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ALLELOPATHIC INFLUENCE OF PREVIOUS PLANTATION ON THE GERMINATION AND SEEDLING DEVELOPMENT OF SUCCESSIVE CROPS

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ABSTRACT

This work was carried out at Desert Research Center, Mataria, Cairo, Egypt to investigate the allelopathic rotational impact of seven plant species on their four succeeding crops. The previous seven plant species were: purple nutsedge, purslane, sunflower, alfalfa, oat, garlic and onion. Allelochemicals of their subsoil surface parts were tested on germination and seedling growth of the successive maize, sunflower, alfalfa and jew's mallow crops. Data indicated that maize germination and seedling growth were more seriously damaged after purslane and onion plantation, moderately affected after sunflower, nutsedge and alfalfa plantation and slightly inhibited following garlic and oat rotation. Purslane was also the most inhibitory previous plantation on growth of successive sunflower seedlings and followed with onion and sunflower. Alfalfa and oat had moderate effect, whereas nutsedge seems without any deleterious effect. Contrary, growth of sunflower seedlings was stimulated when planted after garlic in rotation. Autopathy phenomena was obvious with alfalfa plant, since alfalfa residues toxicity were more pronounced on the following alfalfa and followed in this respect with sunflower. Results on jew's mallow seedling growth showed that onion and purslane previous plantation were the most inhibitory followed by oat and sunflower. Alfalfa and nutsedge had moderate effect whereas garlic had slight activation on the following rotated jew's mallow seedling growth parameters.

Keywords: Allelopathy, Autopathy, Crop rotation, Successive crops, Previous plantations, Germination, Seedling growth

INTRODUCTION

Allelopathy defined as direct or indirect harmful or beneficial effects of one plant on another through the production of chemical compounds that escape into the environment by leaching, decomposition, exudation and volatilization (Rice 1984). The effect of crops on weeds, and weeds on crops has been examined in

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many different agricultural systems (**Einhellig 1996**). Whereas allelopathy is important in both intercrossing and polycultural systems. Both field and laboratory experiments have shown that a large number of plants inhibit the growth of other plants. Rotation studies indicated the role of allelopathic effect, which caused by previous plants producing allelochemicals from their living roots during their life stage (**Kessavalou and Walters 1997**). Whereas allelochemicals accumulate and remain in the soil and affect the following crops and the agriculture systems. In the decayed centenary **Schreiner and Lathrop (1911)** reported that there was a soil-sickness related to soil continuously seeded to alfalfa. After that **Kooper (1927)** concluded that previous vegetation established a soil chemical equilibrium and determined which seed could germinate and the plants that survived. Recently, **Velu *et al* (1992)** found allelopathic potential of nutsedge (*Cyperus rotundus*.L) on crops (sorghum, groundnuts, maize, sesame, vigna mung, *Vigna radiate*, *Pennisetum glaucum* and *Eleusine coracana*.

Eskelsen and Crobtree (1995) found that the growth of biridsrape mustard (*Brassica compestris*L.), purple nutsedge (*Cyperus rotundusL.*) and Large crabgrass (*Digitaria sanguinalis (L.) Scop.*) was inhibited when inter planted with wild perennial buk wheat (*Fagopyrum cymosum L.*). **Mishustin and Naumova (1955)** suggested that saponins leached into the soil from alfalfa roots were responsible for the cotton yield reduction. **Miller (1996)** reviewed the autotoxicity and heterotoxicity in forage crop species. Alfalfa (*Medicago sativa*) has been investigated as both an autotoxic and heterotoxic species. Various allelochemicals and /or families of allelochemicals as being responsible for allelopathic reactions. Some alfalfa cultivars possess some resistance to these allelochemicals. Therefore, a breeding program could provide resistant germplasms. Various forage grasses and some weed species have demonstrated allelopathic effect on alfalfa and alfalfa has allelopathic effect on some weed species.

The aim of this investigation is to study the influence of allelochemicals liberated in soil from previous plant parts on germination and seedling development of successive seven plants. Germination and different seedling growth parameters were recorded after one month from planting.

MATERIALS AND METHODS

Experiments were carried out at the Plant Protection Department of Desert Research Center, Mataria, Cairo, Egypt during the period from 1998-2001.The purpose was to investigate the allelopathic effects of substances released from some plants by rotation effect on germination and growth of successive plants. The tested allelopathic plants were: Purple nutsedge (*Cyprus rotundus,L.*) as a perennial weed, purslane (*Portulaca oleracea*, L.) as a summer annual weeds, sunflower (*Helianthus annuus, L.*) as a summer crop, alfalfa (*Medicago sativa, L.*) as a perrenial forage crop, oats (*Avena sativa ,L.*) as a winter crop, garlic (*Allium sativum*, L.) and onion (*Allium cepa, L.*) as a vegetable winter crops.

The allelopathic effect of these plants were tested against:

maize (*Zea mays,L.*), sunflower (*Helianthus annuus* L) as a summer field

crops, Alfalfa (*Medicago sativa L.*),as a perennial forage crop and jew's mallow (*Corchorus olitorius,L*) as a summer vegetable crops,

To study the allelopathic potentials of the previous seven plantations on the successive crop when cultivated in the same field, eight groups each of 35 pots (20cm in diameter and 14cm in height) were filled with fine soil. On 1/11/1998 six groups were cultivated with oats, onion, garlic, alfalfa, sunflower and purple nutsedge.

Another group was cultivated with purslane on 15/5/1999 while the 8th group was left uncultivated and used as control. All groups were kept under greenhouse conditions till complete their plant growth where the aerial plant parts were cut at the soil surface leaving the root system in pots. Oats and sunflower were cut on 1/5/1999,while purslane was cut on 15/8/1999.Other crops were mowed on 15/6/1999. On mid. August 1999, soils of the eight groups including the uncultivated ones were well mixed (soil and residues) and divided into seven groups, each of five pots. Each of the new seven groups was cultivated with the test plants (maize, sunflower, alfalfa and jew's mallow). Pots were arranged in a complete-randomized design and irrigated as needed and kept for one month. Germination was recorded and by the end of the month plants were harvested and number of leaves, leaf area, fresh and dry weight of shoot and root were determined.

Statistical analysis was performed according to **Snedecor and Cochran (1990).** Treatment means were compared by L.S.D test at 5% level of probability.

RESULTS AND DISCUSSION

1- Effect of previous plants on the following maize germination and seedling growth

Data in **Table (1)** indicate that previous purslane and onion debris inhibited maize seed germination by 15% and 10%, respectively. Purslane previous plantation caused the greatest inhibition in maize shoot length followed by onion, nutsedge, oats and sunflower by 31.8, 23.3, 23.2 and 18.5 and 9.3% respectively, than the check treatment.

The same trend was observed on maize root elongation. Purslane, onion, nutsedge, sunflower and garlic had an inhibition effect on maize seedling root length by 27.5, 21.5, 23.7, 11.6 and 18.8%, respectively.

Results in **Table (1)** showed that onion and purslane, had inhibitory effect on shoot fresh weight amounted to 25.4 and 28.2%, respectively. However oats previous plantations activated maize root fresh weight, by 28.5%. On the other hand, onion decreased root fresh weight by 32.8%. Purslane, onion, sunflower, nutsedge, oats and garlic previous plantation caused inhibitory effect on maize shoot dry weight by 40.7, 39.3,39.3, 37.5, 36.4and 20.0%, respectively. Also, nutsedge decreased significantly maize root dry weight by 21.4 %.

Previous purslane reduced significantly maize leaf number by 15.3%. Other treatments caused no significant effect in this respect. Meanwhile, purslane previous plantation caused the most inhibitory effect on maize leaf area by 38.9%.

Table 1. Effect of previous plants on the following maize germination and seedling growth.

Previous	Germin.	Length (cm)		Fresh weight (g)		Dry weight (g)		Leaves/ plant	
Plant	%	Shoot	Root	Shoot	Root	Shoot	Root	Number	Area(cm)2
Control	100.0	48.05	44.08	9.12	3.95	2.30	1.82	7.15	216.48
Alfalfa	100.0	46.45	46.60	9.34	4.89	2.16	1.72	6.95	147.30
Sunflower	100.0	43.58	38.95	8.90	4.82	1.73	1.90	6.85	194.27
Garlic	100.0	49.25	35.80	10.01	3.99	2.24	1.64	7.00	209.00
Onion	90.0	36.83	34.58	6.80	2.64	1.77	1.8	6.95	146.60
Oats	100.0	39.15	43.80	7.70	5.05	1.78	1.85	6.75	153.10
Purslane	85.0	32.75	31.98	6.55	4.11	1.66	1.61	6.05	132.37
Nutsedge	100.0	36.90	33.60	7.30	3.38	1.75	1.43	6.80	136.32
LSD(0.05)	9.95	3.92	3.89	1.873	1.11	0.379	0.21	0.413	7.500

Nutsedge, onion, nutsedge, alfalfa, oats and sunflower reduced significantly leaf area by 37.1, 32.3, 31.9, 29.3 and 10.3%, respectively.

In general, the aforementioned results indicate that purslane and onion were the most inhibitory. Sunflower, nutsedge and alfalfa had moderate effect and only influenced some growth parameters. Garlic and oats had slight or more different effects on maize growth. Shoot and root lengths, shoot dry weight and leaves area per maize seedling were the most sensitive growth parameters and seriously inhibited with the most applied previous plants. These results are in agreement with those obtained by **Velu *et al* (1992) and Hoffman *et al* (1996).**

2- Effect of previous plantations on the following sunflower germination and seedling growth

Data in **Table (2)** indicate that previous plantations caused no significant effects on sunflower seed germination. However, oats caused the greatest inhibition in sunflower shoot length, followed by alfalfa, purslane and sunflower showing by 21.3, 12.5, 12.3 and 12.3%, reductions, respectively. Meanwhile, alfalfa caused inhibition on root length of following sunflower seedling by 16.1%.

Data in **Table (2)** indicate that onion, purslane, oats and sunflower had inhibitory effect on sunflower shoot fresh weight by 21.9,15.4,8.4 and 8.1%, respectively. However, garlic had activation effect on shoot fresh weight by 37.5%. Concerning to the effects on root fresh weight, purslane and onion previous plants, had an inhibition action on root fresh weight of their following sunflower seedling by 6.7 and 5.9 %, respectively.

Data in the same table show that garlic and alfalfa activated shoot dry weight by 25.1 and 17.1%, respectively. Contrarily, onion and purslane decreased significantly successive sunflower root dry weight by 12.5 and 8.9%, respectively.

Table 2. Effect of previous plants on the following sunflower germination and seedling growth.

Previous plant	Germin. %	Length (cm)		Fresh weight (g)		Dry weight (g)		Leaves/ plant	
		Shoot	Root	Shoot	Root	Shoot	Root	Number	Area $(cm)^2$
Control	100.0	24.18	14.00	3.19	1.19	1.47	0.56	9.75	85.77
Alfalfa	95.0	21.15	11.75	3.29	1.15	1.72	0.58	9.30	106.32
Sunflower	95.0	21.20	12.75	2.93	1.13	1.40	0.53	8.80	82.49
Garlic	95.0	23.63	14.00	4.39	1.21	1.83	0.54	11.25	114.79
Onion	95.0	24.12	12.25	2.49	1.12	1.37	0.49	8.80	82.67
Oats	95.0	19.03	13.08	2.92	1.20	1.55	0.57	11.60	97.53
Purslane	95.0	21.33	13.50	2.70	1.11	1.42	0.51	9.50	82.65
Nutsedge	100.0	23.63	13.13	3.06	1.16	1.38	0.54	9.45	88.78
LSD (0.05)	NS	2.556	1.76	0.20	0.06	0.131	0.03	0.493	6.47

Onion along with sunflower reduced significantly leaf number by 9.2 and 9.2%, respectively. On the other hand oats and garlic increased significantly leaf number by 18.9 and 15.4% %, respectively. Meantime, oats had a moderate activation effect on leaf area by 13.9%. On the other hand, garlic and alfalfa had great activation on sunflower leaf area by 33.8 and 23.9%, respectively.

The aforementioned results indicate, in general that purslane was the most inhibitory plantation on the growth of successive sunflower and followed with onion and sunflower. Alfalfa and oats had moderate effect and only affected some growth parameters. Nutsedge seems without any deleterious effect on germination and seedling growth of the following sunflower crops. Contrarily, garlic soil residues activated most seedling growth traits. Those results are in agreement with those obtained by **Wilson & Rice (1968) and Suwanarit & Suwonarat (1985).**

3- Effect of previous plantation on alfalfa germination and seedling growth

Data in **Table (3)** indicate that purslane and alfalfa previous plantation inhibited alfalfa seed germination, percentage by 13.4 and 13.4%, respectively.

Alfalfa caused the greatest inhibition in alfalfa shoot length followed by sunflower, onion, purslane, nutsedge, and oats by 38.6, 36.9, 28.6, 27.6, 27.2 and 23.4%, respectively. The same trend was observed on alfalfa root elongation. Sunflower caused great inhibition by 33.9%.

Table 3. Effect of previous plants on the following alfalfa germination and seedling growth.

Previous plant	Germin. %	Length (cm)		Fresh weight (g)		Dry weight (g)		Leaves/ plant	
		Shoot	Root	Shoot	Root	Shoot	Root	Number	Area $(cm)^2$
Control	100.0	8.75	17.57	2.90	0.77	0.67	0.33	6.00	30.12
Alfalfa	86.67	4.80	15.00	2.90	0.70	0.53	0.22	4.70	26.16
Sunflower	96.67	5.37	14.60	2.12	0.79	0.62	0.24	5.03	27.72
Garlic	100.0	8.57	16.50	2.80	0.82	0.68	0.23	6.00	30.97
Onion	96.67	5.52	15.82	2.40	0.72	0.61	0.26	4.87	28.98
Oats	100.0	6.70	15.13	2.55	0.73	0.69	0.29	5.40	31.71
Purslane	86.67	6.33	15.50	2.83	0.75	0.63	0.21	5.40	29.60
Nutsedge	93.33	6.37	15.83	2.69	0.79	0.62	0.24	5.03	32.27
LSD(0.05)	6.96	0.95	1.78	0.17	0.03	0.07	0.05	0.88	2.95

Moreover, alfalfa, oats and purslane had an inhibition effect on root length amounted to 14.6, 13.8 and 11.8%, respectively.

For shoot fresh weight, results in **Table (3)** indicate that sunflower, onion, oats and nutsedge had inhibitory effects, reached 26.9, 17.2, 12.1 and 7.29%, respectively. Also, alfalfa, onion and oats previous plantation, had an inhibition action on root fresh weight of the following alfalfa seedling by 9.2, 6.5 and 5.2 %, respectively. Garlic showed significant activation effect on root fresh weight by 6.5%.

Data in **Table (3)** showed that alfalfa previous plantation caused inhibitory effect on the following alfalfa seedling shoot dry weight by 20.9%. Likewise, purslane and alfalfa previous plants decreased root dry weight, of the successive alfalfa seedling by 36.4 and 33.4%, respectively. Meanwhile, garlic, sunflower, nutsedge and onion debris had a moderate inhibition action on such trait and significantly reduced it by 30.3, 27.3, 21.2 and 12.1% respectively than the control.

Alfalfa, Onion, nutsedge and sunflower reduced significantly leaf number by 21.7, 18.8,16.2 and 16.2 %, respectively. As for plant leaves area alfalfa previous plantation was the only inhibitory as it decreased alfalfa leaves area by 13.2%.

As a conclusion, the aforementioned results indicate that alfalfa was the most inhibitory plantation on alfalfa growth and followed with sunflower. This finding confirmed the autopathy phenomena in alfalfa plant since alfalfa residues toxicity were more pronounced on the following alfalfa. In this respect **Chung and Miller (1995a)** demonstrated that alfalfa contains water soluble substances that inhibit the germination and seedling growth of alfalfa. Onion, purslane, nut-

sedge, and oats had moderate effect and only affected some seedling growth parameters. Garlic had slight effects on alfalfa growth. These results are in agreement with those obtained by **Schreiner and Lathrop (1911); Mishustin & Naumova (1955);Guenzi *et al* (1964) and Abdul-Rahman & Habib (1989).**

4- Effect of previous plantation on the following jew's mallow germination and seedling growth

Data in **Table (4)** indicate that previous onion and alfalfa plantation inhibited the following jew's mallow seed germination by to be 86.7 and 90.7%, respectively compared with 100% of the control. Meanwhile, onion and sunflower plants caused the greatest inhibition in jew's mallow shoot length (29.5 and 28.4%, respectively). Otherwise, previous plantation of onion, sunflower, nutsedge and purslane decreased shoot length of the following of jew's mallow seedling by 29.6, 28.4, 25.5 and 22.6%, respectively. Jew's mallow root elongation was also inhibited with the previous plants. Purslane caused great inhibition amounted to 18.0%. On the other hand, alfalfa, onion and sunflower had an inhibition effect reached 16.4 and 16.1, 12.7%, respectively.

As for shoot fresh weight, results in **Table (4)** indicate that sunflower, onion, oat, purslane and nutsedge had inhibitory effects by 41.4, 40.4, 39.7 38 and 34%, respectively. As for root fresh weight, purslane, onion, sunflower and purslane previous plantation which had an inhibition action on seedling than the control by 11.9 and 9.3%, respectively.

Data in **Table (4)** showed that oats and purslane previous plantation caused inhibitory effect on seedling shoot dry weight by 35.5 and 35.5%, respectively. On the other hand all the tested previous plants had no significant effect on jew's mallow root dry weight.

Onion, sunflower, purslane and oats reduced significantly jew's mallow leaves number by 24.5, 21.4, 15.8 and 9.9% respectively. However, garlic activated leaves number by 14.1%. With regard to leaves area, data in the same Table show that onion previous plantation was the most inhibitory on jew's mallow leaves area growth, i.e. 33.2%. Oats, nutsedge and sunflower had a moderate effects while alfalfa and purslane had slight inhibitory effect, i.e. 20.6, 18.9, 16.7, 12.6 and 11.9 %, respectively.

As general trend, the abovementioned results on jew's mallow growth indicate that onion and purslane were the most inhibitory followed by oats and sunflower. Alfalfa and nutsedge had moderate effect and only affected some growth seedling parameters. Garlic had slight activation on some jew's mallow seedling growth parameters. These results are in agreement with those obtained by **Kooper(1927); Abdul-Rahman and Habib (1989) and Velu *et al* (1992).**

Reviewing the aforementioned results, it could be suggested that the greatest potential for allelopathy from previous plants proved to be more potent than that occurred with decayed plant residues. Their toxicity or inhibitory effects persisted in soil by a previous plantations and decreased growth of the following crops.

Previous plantations often lead to a soil sickness problem which is presumed to be due to the unbalance of soil microbes, accumulation of plant toxins in soil , mineral deficiency or an abnormal

Table 4. Effect of previous plants on the following jew's mallow germination and seedling growth.

Previous Plant	Germin. %	Length (cm)		Fresh weight (g)		Dry weight (g)		Leaves/ plant	
		Shoot	Root	Shoot	Root	Shoot	Root	Number	Area $(cm)^2$
Control	100.0	13.73	12.23	2.97	1.18	1.07	0.56	12.63	76.86
Alfalfa	90.0	14.00	10.23	2.89	1.18	1.06	0.56	12.67	67.16
Sunflower	100.0	9.83	10.67	1.74	1.04	0.94	0.53	9.93	63.99
Garlic	100.0	15.27	13.40	3.0	1.25	0.93	0.58	14.40	78.32
Onion	86.7	9.67	10.26	1.77	1.04	0.88	0.488	9.53	51.36
Oats	96.7	11.93	12.43	1.79	1.11	0.69	0.51	11.37	61.05
Purslane	96.7	10.63	10.03	1.82	1.07	0.69	0.51	10.63	67.72
Nutsedge	96.7	10.23	11.13	1.96	1.11	0.90	0.48	13.00	62.28
LSD(0.05)	5.60	0.94	1.33	0.20	0.10	0.36	NS	0.59	5.100

soil pH. A rotation effect causes allelopathic effect, which depends on the accumulation of plant chemicals, which is highly dependent on soil and environmental factors. Results reported here are greatly supported with Anderson and Cruose (1995).

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التأثير الاليلوباثي الناتج عن النباتات السابقة على إنبات ونمو المحاصيل اللاحقة لها

[٢٩]

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٢- مركز بحوث الصحراء- المطرية- القاهرة- مصر

أجريت ٤ تجارب أصص في مركز بحوث الصحراء بهدف دراسة تأثير النواتج الاليلوباثية المتحررة تحت سطح التربة من تعاقب زراعة ٧ أنواع نباتية هم الرجلة، السعد، الشوفان، البرسيم الحجازي، عباد الشمس، البصل، الثوم على نمو وإنبات ٤ محاصيل تالية وهى الذرة الشامية وعباد الشمس والبرسيم الحجازي و الملوخية.

أوضحت النتائج أن الإفرازات المتحررة تحت سطح التربة قد أحدثت تأثيرات تثبيطية كبيرة فى نباتات الذرة الشامية وخاصة الرجلة والبصل بينما تلاها في التأثير التثبيطي على الذرة الشامية عباد الشمس والبرسيم الحجازي بينما كان تأثير الثوم والزمير على صفات النمو والإنبات للذرة الشامية تأثيرا ضعيفا. أتضح من النتائج أن زراعة عباد الشمس بعد نباتات الرجلة فى تعاقب فى نفس التربة كان لها تأثير تثبيطي كبير على خصائص النمو والإنبات، بينما تلاهما فى التأثير السلبي نباتات البصل وعباد الشمس بينما أحدثت نباتات البرسيم الحجازي و الشوفان تأثير متوسط، في حين كان لنباتات السعد تأثير ضعيف على خصائص النمو وعلى العكس أحدثت بادرات تنبيها لصفات النمو والإنبات لعباد الشمس اللاحق.

أتضح من الدراسة وجود السمية الذاتية للبرسيم الحجازي على صفات ونمو بادراتة عند زراعته على التوالي فى نفس التربة العام التالي،وكذلك عباد الشمس على صفات ونمو بادراته.

أوضحت النتائج عند تعاقب بادرات الملوخية بعد نباتات البصل والرجلة فى نفس التربة قد تأثرت خصائص نموها سلبيا فى حين تلاهم فى التأثير كان نباتات الزمير وعباد الشمس بينما أحدث البرسيم الحجازي والسعد تأثير سلبي متوسط على نمو وإنبات بادرات الملوخية وعلى العكس أحدثت نباتات الثوم تأثير تنشيطي على خصائص نمو وإنبات الملوخية عند تربية فى نفس التربة.

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