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Determining Bio-herbicidal Potential of Rapeseed, Radish and Turnip Extracts on Germination Inhibition of Cutleaf Ground-Cherry (*Physalis angulata* L.) Seeds

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Abstract: A laboratory study was conducted to determine bio-herbicidal potential of fresh shoot and root extracts of rapeseed (*Brassica napus* L. ssp. *oleifera* DC.) cv Westar, round white radish (*Raphanus sativus* L.), garden radish (*Raphanus sativus* L.), black radish (*Raphanus sativus* L. var. *niger*), little radish (*Raphanus sativus* L. var. *radicula*) and turnip (*Brassica campestris* L. subsp. *rapa*) at various concentrations (20, 40 and 80 mL L⁻¹) on cutleaf ground-cherry (*Physalis angulata* L.) seed germination. The experimental design was a Randomized Complete Block in a split plot arrangement with three replications. Fresh shoot and root extracts of *Brassica* species had different levels of germination inhibition rates. The highest germination inhibitions were obtained from rapeseed shoot extract with 58.7% and turnip root extract with 54.3%. Inhibitory effects of fresh shoot and root extracts increased with the increasing rate of extract concentrations.

Key words: Allelopathy, germination inhibition, *Brassica* spp., turnip, rapeseed, cutleaf ground-cherry, *Physalis angulata*

INTRODUCTION

The infestation of cutleaf ground-cherry (*Physalis angulata* L.) tended to increase in cotton, corn and soybean fields in Turkey^[1-4]. It was also reported as a problem weed in cotton fields of the western cotton belt of United States^[5], in rice followed peanut fields in Philippines^[6]. Control of cutleaf ground-cherry is difficult without soil applied herbicides due to the great amount of seeds deposited in the seed bank^[7] and flash germination of seeds^[8]. Cutleaf ground-cherry has been successively controlled by certain herbicides^[4]. However, excessive use of herbicides seriously treats environment and human health and causes development of herbicide resistant weed biotypes^[9-11]. Therefore, great attention has been given to allelopathy for weed management in cropping systems.

Several members of the Brassicaceae family were examined for their allelopathic potential on plant emergence and growth^[12-15]. Plants in *Brassica* species may suppress growth and development of weeds through the release of allelochemicals from plant residues incorporated into the soil. The allelopathic properties of Brassicaceae family have been attributed to isothiocyanates that are the breakdown products of glucosinolates by the plant enzyme myrosinase^[16]. Beside isothiocyanates, oxazolidinethiones, ionic thiocyanate

and organic cyanides are produced by the enzymatic hydrolysis of glucosinolates^[17]. Among the breakdown products, isothiocyanates are generally regarded as the most phytotoxic. The susceptibility of different weed species to isothiocyanates mainly depends on seed size. Small seeded (thousand seed mass) annual weeds tend to be more sensitive to isothiocyanates^[18-19]. Susceptible weed species can be controlled by the release of isothiocyanates from the incorporated plant parts of *Brassica* spp. into soil^[18-21]. Glucosinolate contents in *Brassica* species vary considerably, depending on tissue type, stage of development and environmental conditions^[22-23].

The objectives of the current study were to determine the bio-herbicidal potential of fresh shoot and root extracts of widely cultivated six *Brassica* species on the germination inhibition of cutleaf ground-cherry seeds and to determine the effective concentrations of the extracts.

MATERIALS AND METHODS

Six commercial *Brassica* crops, round white radish (*Raphanus sativus* L.), garden radish (*Raphanus sativus* L.), black radish (*Raphanus sativus* L. var. *niger*), little radish (*Raphanus sativus* L. var. *radicula*), turnip (*Brassica campestris* L. ssp. *rapa*) and rapeseed (*Brassica napus* L. ssp. *oleifera* DC.) cultivar Westar were

chosen to test their allelopathic potential on the germination of cutleaf ground-cherry (*Physalis angulata* L.). *Brassica* species were planted on November 2002 in an individual plot of 20 m² at Telkalis Research Farm of Mustafa Kemal University. The soil was a clay silt loam with pH of 7.5, 0.8% organic matter and water holding capacity of 0.34 cm³. Fertilizer was applied prior to planting at a rate of 20-18-0 kg ha⁻¹ NPK and later top dressed with 50 kg N ha⁻¹ as urea to ensure vigorous growth.

On April 2003, when the plants were in the early flowering stage 1.0 m² quadrats of plants including roots were removed from each plot to obtain fresh shoot and root extracts. The plants were taken immediately to the laboratory where they were washed with tap water and rinsed with distilled water, separated into root and shoot and sub-sampled for fresh shoot and root extraction. For fresh sap extraction, the fresh shoots and roots of each crop is chopped separately with a knife and squeezed with a hydraulic plant sap press to extract sap. The extracted shoot and root sap of each species was diluted with distilled water to get the concentrations of 2, 4 and 8% (v/v) and stored in plastic containers at -24°C until needed.

Germination bioassay: The fruits of cutleaf ground-cherry were collected from the experimental field of Mustafa Kemal University. The fruits were shade dried in the laboratory at 25°C for 30 days and then the seeds were hand separated and floated in distilled water to remove trashes. The seeds were rinsed with distilled water and then shade-dried on the filter paper in the laboratory at 25°C for 7 days. Two layer of Whatman No. 1 filter papers were placed in 90 mm diameter glass petri-dishes. In each treatment, 100 seeds were placed in petri dishes and moistened with 10 mL of extract and distilled water was used as control. Three replicates were made for each treatment, the petri dishes were placed in an illuminated growth chamber at 33±1°C, 75±3 RH. Germination counts were made after 1, 3, 5, 7 and 14 days and germinated seeds (0.5 cm radicle length) were removed from the petri dishes at each count. Rate of germination was calculated by dividing the number of germinated seed each day by the number of days and summing the values^[24]. The entire experiment was repeated twice. The inhibitory percent was calculated using the following equation:

$$\text{Inhibition percentage} = [(\text{Control-Aqueous extract})/\text{Control}] \times 100$$

Statistical analysis: All experiments were conducted twice in a split plot arrangement with six replications. *Brassica* species were employed as main plots and concentrations (20, 40 and 80 mL L⁻¹) as split plots. Analysis of variance was performed for all data using a

general linear model procedure^[25]. Data from two experiments were pooled and mean values were separated on the basis of Least Significant Difference (LSD) at the 0.05 probability level.

RESULTS

Fresh shoot and root extracts of rapeseed (*Brassica napus* L. ssp. *oleifera* DC.) cv Westar, round white radish (*Raphanus sativus* L.), garden radish (*Raphanus sativus* L.), black radish (*Raphanus sativus* L. var. *niger*), little radish (*Raphanus sativus* L. var. *radicula*) and turnip (*Brassica campestris* L. ssp. *rapa*) reduced germination rate of cutleaf ground-cherry (Table 1). Compared with control, the highest (58.7%) and the lowest (31.1%) germination inhibition rates were obtained from the fresh shoot extract of rapeseed and turnip, respectively. When root extract was in consideration, the highest (54.3%) and the lowest (32.5%) germination inhibitions were obtained from turnip and little radish, respectively.

To determine the most effective extract concentration on the germination inhibition of cutleaf ground-cherry seeds, three different concentrations (20, 40, 80 mL L⁻¹) of fresh shoot and root extract were applied (Table 2). The highest germination inhibition rates were obtained from 80 mL L⁻¹ extract concentration with 50.6 and 55.1% for fresh shoot and root extracts, respectively. For all extract types, crop species and extract rates affected germination significantly, but *Brassica* species had not similar pattern of germination inhibition on cutleaf ground-cherry seeds at different concentrations. However, for all species, germination inhibition increased parallel to increasing extract rate.

Table 1: Inhibitory effect of sap extract of rapeseed, radish and turnip on cutleaf ground-cherry germination

Species	Germination, % of control	
	Shoot extract	Root extract
Round white radish	37.1	39.7
Garden radish	43.8	37.6
Black radish	37.7	44.3
Little radish	40.0	32.5
Turnip	31.1	54.3
Rapeseed	58.7	na
LSD % 0.05	8.9	10.3

na: not available

Table 2: Inhibitory effect of sap extract concentrations of rapeseed, radish and turnip on cutleaf ground-cherry germination

Concentration (mL L ⁻¹)	Germination, % of control	
	Shoot extract	Root extract
20	33.1	28.7
40	40.5	41.3
80	50.6	55.1
LSD % 0.05	7.5	8.4

Table 3: Effect of fresh root extracts of five *Brassica* species on the germination of cutleaf ground-cherry

Concentration (mL L ⁻¹)	Little radish	Black radish	Garden radish	Turnip	Round white radish
20	26.8±2.4	24.1±8.0	25.0±5.8	34.3±4.3	33.3±3.7
40	30.2±3.3	44.7±7.4	32.5±6.5	60.2±9.7	39.1±4.2
80	40.7±5.2	64.3±4.7	55.5±9.8	68.6±10.8	46.6±7.5

Table 4: Effect of fresh shoot extracts of six *Brassica* species on the germination of cutleaf ground-cherry seeds

Concentration (mL L ⁻¹)	Little radish	Black radish	Garden radish	Turnip	Round white radish	Rapeseed
20	33.1±5.5	28.2±6.6	39.9±5.3	22.1±4.1	27.0±8.3	48.4±5.8
40	38.4±5.3	37.8±6.3	43.9±9.1	31.1±8.6	32.6±7.0	59.3±8.4
80	48.6±7.4	47.3±8.5	47.8±7.6	40.0±5.7	51.5±7.6	68.6±6.1

Germination inhibition by either fresh root extracts or fresh shoot extracts did not exceed 70%. Turnip root extract caused the highest inhibition at all application rates (Table 3). Root extracts of round white radish and little radish gave inhibition below 50%. Rapeseed shoot extract inhibited germination at the highest rate at all extract rates (Table 4). Except round white radish at 80 mL L⁻¹ rate, all remaining shoot extract preparations inhibited germination less than 50%.

DISCUSSION

Both fresh shoot and root extracts inhibited germination of cutleaf ground-cherry seeds. Inhibition rate was less than 70% for both fresh shoot and root extract applications. However, higher inhibition rates were reported for dry shoot powder of *Brassica* species^[26,27]. Jimenez-Osornio and Gliessman^[27] speculated that the reason might be that drying plant material causes hydrolysis of glucosinolates to isothiocyanates, while autolysis of fresh crucifers yields predominantly nitriles.

Most of the researches on the allelopathic potential of *Brassica* species have been focused on green manure and cover crops^[18,21,28]. In practice, growing *Brassica* species as green manure or cover crops brings additional cost to the growers. Also additional herbicide application was suggested to achieve weed control at an acceptable level^[21,28]. However, the integration of *Brassica* crops into cropping systems could suppress weeds subsequently can help decreasing seedbank for the next crop and brings extra incomes to the growers.

In the current study, the allelopathic effects of fresh shoot and root extracts of rapeseed cv Westar, round white radish, garden radish, black radish, little radish and turnip on the germination of cutleaf ground-cherry seeds were determined under the laboratory conditions. However, more researches are needed to evaluate their effectiveness under field conditions to determine their bio-herbicidal potential.

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