليلوكيميائيات) التي تحسن إنبات القطن ونموه وتطور القطن. على العكس من ذلك، أدى زراعة القطن بعد مخلفات الشعيرإلى نقص نسبة الإنبات ونمو الشتلات والمكونات الكيميائية للأوراق والمحصول في كلا الموسمين مقارنة بالنباتات الكنترول، حيث أدى التركيز العالي لمركبات الأليلوكيميائيات (الفينولات والفلافونويدات) في بقايا الشعير إلى إنخفاض إنبات ونمو وتطورالقطن. القدرة الأليلوباثية لبقايا البصل حققت أعلي تأثير إيجابي على إنبات بذور القطن (٤,٩٩ و ٣,٩٨٪) ،ووزن البادرات الرطب (١٨,٢١ و ١٦,٦٨٪)، ووزن اللوز (١٤,٠١ و ١٩,٥٩٪) ومحصول القطن (٣٢,٢٦ و ٤٣,٠١٪) على التوالي. في كلا الموسمين مقارنة بالنباتات الكنترول. علي العكس من ذلك، القدرة الأليلوباثية لبقايا الشعير حققت أقل نتائج على إنبات بذورالقطن (٩,٤٢ و ١٣,٣٤٪) ،ووزن البادرات الرطب (١٣,٦ و ١٦,٤٦٪)، ووزن اللوز (٨,٢٨ و ٦,٧٥٪) ومحصول القطن (١٣,٧٣ و ١٣,٢٢٪) على التوالي. في كلا الموسمين مقارنة بالنباتات الكنترول.