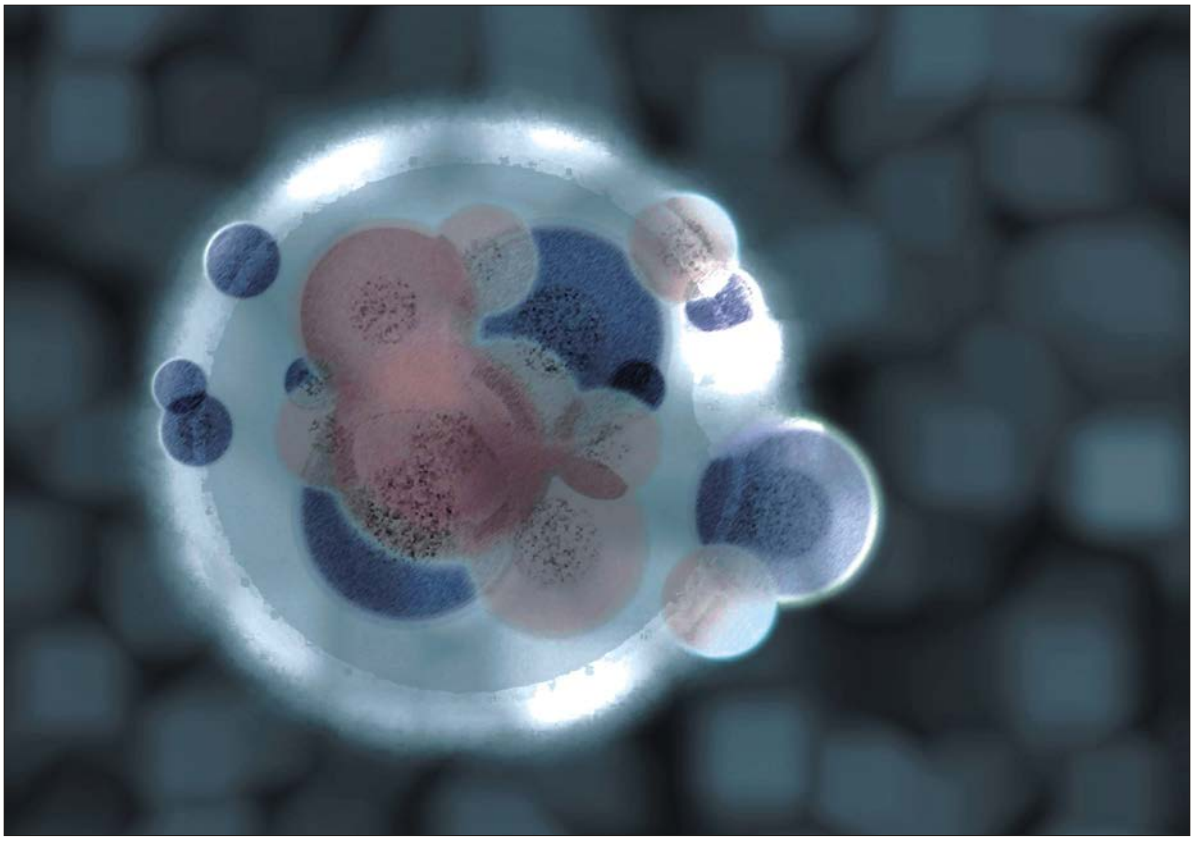

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Allelopathic Effects of Some *Brassica* Species on Germination and Growth of Cutleaf Ground-Cherry (*Physlis angulata* L.)

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Abstract: The objective of the current study was to determine the allelopathic potential of six *Brassica* species widely cultivated in Turkey which are 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 on the germination and seedling growth of cutleaf ground-cherry using shoot powder extracts. Allelopathic effects of shoot powder extracts of six *Brassica* species at various concentrations (2, 4 and 8%) on cutleaf ground-cherry (*Physalis angulata* L.) were investigated under laboratory conditions. There were differences among *Brassica* species for allelopathic inhibition of cutleaf ground-cherry seed germination and seedling growth. Shoot powder extracts of *Brassica* species exhibited marked differences in the inhibition of cutleaf ground-cherry seed germination. Inhibition on seedling growth was not as much as inhibition on germination. The inhibitory effects of shoot powder extracts on cutleaf ground-cherry seed germination and seedling growth increased as their concentrations increased. These results imply that *Brassica* species have great potential for cutleaf ground-cherry control. However, more research is needed under field conditions to investigate allelopathic potential and practical applications.

Key words: Allelopathy, germination inhibition, growth inhibition, radish, turnip, rapeseed, cutleaf ground-cherry, *Physalis angulata*

INTRODUCTION

Cutleaf ground-cherry (*Physalis angulata* L.) from the Solanaceae family is an annual small seeded weed species which is native of tropical America[1]. It has been reported as a problem weed in cotton, soybean and maize fields in Turkey[2-4] as well as other countries[5]. Although it is reported that cutleaf ground-cherry is successively controlled by some soil incorpoted herbicides[4] farmers are not satisfied because control does not last long enough as expected due to the great amount of seeds deposited in the seedbank[6] and flash germination of seeds[7]. In addition, increasing public concerns on environmental issues require alternative farming systems which are less pesticide dependent or based on naturally occurring compounds[8,9]. Allelopathy as an ecological approach and allelochemicals as biological herbicides have been a challenge to current approaches[10-12].

Different plant species/families have been reported having allelopathic activity and could be used in agricultural/ecological systems. Among the families, *Brassica*ceae have had great attention either in nonfield areas or agricultural areas[13-15]. Both weedy[16,17] and crop *Brassica* species[18,19] have had attention as source of allelochemicals. Brown and Morra[20] suggested that glucosinolate-containing plants could be used as herbicides if weed seeds were targeted. Glucosinolates are a group of plant secondary compounds whose biologically active hydrolasis products are produced when cells containing them are raptured and the glucosinalates are hydrolysed by the enzyme myrosinase[21]. Although variations among populations, species, varieties, years, development time and/or plant tissues occur[22-24], all *Brassica* species seem have glucosinolate compounds[25].

The purpose of the current study was to determine the allelopathic potential of six *Brassica* species widely cultivated in Turkey which are 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

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rapeseed (*Brassica napus* L. ssp. *oleifera* DC.) cultivar Westar on the germination and seedling growth of cutleaf ground-cherry using shoot powder extracts.

MATERIALS AND METHODS

Weed seed source: The fruits of cutleaf ground-cherry were collected from infested areas. 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 again on the filter paper in the laboratory at 25°C for 7 days.

Crops source: *Brassica* species, round white radish, garden radish, black radish, little radish, turnip and rapeseed cv. Westar, were planted to plots in Telkalis Research Farm of Mustafa Kemal University on November 2002. The soil was a clay silt loam with pH of 7.5, 0.8% organic matter and water holding capacity of 0.34 cm^3. Fertiliser was applied prior to planting at a rate of 45-45-45 kg ha^{-1} NPK and later top dressed with 65 kg N ha^{-1} as ammonium nitrate to ensure vigorous growth.

Extract preparation: On April 2003, in the early flowering stage, crops were uprooted and were taken immediately to the laboratory where they were washed with tap water and rinsed with distilled water, separated into root and shoot to prepare shoot powder.

For shoot powder preparation, shoots were shade dried at room temperature of 24°C. Then powder of each species was obtained via grinding in a Wiley mill through a 40 mesh screen and the powders were stored at 4°C until needed. Ground shoot powder of 20, 40 and 80 g were soaked in 1000 mL^{-1} distilled water for 24 h at 24°C in the laboratory to get concentrations of 2, 4 and 8 g 100 mL^{-1} (w/v) water extract. The solutions were filtered through a double layer of muslin cloth followed by a Whatman No. 1 filter paper. These were kept in a refrigerator at 4°C until further use. The pH of the water extracts of shoot powders of *Brassica* species varied between 6.3 and 7.7, the lowest and the highest pH were obtained from round white radish and rapeseed, respectively.

Germination bioassays: Two layers of Whatman No. 1 filter paper were placed in 90 mm diameter glass petri dishes. In each petri dish, 100 seeds were placed and 10 mL of *Brassica* extract added in a concentration of 2, 4 or 8 g 100 mL^{-1} (w/v). A check treatment was assigned with distilled water. Petri dishes were placed in a growth chamber with illumination 24 h at 33±1°C, 75±3 RH. Starting from the first day after experiment set on, germinated seeds were counted and removed at 3rd, 5th, 7th and 14th Day After Treatment (DAT). A seed with 0.5 cm of radicula was considered germinated. Experimental design was RCB with three replicate and experiment was repeated twice. Rate of germination was calculated by dividing the number of germinated seed each day by the number of days and summing the values[26]. The inhibition percentage was calculated using the following equation:

$$\text{Inhibition percentage} = ((CG-TG)/CG)*100$$

Where, inhibition percentage in %, CG; germination rate in check treatment; TG, germination rate in extract treatment. The data were subjected to ANOVA. 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.

Growth bioassays: Seeds of cutleaf ground-cherry were germinated on filter paper in the dark at 33±1°C for 4 to 5 days. Fifteen germinated seeds were transferred to petri dishes which were filled with 25 g quartz sand and 10 mL of shoot powder extracts added in concentrations of 2, 4 and 8 g 100 mL^{-1} (w/v). In addition a check added to experiment without any powder treatment. Petri dishes were, then, incubated in an illuminated growth chamber at 33±1°C. Experimental design was RCB with three replicate and experiment was repeated twice. The shoot and root lengths of seedlings were measured on 5 DAT and growth inhibition at root and shoot lengths was calculated[27].

$$\text{Growth inhibition} = ((LC-LT)/LC)*100$$

Where, growth inhibition in %; LT, shoot or root length of powder treated weed; LC, shoot or root length of untreated check weed. The data were subjected to ANOVA. Data from two experiments were pooled and mean values were separated on the basis of LSD at the 0.05 probability level.

RESULTS AND DISCUSSION

Germination rate of cutleaf ground-cherry in distilled water was 97% at 14th DAT. The germination mainly occurred at 3rd and 5th DAT, total 75%. But, in extract applications, seeds generally germinated at 7th and especially 14th DAT at 8 and 4% rates and from 3rd to 14th DAT at 2% rate (data not shown).

Table 1: Effect of shoot powder extracts of six *Brassica* crops on the germination of cutleaf ground-cherry seeds

Concentration (g 100 mL^{-1})	Little radish	Black radish	Garden radish	Turnip	Round white radish	Rapeseed
2	54.8±3.3	52.3±4.2	63.9±4.0	51.6±7.2	58.2±8.8	68.8±5.0
4	61.3±6.9	64.1±6.7	69.5±6.8	75.0±5.6	84.1±3.4	77.4±7.2
8	81.3±3.7	89.9±1.2	91.1±2.8	81.5±7.6	91.2±3.3	82.2±5.5

Table 2: Effect of shoot powder extracts of six *Brassica* crops on root length of cutleaf ground-cherry

Concentration (g 100 mL^{-1})	Little radish	Black radish	Garden radish	Turnip	Round white radish	Rapeseed
2	36.0±1.8	36.0±1.0	35.8±1.6	30.9±2.7	24.7±2.5	24.5±2.3
4	42.7±1.7	39.3±1.5	44.7±1.0	40.4±1.7	36.0±1.6	37.5±1.9
8	46.6±1.5	45.4±1.4	47.0±0.7	44.7±1.4	39.5±1.3	45.0±1.0

Table 3: Effect of shoot powder extracts of six *Brassica* crops on shoot length of cutleaf ground-cherry

Concentration (g 100 mL^{-1})	Little radish	Black radish	Garden radish	Turnip	Round white radish	Rapeseed
2	37.3±1.5	31.6±4.5	39.1±2.6	40.7±2.6	37.6±2.3	36.9±2.7
4	46.6±2.2	45.8±1.9	44.8±2.1	43.6±2.5	49.1±2.1	49.2±2.7
8	56.3±1.5	57.1±1.1	55.7±2.0	46.3±2.4	55.3±1.1	54.6±1.8

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.

When extract concentrations were in consideration, the highest germination inhibition rates 2 and 4 g 100 mL^{-1}, was held from rapeseed and round white radish, respectively. However, round white radish and garden radish had the highest inhibition rates (91.2%) at 8 g 100 mL^{-1} (Table 1). At 8 g 100 mL^{-1} concentration, round white, garden and black radishes had the highest inhibition ratios (91.2, 91.1 and 89.9%, respectively) then the inhibition ratios of little radish, turnip and rapeseed (81.3, 81.5 and 82.2%, respectively). At the lower concentrations, rapeseed had the highest inhibition ratios then the other *Brassica* species, except for round white radish at 4 g 100 mL^{-1}. Germination inhibitions of garden, black and little radishes drastically decreased at 2 and 4 g 100 mL^{-1} concentrations. Among the tested *Brassica* species, germination inhibition variations of rapeseed shoot powder extract concentrations were not as high as the other tested *Brassica* species.

The effect of *Brassica* species on both root and shoot lengths was rate dependent. Root length inhibition did not exceeded 50% for all applications (Table 2). In all rates, garden radish had the highest root length inhibition while round white radish the lowest. The inhibition on shoots elongation exceeded 50% for the highest application rates except that of turnip (Table 3).

During the grinding process, certain enzymes, amino acids and other organic compounds are released. Although no attempt was made to identify the allelochemicals inducing the observed responses in this study; glucosinolates play a key role for weed suppression as they can be converted to the corresponding ITCs by the enzyme myrosinase[28]. This might be the reason for the higher inhibitory rate of shoot powder extract on germination and seedling growth of cutleaf ground-cherry. Brown and Morra[20] concluded that myrosinase, normally sequestered from glucosinolates in plant tissues, is released upon crushing of the seed. The glucosinolates remain stable in the defatted meal for extended periods of time, however, because of its low moisture content.

At shoot powder extracts application, germination inhibition by round white radish, garden radish and black radish with 8 g 100 mL^{-1} application reached to 90%. The other three species also gave higher inhibition rates, over 80%. However, germination inhibition dropped drastically at lower application rates. It shows that the amount of allelochemical should be given attention although it is not only species dependent but also dependent on years and environmental factors[29]. At least in practice, amount of crop residues can be kept high enough to have possible highest weed control. Data from growth assays support this conclusion too although lower growth inhibition rates were held and, they were highly low at lower application rates.

All six *Brassica* species inhibited cutleaf ground-cherry germination higher than its early growth. Brown and Morra[30] stated that correlations do not always exist between germination inhibition and growth inhibition. Brown and Morra[20] concluded that allelopathic control of germination with glucosinolate containing plants could be achieved. We might speculate that they are germination inhibitors rather than growth inhibitors. However, in field conditions due to additive effect on germination inhibition and growth reduction, a satisfactory control could be expected.

As is at earlier studies[31,32], species behaved differently. However it is difficult to say which species can be the best. Especially comparing to germination results with shoot powder extracts results, all species can be recommended at higher residue rates. In addition, many other factors such as plant part, plant age and environmental conditions can affect the allelopathic potential of a given species in the nature[29,33-35]. This result gives more elasticity on choosing *Brassica* crop in rotation.

We conclude that these six *Brassica* species have allelopathic affect on germination and seedling growth of cutleaf ground-cherry. However, additional researches are

needed to confirm the allelopathic potential of *Brassica* species on the germination and seedling growth of cutleaf ground-cherry in a natural environment.

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