Incorporation of residues of the medicinal plant *Echinacea purpurea* for the weed management in organic sunflower

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Abstract

Eastern purple coneflower [Echinacea purpurea (L.) Moench.] is globally recognized as one of the most popular medicinal herbs. In the present study, the effects of incorporation of the plant residues on weed flora and early growth of a sunflower crop were investigated. A field experiment was conducted under organic conditions at the Agricultural University of Athens. The results showed that there was a significant effect of plant residues on weed flora and biomass, especially during the first crucial growth stages of sunflower. Particularly, the incorporation of E. purpurea residues resulted to a lower number of different weed species (low richness) and an intense effect on most weed species. In a pot experiment it was revealed that sunflower seed germination was not affected by the incorporation of E. purpurea residues. However, the activity of the specific residues was inadequately selective (and needs to be further evaluated), since there was a negative effect on sunflower growth.

Introduction

Incorporation of plant residues can be a useful tool for integrated weed management since their biomass is produced at high levels and it affects weeds, especially during the early stages of crop growth (Mohler and Teasdale 1993). *Echinacea spp.* includes species famous for their medicinal properties (Hart and Dey 2009). *Echinacea purpurea* L. is a species of American origin which is lately extensively studied because of its noteworthy chemical and pharmacological properties. Many aromatic, medicinal and other plants were found to release toxic substances in the environment, through either root exudation or decay of their plant residues (Chon and Kim 2004). Although numerous studies have examined the effect of plant residues on weed suppression, however there is no information on residue effects of *E. purpurea* on weed density and biomass and sunflower response at the early growth stages and this was the objective of the present study.

Material and methods

One field and one pot experiment were conducted under organic management in the experimental field of Agricultural University of Athens (37^o 59′01.83″ N, 23^o 42′07.37″ E). The soil was a clay loam, whose physicochemical characteristics (0- to 15-cm depth increment) were clay 35.2 %, silt 45.7 %, sand 19.1 %, pH (1:2 H_2O) 7.36, $CaCO_3$ 12 g kg^{-1} and organic matter content of 24.4 g kg^{-1}. Sowing of a sunflower hybrid (Sanay MR) occurred on 3 May of 2012. This is a commonly used hybrid in Greece, and it was sown in rows (70 and 20 cm distances between and within rows). The field experiment was arranged in a randomized complete block design with three replicates and two treatments: a) incorporation of *E. purpurea* residues (246 g m^{-2}) and b) Untreated (without any incorporation). Plot size was 4.3 by 5 m. Irrigation and other common cultural practices were conducted as needed during the growing season, while the residues of the medicinal plant came from organically cultivated plants in Greece (provided by KORRES S.A. Co.). The number and dry weight of the dominant weeds were assessed. A wooden square quadrat (40 × 40 cm) was placed at random three times in each plot. Weeds in the 40 × 40 cm area were counted for each species present, and fresh and dry matter were determined (dry weight was determined after drying for 48 h at 70^{o}C). Weed assessments were made at 51, 63, 77, 94 and 115 days after sowing (DAS). Weed density per unit area (no. m^{-2}) was also recorded and furthermore the species diversity of weeds was characterized by means of the Shannon-Weiner and Simpson indices. For calculation of these indices, the software Bio DAP was used. A pot experiment was also conducted arranged in a randomized complete block design with eight replicates (pots of 15 L) for each of the two treatments (as in the field experiment). Measurements on seed germination and seedling emergence of sunflower were taken while plant height was also recorded. Statistical analysis of the results was performed using one-way ANOVA, while mean comparison was

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performed using Fisher's least signification difference (LSD) test at P < 0.05 by means of Statsoft package (1996).

Results

In some cases, the fresh and dry biomass of the weeds was significantly reduced after *E. purpurea* incorporation. In particular, this effect was significant for the fresh weight especially until 94 DAS, while later no differences were revealed. This is a clearly interesting finding, since weed control is crucial especially at the first growth stages of the crop, however in some cases these differences were not reflected on dry weight values (Table 1).

Table 1: Total fresh and dry matter of weeds sampled in the field experiment. Different letters between plots after incorporation of *E. purpurea* and untreated ones denote significant differences (LSD test, P < 0.05) within each sampling date.

Sampling date	Fresh weight (g)			Dry weight (g)	
	E. purpurea	Untreated		*E. purpurea*	Untreated
51 DAS	915.08 b	1406.29 a		173.28 b	249.31 a
63 DAS	783.17 a	708.16 a		157.23 a	157.56 a
77 DAS	1204.99 b	1537.48 a		280.4 a	294.87 a
94 DAS	772.01 b	848.76 a		242.76 b	286.95 a
115 DAS	678.75 a	628.47 a		305.37 a	307.61 a

Concerning the values of the Shannon-Weiner (H) index, in many cases there were significant differences between the two treatments, with incorporation of *E. purpurea* residues resulting to higher values (Table 2). During the early growth stages, no significant differences were noted, however, weed flora progressively had high species evenness in plots with *E. purpurea* incorporation. According to Booth *et al*. (2003) this index is increased because of emergence of additional species and that was the case in our experiment, with *E. purpurea* controlling several serious weed species (e.g. *Echinochloa crus-galli, Amaranthus retroflexus*) and thus other less competitive weeds finding the vital place to emerge (e.g. *Sonchus oleraceous*). Our results also revealed significant differences regarding Simpson index values. It could be said that the progressive decomposition of *E. purpurea* residues did not allow several noxious weed species to disperse and dominate (resulting to a lower Simpson index compared to the untreated plots), thus a balanced weed flora arised.

Table 2. Shannon-Weiner and Simpson indices for the weed community of the field experiment. Different letters between plots after incorporation of *E. purpurea* and untreated ones denote significant differences (LSD test, P < 0.05) within each sampling date.

Sampling date	Shannon-Weiner index			Simpson index	
	E. purpurea	Untreated		*E. purpurea*	Untreated
51 DAS	1.31 a	1.22 a		0.33 a	0.44 a
63 DAS	1.67 a	1.49 a		0.24 a	0.28 a
77 DAS	1.43 a	1.11 b		0.28 b	0.40 a
94 DAS	1.14 a	0.74 b		0.42 b	0.57 a
115 DAS	1.38 a	1.11 b		0.27 b	0.38 a

The results of our preliminary pot experiment revealed that the incorporation of *E. purpurea* residues in the soil had a negative effect on sunflower growth, although seed germination and seedling emergence of sunflower was rather unaffected (data not shown). However, it is noteworthy that sunflower plants after *E. purpurea* incorporation had the same height with the untreated plants at 63 DAS, so any differences seem to progressively decrease, without any permanent fitness cost for the crop.

Table 3. Time course of sunflower height during the experimental period (pot experiment). Different letters between plots after incorporation of *E. purpurea* and untreated ones denote significant differences (LSD test, P < 0.05) within each sampling date.

Treatment	Plant height (cm)					
	Days after sowing (DAS)					
	8	15	25	35	47	63
E. purpurea	1.94 b	5.50 b	11.50 b	19.34 b	42.25 b	72.94 a
Untreated	6.25 a	13.19 a	26.25 a	39.06 a	63.75 a	72.69 a

Discussion

The phytotoxicity action of residues used in this research can be plausibly attributed to the presence of several allelochemicals as previously shown in other studies (Viles and Reese 1995, Piechowski et al. 2006). There were noticeable differences among several weeds regarding their response to phytotoxical effects of *E. purpurea*, however, the number of different weed species was rather favored. Moreover, there were some negative effects on sunflower crop at early growth stages, however this reduction progressively dissapeared. Taking all the above into account and under the view of organic agriculture, integrated weed management and development of more environmentally feasible methods of weed control, the indicated allelopathic activity of plants like *E. purpurea* could be further exploited and complemented with future studies focusing on the identification and isolation of the responsive allelochemicals and additional field experiments.

Acknowledgent

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