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Allelopathic effects of *Allium sativum* cloves on growth and yield of *Helianthus annuus* plants associating *Cyperus rotundus*

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ABSTRACT

Two pot experiments were carried out in the greenhouse of the National Research Centre, Dokki, Giza, Egypt, in the two successive summer seasons, 2015 and 2016 to study the allelopathic potentiality of garlic cloves water extracts (gcwe) on sunflower growth and yield as well as its effect on the growth of purple nutsedge associating garlic plants. Treatments were applied by the spraying of garlic cloves water extracts (gcwe) at 15, 30, 45 and 60 %. The results showed that sunflower growth and yield exhibited the most increase at lower concentrations of garlic cloves water extract. On the other hand, purple nutsedge growth showed complete inhibition with the high concentrations. The results suggested the use of garlic cloves water extract as an alternative to the use of herbicides for controlling purple nutsedge associating sunflower plants.

Key words: garlic cloves extract, sunflower, purple nutsedge.

Introduction

Allelopathy is a natural process in which plants interact with other plant species through releasing allelochemicals into the environment, hence affecting the growth of each other (Rice, 1984). Many higher plant species contain chemicals with an allelopathic activity in different parts (Duke *et al.*, 2000). Under certain conditions, these allelochemicals are released into environment, either as exudation or through decomposition of plant residues that affect the neighboring plants (Einhellig, 2004). This effect may be positive or negative (Zhou *et al*., 2011).

Sunflower (*Helianthus annuus* L.) is considered one of the most important oil crops (annual statistical report of the Ministry of Agriculture and Land Reclamation in Egypt). Weeds compete for water, nutrients, light and space and consequently caused reduction in sunflower yield. Purple nutsedge is the world's worst weed (Horowitz, 1992). The main propagative way of purple nutsedge is through the basal bulbs and tubers (Nishimoto, 2001). Purple nutsedge caused serious losses when compete with crops (William and Hirase, 2005). In, general the reduction in sunflower yield due to weed competition ranged from 18.6 to more than 60 % (Dawood *et al*., 2012). So, weeds are considered to be a dangerous problem. So, effective management of weeds is the strategy for increasing and producing high sunflower yield and accordingly increasing oil production.

Garlic (*Allium sativum* L.), a species of the genus *Allium*, is one of the considerable vegetable and medicinal plant used around the world. Garlic extracts were evaluated against different plants, it have been documented to possess allelopathic activity (Wei *et al.*, 2008; Wang *et al.*, 2009; Cheng *et al.*, 2011; Xu *et al*., 2012; Xiao *et al*., 2012&2013; Wang *et al.*, 2014 ; Cheng *et al*., 2016; Ding *et al*., 2016 and Hayat *et al*., 2016). Zhou *et al*. (2011) reported that high concentration of garlic root extract inhibited seedling growth of hot pepper and tomato as well as lettuce. Garlic bulb aqueous extracts at high concentration inhibited germination and seedling growth of cucumber (Dong *et al*., 2008). Ultrasonic extracts of three garlic varieties at 0.04g/ml were found to inhibit seed germination, seedling length and root fresh weight of lettuce and hot pepper (Wang *et al*., 2009). The decomposed stalk of three garlic cultivars showed allelopathic inhibitory effects on carrot and lettuce but promoted Chinese cabbage growth (Xu *et a*l., 2012 and 2013). Yuan *et al*. (2012) cited that garlic root exudates especially at high concentration inhibited significantly seed germination as well as seedling growth of

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lettuce, rape and radish. Garlic cloves extracts (10, 30 and 60%) reduced significantly seed germination, growth parameters and metabolic activities of pea seedlings (Abou El-Ghit, 2016).

Aim of work: Our goal is to have a clean environment by using natural materials (bioherbicides); so evaluating natural extract of *Allium sativum* (garlic) plants for controlling weeds associating *Helianthus annus* plants.

Materials and Methods

Allium sativum (garlic) plants were allowed for complete dryness in shadow then the cloves and stalk were separated, cut and grinded. Water extracts at concentrations of 15, 30, 45 and 60% were prepared.

On the basis of the results of chemical analysis of the garlic cloves and stalk, the experiment was carried out with cloves.

Pot experiments

Two pot experiments were conducted in the greenhouse of the National Research Centre, Egypt during two summer seasons of 2015 and 2016 cloves of sunflower (Cv. Giza 102) were obtained from the Agricultural Research Centre, Giza, Egypt. The stock of purple nutsedge (*Cyperus rotundus* L.) used as a source of tubers was collected from a dense stand at the National Research Centre garden. The pots, 30 cm in diameter and 30 cm in height, contained equal amounts of sieved soil (2: 1 v/v clay and sand). Sunflower seeds were sown 2 cm deep and allowed to germinate. One dormant tuber of purple nutsedge was planted in each pot in the same time 2 cm depth in the soil. Sunflower seedlings were thinned two weeks after sowing so that two homogeneous seedlings were left per pot. Super phosphate was added to each pot before sowing while Ammonium nitrate was added during plant growth. (2:1w/w). The experiment was arranged at complete randomized design and consisted of seven treatments including: three untreated controls, purple nutsedge only, sunflower only, sunflower with purple nutsedge (unweeded treatment). The other four treatments were used to study the effect of garlic cloves water extracts at concentrations 15, 30, 45 and 60%. The prepared extracts at 15, 30, 45 and 60% of garlic cloves extract were sprayed on sunflower plants and purple nutsedge at the rate of 150ml / pot. The treatments were applied three times during the three weeks starting from 15-day--old plant. The data were taken at 40 days after sowing and at harvest.

Characters studied

Purple nutsedge

Three replicates were collected from each treatment in both seasons at 40 days after sowing (DAS) and at harvest and the following measures were taken:

1	Number of mother shoots / tuber	2	Number of leaves of mother shoots / tuber
3	Length of mother leaves (cm)	4	Number of daughter shoots / tuber
5	Number of leaves of daughter shoots / tuber	6	Number of rhizomes / tuber
7	Length of rhizomes / tuber	8	Number of propagative organs / tuber (basal bulb and tubers) / plant
9	Dry weight of foliage (g/plant)	10	Dry weight of underground organs (g/plant)
11	Total dry weight (g/plant)		

Sunflower

Sunflower samples were taken from three pots at two stages (40 days after sowing and at harvest) to determine plant height, fresh and dry weights.

At harvest, Sunflower plants were collected to determine plant height, head diameter and head weight. Heads were air dried and threshed to determine seeds weight/head and 100-seeds weight.

Determination of total phenolic and total flavonoids contents in the plant extracts

Total phenol and total flavonoids were determined in cloves and stalk water extract of *Allium sativum* according to Srisawat *et al*. (2010).

Statistical analysis

All data were statistically analyzed according to Snedecor and Cochran (1980) and the treatment means were compared by using LSD at 5% level of probability.

Results

Purple nutsedge

Growth characters of mother shoots

The results in Table (1) show significant reduction in the number of mother shoots tuber with all concentrations at 40 days after sowing (DAS) and at harvest when compared with the purple nutsedge alone. The number of mother shoots show the highest reduction with spraying garlic cloves extract at 60% at harvest. This later concentration induced more than 50% reduction in the number of leaves of mother shoots as well as the length of mother leaves especially at harvest as compared to the corresponding untreated control (sunflower + purple nutsedge).

Growth characters of daughter shoots

The results in Table (1) show significant inhibition in the number of daughter shoots as well as number of leaves of daughter shoots with spraying of garlic cloves water extracts (gcwe) up to 60%. The reduction in number of daughter shoots as well as number of leaves of daughter shoots increased with increasing concentration reaching to complete eradication at harvest by using garlic extract at both 45 and 60% in comparison to the corresponding control.

Table 1: Effect of spraying different concentrations of garlic cloves on different growth parameters of foliage of purple nutsedge at two stages of growth. (Average of the two seasons).

Treatments		Growth parameters									
Plants	% of garlic cloves extract	No.of mother shoots/plant		No.of leaves of mother shoots/plant		Length of mother leaves(cm)		No.of daughter shoots/plant		No.of leaves of daughter shoots/plant	
		At 40 DAS	At harvest	At 40 DAS	At harvest	At 40 DAS	At harvest	At 40 DAS	At harvest	At 40 DAS	At harvest
Purple nutsedge (alone)	……	1.5	3.0	15.5	18.5	57.0	62.0	4.5	16.0	30.5	77.0
Purple nutsedge + sunflower	……	1.0	2.5	13.0	15.5	53.0	56.0	4.0	9.0	23.0	56.0
Purple nutsedge + sunflower	15	1.0	2.0	12.0	10.0	50.0	45.0	3.0	3.0	12.0	18.0
	30	1.0	2.0	9.0	8.4	38.0	35.0	2.0	1.0	6.0	4.0
	45	1.0	2.0	8.0	7.1	37.5	28.5	1.0	0.0	4.0	0.0
	60	1.0	2.0	6.0	5.3	30.0	24.0	1.0	0.0	3.0	0.0
LSD at 5%		0.28	0.70	1.36	1.14	1.92	2.45	0.87	1.40	1.75	1.98

Growth parameters of underground organs

Table (2) reveal significant decrease in the underground organs (basal bulb and tubers) of purple nutsedge in all pots sprayed with garlic cloves water extract as compared to untreated pots. The reduction was maximum with 45% of the extract, reached to zero by using 60% of the garlic extract. The inhibition in basal bulb and tubers in turn resulted in strong reduction in the number of rhizomes as well as their lengths reaching to complete eradication by using 60% at both 40 DAS and at harvest.

Table 2: Effect of spraying different concentrations of garlic cloves on different growth parameters of underground organs of purple nutsedge. (Average of the two seasons).

Treatments		Growth parameters					
Plants	% of garlic cloves extract	No. of rhizomes/plant		Length of rhizomes (cm)		No. of basal bulbs and tubers/plant	
		At 40 days	At harvest	At 40 days	At harvest	At 40 days	At harvest
Purple nutsedge (alone)	……	4.9	17.0	7.9	9.75	3.5	16
Purple nutsedge + sunflower	……	3.6	10.5	6.7	7.75	3.0	9
Purple nutsedge + sunflower	15	3.0	5.0	5.5	4.20	2.0	4
	30	2.5	1.5	5.3	3.83	1.0	1
	45	2.0	1.0	4.6	3.00	1.0	1
	60	0.0	0.0	0.0	0.00	0.0	0
LSD at 5%		0.48	1.40	0.66	0.98	0.63	1.24

Fresh and dry weight of foliage (g / plant)

The results in Table (3) reveal significant inhibition in both fresh and dry weight of mother shoot in foliage of purple nutsedge as a result of spraying different concentrations of cloves water extract of garlic up to 60%. The use of high concentration has the highest rate of reduction in foliage of purple nutsedge reached to 98% at harvest as compared to the control. The reduction in dry weight was more or less similar to the reduction in fresh weight (Table 3).

Fresh and dry weight of underground organs (g / plant)

Garlic cloves water extract at different concentrations inhibited significantly both fresh and dry weight of underground organs. The inhibition in fresh and dry weight of underground organs was most detectable with using 60% of the extract leading to complete control at 40 DAS and at harvest in comparison to the untreated control.

Total fresh and dry weight of purple nutsedge

The reduction in total fresh and dry weight (foliage + underground organs) was to a great extent similar to that recorded in fresh and dry weight of foliage and underground organs (Table 3) at 40 DAS and at harvest as compared to the corresponding controls.

Sunflower

Effect of garlic cloves water extract on growth of sunflower plants

Growth parameters

Garlic cloves water extract increased significantly plant height and number of leaves of sunflower as compared to unweeded control. On the contrary, the lowest concentration of the extract (15%) gave an increase in these two characters. The lowest significant increase was recorded by 60% extract at 40 (DAS) as compared to the control (Table 4). Both fresh and dry weight of sunflower plants increased significantly with different concentrations of the garlic cloves water extract. The lowest concentration recorded the highest increase in both fresh and dry weight over their corresponding controls. Similar trends were recorded at harvest (Table 5).

Table 3: Effect of spraying different concentrations of garlic cloves extract on the fresh and dry weight of foliage, fresh and dry weight of underground organs and total fresh and dry weight (g/plant) of purple nutsedge. (Average of the two seasons).

Treatments		Growth parameters											
Plants	% of garlic cloves extract	Fresh weight of				Total fresh weight (g/plant)		Dry weight of				Total dry weight (g/plant)	
		Foliage (g/plant)		Underground organs (g/plant))				Foliage (g/plant)		Underground organs (g/plant))			
		At 40 DAS	At harvest	At 40 DAS	At harvest	At 40 DAS	At harvest	At 40 DAS	At harvest	At 40 DAS	At harvest	At 40 DAS	At harvest
Purple nutsedge (alone)	…….	15.70	22.50	4.43	20.0	20.13	42.50	3.85	7.25	2.51	10.41	6.36	17.66
Purple nutsedge + sunflower	……..	10.54	15.10	2.69	9.9	13.23	25.00	2.60	4.89	1.46	5.73	4.06	10.62
Purple nutsedge + sunflower	15	3.59	1.50	1.90	1.5	5.49	3.00	0.85	0.49	0.50	0.78	1.35	1.27
	30	2.33	0.32	0.74	0.6	3.07	0.92	0.60	0.11	0.35	0.30	0.95	0.41
	45	1.19	0.25	0.64	0.3	1.83	0.55	0.30	0.09	0.30	0.20	0.60	0.29
	60	0.32	0.22	0.00	0.0	0.32	0.22	0.10	0.07	0.00	0.00	0.10	0.07
LSD at 5%		0.98	1.82	0.37	1.15	1.19	1.36	0.49	0.50	0.15	0.52	0.66	0.82

Table 4: Effect of spraying different concentrations of garlic cloves extract on some growth parameters of sunflower at 40 days after sowing. (Average of the two seasons).

Treatments		Growth parameters			
Plants	% of garlic cloves extract	Plant height (cm)	No. of leaves/plant	Fresh weight of plant (g)	Dry weight of plant (g)
sunflower (alone)	……	89.0	16.75	44.00	18.30
sunflower +purple nutsedge	……	70.3	12.67	15.10	6.45
sunflower + purple nutsedge	15	100.0	17.33	57.17	27.30
	30	87.0	16.65	43.00	13.40
	45	81.5	16.33	36.28	11.90
	60	75.6	16.00	31.00	7.50
LSD at 5%		2.90	1.31	2.43	1.70

Table 5: Effect of spraying different concentrations of garlic cloves extract on some growth parameters of sunflower at harvest. (Average of the two seasons).

Treatments		Growth parameters			
Plants	% of garlic cloves extract	Plant height (cm)	No.of leaves/plant	Fresh weight of vegetative growth (g)	Dry weight of vegetative growth (g)
sunflower (alone)	……..	154.0	25.5	161.80	47.00
sunflower +purple nutsedge	……..	118.7	21.0	63.90	26.25
sunflower + purple nutsedge	15	169.7	27.7	180.00	50.40
	30	150.9	22.5	130.30	37.20
	45	140.5	21.9	100.25	33.05
	60	125.0	21.5	90.40	31.35
LSD at 5%		3.29	1.60	2.54	1.81

Sunflower yield/plant

Head diameter show different responses according to the concentration of the extract. Spraying garlic cloves extract at 15% was the most effective in raising head diameter over the control treatment (98.4%) as pointed out in Table (6).The fresh and dry weight of sunflower heads significantly increased over the untreated control with spraying garlic cloves water extract with all concentrations. The stimulatory effect was most observable by using 15% of the extract. The results also reveal a significant increase in the weight of seeds / head (yield/plant) especially by spraying treatment with 15% (184.6% over untreated control). Data in Table (6) also reveal the highest significant increase in the weight of 100 seeds by spraying the extract with the concentration 15% reaching 72% over the unweeded control. However, purple nutsedge competition (untreated plants) reduced seed weight/head as well as weight of 100 seeds by 48.2% and 40.2% when compared by the healthy plants.

Table 6: Effect of spraying different concentrations of garlic cloves extract on yield and yield components of sunflower at harvest. (Average of the two seasons).

Treatments		Yield /plant				
Plants	% of garlic cloves extract	Head diameter (cm)	Fresh weight of head (g)	Dry weight of head (g)	Weight of seeds/head	Weight of 100 seeds (g)
sunflower (alone)	……..	11.50	74.5	16.18	10.06	3.83
sunflower +purple nutsedge	……..	6.25	25.7	7.50	5.21	2.29
sunflower + purple nutsedge	15	12.40	97.7	26.73	14.83	3.94
	30	11.00	58.4	12.60	9.06	3.11
	45	10.00	55.2	11.93	8.68	2.92
	60	9.00	45.6	9.72	7.45	2.84
LSD at 5%		1.54	2.78	1.46	1.12	0.65

Total phenols and flavonoids in the garlic extracts

The results in Table (7) show that the contents of both phenolic compounds and flavonoids in garlic seeds water extract is highly superior over their corresponding in garlic stalk water extract.

Table 7: Total phenols and flavonoids in the water extracts of both garlic cloves and stalk

Plant parts	Total phenols as mg/100g dry weight	Total flavonoids as mg /100g dry weight
Cloves	65.95	31.13
Stalk	14.76	10.24

Discussion

Garlic (*Allium sativum* L.) extract is thought to be a good allelochemical resource (Wei *et al*., 2008 and Yuan *et al*., 2012). Consequently, it can be efficiently reduce environmental pollution and realize good management in agricultural sustainable development.

The results of the current study indicated that garlic cloves water extract caused significant reduction in the growth of mother shoots / tuber and the growth of daughter shoots as well as reduction in the growth of underground organs. Using the aqueous extracts of garlic cloves at 45 and 60% caused complete inhibition to underground tuber formation (Table 2). These results are in accordance with those reported by (Xiao *et al*., 2012&2013; Xu *et al*., 2012 and 2013; Wang *et al*., 2014; Cheng *et al*., 2016; Ding *et al*., 2016 and Hayat *et al*., 2016).

Previous studies carried out by El-Rokiek *et al*. (2016 and 2017) using natural extracts of *Chenopodium album* and *Moringa oliefera* plants suggested that the inhibitions in weed growth may be due to the presence of flavonoids and phenolic compounds. The authors also proved that the inhibition in weed growth was correlated with the concentrations of flavonoids and phenolic compounnds in plant extracts. Analysis of both cloves and stalk extract of garlic indicated that phenolic contents and flavonoids in the cloves are highly elevated over that in the stalk (Table 7) which could explain the inhibiting activity of garlic cloves extract according to the suggestion of El-Rokiek *et al*. (2016 and 2017). These results were confirmed by Roby *et al*., (2013) who attributed the bioherbicidal potentials of the allelopathic extract to the presence of phenolic compounds.

The results indicated increase in the growth characters of sunflower plants which in turn lead to increase in yield and yield components (Tables 4-6). The increase in growth and yield was realized by spraying garlic cloves water extract at all concentrations especially at the low concentration. Although complete inhibition of purple nutsedge growth was obtained by the high concentrations, this inhibition was concomitant with increase in growth and yield of sunflower which was lower than the increase caused by low concentrations. In this connection, Singh *et al.* (2005) reported that plants produce metabolites, which are inhibitor or stimulator depending on their concentrations and subsequently alter the growth and physiological functions of plants. Additive similar confirming results were obtained by (Ahmad *et al.*, 2013) in pepper and Xiao *et al*. (2013) in cucumber. Additive confirming results were obtained on Squash and *Schefflera arboricola*, by El-Desouky *et al*. (1998) and Hanafy *et al*. (2012)

In general controlling weeds in crop plants decrease their competitions with associated weeds and consequently increase growth and yield of the target plants (El-Masry *et al* 2015; Ahmed *et al.*, 2016 and El-Rokiek *et al*., 2016 and 2017).

Conclusion

The results suggested that treatment of sunflower plants with cloves water extract of garlic could be used as bio-herbicide for controlling purple nutsedge in sunflower beside its promoting activity at low concentrations.

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