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Full Length Research Paper

Allelopathic potential of sunflower and caster bean on germination properties of dodder (*Cuscuta compestris*)

M. Seyyedi, P. Rezvani Moghaddam, R. Shahriari, M. Azad and E. Eyshi Rezaei*

Ferdowsi University of Mashhad, Faculty of Agriculture, P. O. Box 91775-1163, Mashhad, Iran.

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Allelopathic impacts of two crops, sunflower (*Helianthus annus* L.) and caster bean (*Ricinus communis* L.) were evaluated against dodder (*Cuscuta compestris*) germination properties. Different plants residue, plant parts (root, shoot, leaf and whole plant), various concentrations of aqueous extract and decay durations were employed as study factors under completely randomized design (CRD) with factorial arrangement by three replications in this study. The results indicated that germination percentage, germination rate, emergence rate, seedling length of dodder was sharply influenced by sunflower and caster bean residue application. Aqueous extract of sunflower inhibited dodder seed germination more efficiently in comparison with caster bean especially in higher concentrations. Moreover, shoot aqueous extract allelochemicals showed substantial potential to the inhibition of dodder germination in contrast with other parts of plants. However, fresh leaf solid residue indicated great potential to dodder germination suppression. Increasing aqueous extract concentration significantly inhibited dodder germination and emergence under controlled conditions. In conclusion, dodder germination can be controlled by sunflower and caster bean allelochemicals. Therefore, allelopathic potential of these two plants can be consider as a sustainable approach in integrated management systems.

Key words: Allelochemicals, aqueous extract, decay duration, *Cuscuta compestris.*

INTRODUCTION

Dodder (*Cascuta campestris*) is an annual holoparasitic higher plant in the Convolvulaceae family (Mishra et al., 2007). Dodder seedlings are thin, long, delicate, rootless and leafless (Weinberg et al., 2003). Potatoes, tomatoes and sugar beets are most important crops highly influenced by parasitic impact of dodder (Nadler-Hasasr and Rubin, 2003). Dodder life cycle is entirely dependent on host for water supplying, assimilates and minerals (Mishra et al., 2007). There is no large number of chemical control patterns to avoiding from parasitic impact of dodder. In addition, environmental concerns about synthetic herbicides application become rising (Lanini and Kogan, 2005).

*Corresponding author. E-mail: eh_ey145@stu-mail.um.ac.ir. Tel: +98 - 511 – 8795616. Fax: +98 - 511 – 8787430.

In general, allelopathy refers to any direct or indirect beneficial or harmful effects produced by plants which influence the growth and developments of other plants (Narwal, 2010). Allelopathic plants compete with other plants, by producing different secondary metabolic components such as alkaloids and glycosides and introducing them to the soil rhizosphere of plants (Jarchow and Cook, 2009; Morris et al., 2009; Weston, 2005). All plant species produce a variety of natural compounds that may be released into the environment as exudates, leachate, or volatile. Therefore, allelopathy may be a widespread occurrence (Morris et al., 2009). Allelochemicals which produce by allelopathic plants showed directly negative influences on seed germination and plant growth of other plants even in low concentrations (Kupidłowska et al., 2006). Consequently, the inhibitory effects of allelochemicals might be used against weeds as a controlling tool for decreasing the

weed emergence in field conditions (Xuan et al., 2005; Belz, 2007).

The allelochemicals derived from many crops such as sunflower (*Helianthus annus*) and caster bean (*Ricinus communis*) and could prevent some broad and narrow leaf weeds growth (Bhowmik and Inderjit, 2003; Khanh et al., 2005). Anjum and Bajwa (2005) studied the effects of bioactive annuionone from aqueous extracts of sunflower leaves on growth of five weeds including *Chenopodiun album* L., *Coronopis didymus* L., *Medicago polymorpha* L., *Rumex dentatus* L. and *Phalaris minor*; they reported this extract can be used as a natural herbicides. Moreover, some studies demonstrated that Sunflower residues decreased growth of different weeds such as *Cyamopsis tetragonoloba*, *Pennisetum americanum* and *S. biocolor* (Batish et al., 2002). They concluded that due to decomposing tissue of sunflower by soil microorganisms, some allelochemicals such as phenolics were released and inhibited the growth of those weeds (Batish et al., 2002).

Jamil et al. (2009) reported that sunflower water extract can be used for controlling wild oats (*Avena fatua*) and canary grass (*Phalaris minor*). Ricin is one of the plant toxins which derived from caster been seeds has been used as an organic herbicide for weed controlling (Doan, 2004; Aslani et al., 2007). It was well documented that there was allelopathic activity in different plant parts of caster bean (Ilavarasan et al., 2006). On the other hand, some studies reported that caster bean extract can be used for insect controlling (Upasani et al., 2003). This study was built on assessment of the allelopathic effects of sunflower and caster bean on germination and emergence of dodder inhibition.

MATERIALS AND METHODS

Evaluation of sunflower and caster bean parts allelopathic impacts on germination and emergence properties of dodder were conducted in three separate experiments. These experiments were performed under laboratory and greenhouse conditions. All experiments were carried out by using completely randomized designs (CRD) with factorial arrangement by three replications.

Experiment one

Three factors employed in this experiment, first factor was two levels of allelopathic plant residue species (sunflower and caster bean), the second factor was different parts of sunflower and caster bean included root, stem, leave and whole plant without inflorescence and the third factor was concentrations of aqueous extract at 10 levels (0, 2, 3, 4, 5, 6, 7, 8, 9 and 10%). Sunflower and caster bean were collected at the end of flowering and beginning with seed filling stage, from research station of faculty of agriculture, Ferdowsi University of Mashhad, Iran. Parts of plants were dried in shade for seven days and then grinded separately. Stock solution was prepared through 10 g of each plant samples powder mixing with 100 ml distilled water. The prepared solutions were shaken for three days at 25 to 30°C and subsequently filtered through a double Whatman (No.2) filter paper. Obtained 10% (w/v) extracts of different parts were diluted to gain study solutions.

Dodder seeds were collected from a potato farm in 2009, and then treated with 98% sulfuric acid-scarified for 20 min (Nadler-Hassar and Rubin, 2003). Various concentrations of aqueous extracts (4 ml) which gained from different parts were added to each sterilized Petri dishes contained a filter paper and then 20 dodder seeds were sown in Petri dishes. The Petri dishes were placed in dark germinator at 30°C (Benvenuti et al., 2005). The daily counting of germinated seeds started 24 h after sowing and it continued until germination process is completed (13 days). Seedlings with 2 mm length of radicle were termed "germinated" (Benvenuti et al., 2005). Germination rate was calculated by:

$$GR = \sum_{i=1}^{n} \frac{nt}{di} \quad (1)$$

Where *ni* is number of germinated seeds in first day of counting, and *di* is first day of counting.

Experiment two

Similar to first experiment, three factors included two different allelopathic plants residue (sunflower and caster bean), four parts of sunflower and caster bean (root, stem, leaves, and total plant without inflorescence) and various aqueous extract concentrations of them at 5 levels (0, 2.5, 5, 7.5 and 10%) were employed in this experiment. Aqueous extracts were prepared according to experiment one instruction. In addition, 10 seeds of dodder were sown in plastic pots (10 cm × 15 cm × 8 cm) after acid-scarifying dodder seeds. In that case, different aqueous extract concentrations were added to each pot.

Experiment three

The third experiment was performed by three factors same as pervious experiments; two different allelopathic plants residue (sunflower and caster bean), sunflower and caster bean parts at 4 levels (root, stem, leaf and whole plant without inflorescence) and decay durations at 7 levels (0, 15, 30, 45, 60, 75 and 90 days decay) were employed in this experiment. All plant parts were separately chopped (in 2 mm) and added to the soil by 5% (w/w) in each pot at the same time. Afterward, 10 dodder seeds which scarified previously were sown in each pot.

The pots of experiments two and three were kept in 25 to 30°C room temperature. The irrigation of pots was carried out by distilled water every day. Daily counting of emerged seeds in each pot in experiments two and three were recorded 24 h after sowing and it continued until seeds emergence is fixed. The rate of emergence for second and third experiments was calculated by:

$$ER = \sum_{i=1}^{n} \frac{ni}{di} \quad (2)$$

Where *ni* is number of emergence seeds in first day of counting, *di* is first day of counting.

Study measurements

Germination percentage and rate, and length of dodder seedlings were measured in pot/Petri dish levels.

Statistical analysis

In order to evaluate the treatments impacts on study parameters,

Table 1. Effects of different allelopathic plant species, plant parts and aqueous extract concentrations on germination percentage, germination rate, and seedling length of dodder.

Plant species	Germination percentage (%)	Germination rate (seed per day)	Seedling length (mm)
Sunflower	55[b]	2.9[b]	43[b]
Caster bean	61[a]	3.6[a]	47[a]
LSD	1.9	0.1	5
Plant part			
Root	62[a]	3.6[a]	59[a]
Shoot	50[c]	3.0[c]	34[c]
Leaf	57[b]	3.1[bc]	43[b]
Whole plant	62[a]	3.3[b]	44[b]
LSD	2.7	0.22	3.7
Aqueous extract concentration (%)			
0	83[a]	4.4[a]	56[ab]
2	65[bc]	4.2[a]	60[a]
3	59[d]	3.5[bc]	47[cd]
4	62[cd]	3.8[b]	43[de]
5	50[ef]	2.7[d]	51[bc]
6	67[b]	3.7[b]	40[fe]
7	52[e]	2.6[d]	40[fe]
8	60[d]	3.2[c]	37[f]
9	37[g]	1.7[e]	39[fe]
10	46[f]	2.4[d]	36[f]
LSD	4.3	0.34	5.8

Similar letters in each column show non-significant differences according to Duncan's Multiple Range Test at 5% level of probability.

analysis of variance (ANOVA) was performed as standard procedure for factorial randomized block designs. The t-test was used to find significant differences among treatments. The significant differences between treatments were compared by Duncan's multiple range tests at 5% probability level.

RESULTS

First and second experiments

Allelopathic plant species, part and aqueous extract concentration

Different allelopathic plants, plant parts and aqueous extract concentrations of allelopathic plants showed significant impact ($P > 0.05$) on germination properties of dodder seeds in Petri dish level (Table 1).

Sunflower residue inhibited dodder seed germination more efficiently in comparison with caster bean residue. Germination percentage and rate of dodder was 55% and 2.9 seed per day whenever sunflower residue was applied in Petri dish level (Table 1).

In addition, sunflower residue application cause sharply decreases in seedling length of dodder in contract to caster bean residue in Petri dish (43 mm) level (Table 1). However, plant species did not indicate significant effect on dodder seed germination percentage and emergence rate on pot level (Table 2). Seedling length of dodder was higher under sunflower residue in pot level (Table 2).

Application of shoot residue significantly decline the germination percentage (50% in Petri dish and 42% in pot levels), rate (3 seed per day in Petri dish and 0.76 seed per day in pot level) and seedling length (34 mm in Petri dish level) in contrast to other parts of study plants in both Petri dish and pot levels (Table 1 and 2).

Various parts of allelopathic plants did not showed significant impact on seedling length in pot level (Table 2).

The results were shown that different aqueous extract concentrations of allelopathic plants directly influenced germination percentage, rate and seedling length of dodder.

Increment of aqueous extract concentration penetratingly decrease study parameters in both Petri dish and pot levels (Table 1 and 2). Lowest values of germination percentage (46 and 37% in Petri dish and 30% in pot levels), germination and emergence rate (2.4 and 1.7 seed per day in Petri dish and 0.41 seed per day in pot level) and seedling length (36 mm in Petri dish and 36 mm in pot levels) was obtained on highest concentration of aqueous extract (Table 1 and 2).

Table 2. Effects of various allelopathic plant species, plant parts and aqueous extract concentrations on germination percentage, emergence rate, and seedling length of dodder.

Plant species	Germination percentage (%)	Emergence rate (seed per day)	Seedling length (mm)
Sunflower	48[a]	0.88[a]	55[a]
Caster bean	50[a]	0.91[a]	47[b]
LSD	4.7	0.09	6.2
Plant part			
Root	53[a]	0.97[a]	54[a]
Shoot	42[b]	0.76[b]	54[a]
Leaf	49[a]	0.87[ab]	49[a]
Whole plant	54[a]	0.97[a]	47[a]
LSD	6.6	0.13	8.8
Aqueous extract concentration (%)			
0	90[a]	2.13[a]	74[a]
2.5	44[b]	0.69[b]	46[bc]
5	44[b]	0.64[b]	54[b]
7.5	40[b]	0.59[b]	45[bc]
10	30[c]	0.41[c]	36[c]
LSD	7.4	0.15	9.9

Similar letters in each column show non-significant differences according to Duncan's Multiple Range Test at 5% level of probability.

Interactive effects of plant residue species, part and aqueous extract concentration

The results showed tooth response of dodder germination properties to application of aqueous extract of sunflower and caster bean which were extracted from different parts of plant residue. Effects of applied treatments indicated more influence on dodder germination in Petri dish level (Figure 1 and 2).

In general, sunflower aqueous extract gradually decrease the germination percentage, emergence and germination rate and seedling length of dodder in both Petri dish and pot levels especially under higher concentrations of aqueous extract (Figures 1 and 2).

Uppermost decrease in dodder germination and seedling length were obtained under higher extract concentrations gained from sunflower shoot in both Petri dish and pot levels except seedling length parameter in pot levels (Figures 1 and 2) .

Third experiment

Plant species, part and decay duration

Plant species did not show significant effect on germination percentage and seedling rate on third experiment, but sunflower residue (0.59 seed per day) considerably decrease emergence rate of dodder in comparison with caster bean residue (0.70 seed per day) Table 3). All study parameters significantly influenced ($P > 0.05$) by various parts of allelopathic plants (Table 3). Utmost decrease in germination percentage (20%), emergence rate (0.30 seed per day) and seedling length (44 mm) of dodder was gained in application of leaf residue (Table 3). Summations of decay duration gradually decrease germination percentage (28% in 0 days of decay duration), emergence rate (0.34 seed per day in 30 days decay duration) and seedling length (53 mm in days decay duration) (Table 3).

Interactive effects of plant residue species, part and decay duration

Residue decay duration increment showed direct impact on germination properties of dodder seeds. Caster bean residues showed momentous efficiency in prevention of dodder germination in comparison with sunflower residue especially under lower decay duration in the third experiment (Figure 3). Leaf residue of sunflower and caster bean showed highest prevention of dodder seeds in lower decay durations. However, shoot residue indicated maximum germination inhibition under higher decay durations (Figure 3).

DISCUSSION

The results evidently demonstrated that sunflower and caster bean residues significantly inhibited seed germination and seedling elongation of dodder under controlled conditions. High inhibition of dodder germination was

Table 3. Impacts of various allelopathic plant species, plant parts and decay duration of plant materials on germination percentage, emergence rate, and seedling length of dodder.

Plant species	Germination percentage (%)	Emergence rate (seed per day)	Seedling length (mm)
Sunflower	38[a]	0.59[b]	69[a]
Caster bean	41[a]	0.70[a]	76[a]
LSD	3.6	0.07	7.6
Plant part			
Root	58[a]	0.97[a]	85[a]
Shoot	35[c]	0.55[c]	79[a]
Leaf	20[d]	0.30[d]	44[b]
Whole plant	46[b]	0.75[b]	82[a]
LSD	5.1	0.1	10
Decay duration (day)			
0	28[d]	0.59[c]	58[c]
15	37[c]	0.67[bc]	59[c]
30	22[d]	0.34[d]	53[c]
45	24[d]	0.36[d]	48[c]
60	47[b]	0.70[bc]	94[b]
75	48[b]	0.77[b]	115[a]
90	72[a]	1.09[a]	84[b]
LSD	6.7	0.13	14

Similar letters in each column show non-significant differences according to Duncan's Multiple Range Test at 5% level of probability.

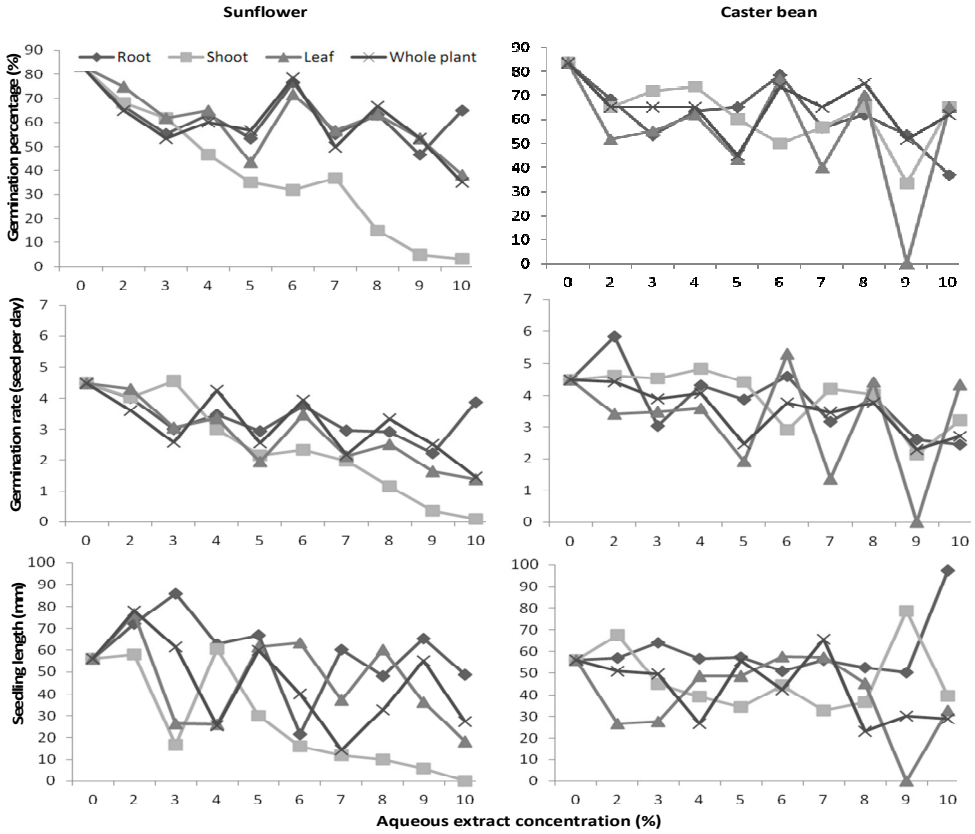

Figure 1. Interactive effects of plant residue species, part and aqueous extract concentration on germination percentage, rate and seedling length of dodder in first experiment.

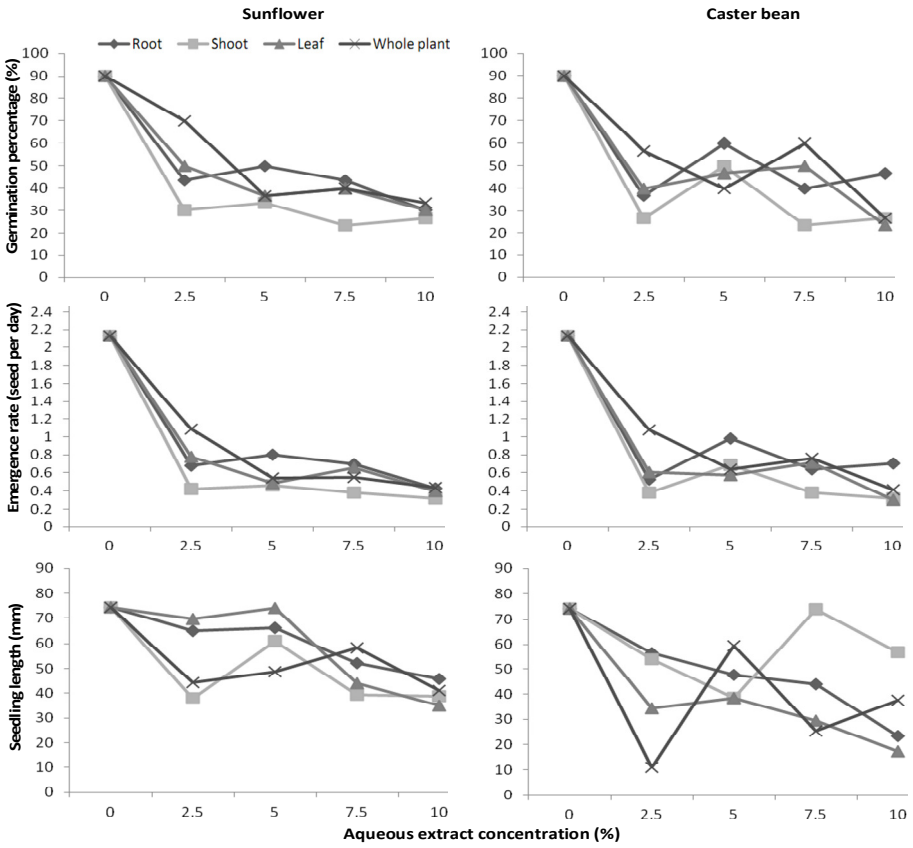

Figure 2. Interactive effects of plant residue species, part and aqueous extract concentration on germination percentage, emergence rate and seedling length of dodder in second experiment.

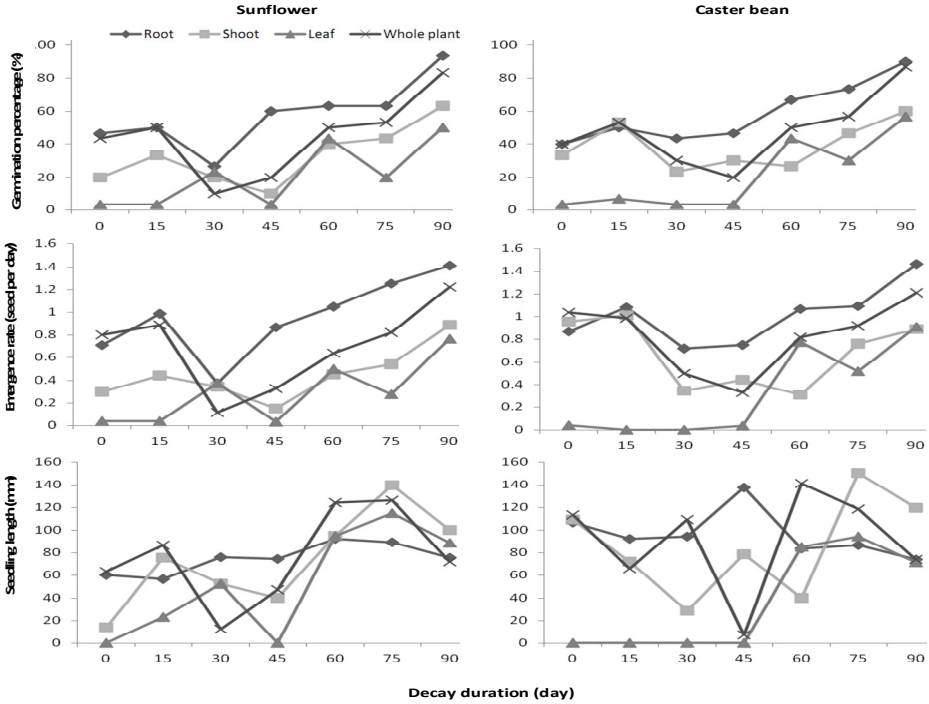

Figure 3. Interactive effects of plant residue species, part and decay duration on germination percentage, emergence rate and seedling length of dodder in third experiment.

obtained whenever aqueous extract of sunflower residues applied as allelochemical in comparison with aqueous extract of caster bean in both Petri dish and pot levels. The present study results confirmed sunflower allelopathic inhibition impact on germination of weeds. Anjum and Bajwa (2007) found sunflower aqueous extract significantly restrain *R. dentatus* germination in field condition.

Chemical studies on sunflower extract represented that this species is a wealthy source of phenolic compounds and terpenoids, particularly sesquiterpene lactones with a broad range of biological activities such as allelopathy (Macias et al., 2000). Highest decrease in dodder germination was gained by shoot residue aqueous extract but leaf residue showed maximum decline in dodder germination whenever fresh solid caster been residue was applied. Machado (2007) indicated that shoot residues extract of different allelopathic plants prevented downy brome (Bromus *tectorum* L.) growth efficiently in comparison with leaf residues extract. Differences in shoot, leaf and root extract effects may point toward the existence of different allelochemicals or concentrations of allelochemicals in roots and shoots.

Germination declines of dodder was raise appreciably when higher concentrations of sunflower and caster bean were applied. It shows that general effect of allelopathic plants was extremely quantity dependent (Skulman et al., 2004). Application of sunflower extract in higher concentrations inhibited seed germination of mustard (*Sinapis alba*) under controlled conditions (Bogatek et al., 2006). In conclusion, sunflower and caster bean residues showed great potential for dodder germination control but relative effectiveness of different plant parts such as shoot, leaf and root extracts and their concentration and decay duration are important in creating weed control strategies.

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