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# Germination and growth management of some common annual weeds by phytotoxicity of selected vegetable crops

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ABSTRACT

Phytotoxic effects of some vegetable crops including bean, cabbage, cauliflower, eggplant, pepper, potato, radish and tomato were investigated against *Amaranthus retroflexus*, *Chenopodium murale*, *Eruca sativa*, *Malva sylvestris*, *Portulaca oleracea* and *Solanum nigrum* weed species under laboratory and glasshouse conditions. Shoot extracts, foliage leachates and volatile materials of different crops significantly reduced seed germination and seedlings growth of different weed species in Petri-dishes. Leachates of cauliflower, pepper and potato were highly toxic to weeds. Extracts effects were concentration-dependent and roots were more inhibited than shoots. The effects of crops soil-incorporated dried shoot residues were varied on weeds and ranged from highly toxic to stimulatory. Residues of cabbage, cauliflower and bean were most toxic, while *A. retroflexus*, *C. murale* and *P. oleracea* were most sensitive weeds. Decayed residues of tomato, cabbage, bean and eggplant in the soil were most toxic to the tested weeds. Soil-applied extracts significantly reduced germination and growth of certain weeds. Growing weeds in the same soil after crops severely reduced shoot dry weight of most weed species with radish, cauliflower and bean were most toxic to *A. retroflexus*, *C. murale* and *S. nigrum*. Among weeds, *M. sylvestris* was most tolerant.

## 1. Introduction

Phytotoxins or allelochemicals both could serve the search for alternative natural chemicals to replace synthetic pesticides. Since herbicides are the largest marketed group of pesticides worldwide, it becomes necessary looking for eco-friendly alternatives of low or no hazards. Plant materials could play totally or partially this role if proved phytotoxic against certain weeds.

Most allelopathic evidences have been associated with the effect of weeds on crops and crops on others (Qasem and Foy, 2001). However, an important economical potential of allelopathy may be through the ability of crops to suppress weeds. Interest in the subject has been kept pace with increasing public pressure against the use of environmentally damaging agrochemicals. This increased the need for weed suppression by crop plants (Weston and Duke, 2003; Jabran, 2017).

Certain crops can smother weeds and greatly restrict their growth through competition, allelopathy or both. This is of a great potential in future weed control strategies (Duke et al., 2005; Belz, 2007; Bhadoria, 2011; Jabran et al., 2015). Certain crops, varieties or cultivars are potentially allelopathic against some noxious weed species through their residues and/or root exudates which could be manipulated in cropping system, as smother crops or in intercropping and crop rotation systems (Weston and Duke, 2003; Khanh et al., 2009; Kong et al., 2011; Al-Bedairy et al., 2013; Mahajan and Chauhan, 2013). However, some of the cropping systems such as organic farming mainly depends on cover cropping for weed management.

Research on possible allelopathic effect of crops on weeds in general is limited (Weston and Duke, 2003; Belz, 2007; Qasem, 2010a; Jabran and Farooq, 2013; Weston, 2015) and most available literature reported results on use of certain monocot crops including corn, oat, rye, sorghum, barley, maize, and wheat (Nekonam et al., 2013; Qasem, 2013; Weston, 2015). However, Several dicotyledonous crops were also implicated including cucumber (Pramanik et al., 2000; Holethi et al., 2008; Qasem and Issa, 2008).sunflower (Javaid et al., 2006; Alsaadawi et al., 2012; Rawat et al., 2012; Jabran, 2017), squash (Qasem and Issa, 2005; Fujiyoshi et al., 2007), soybean (Rose et al., 1984; Bernstein et al., 2014), clover (Conklin et al., 2002; Mirsky et al., 2013) and some other important cover crops including canola, rape seed, cowpea, fodder radish, mustards, buckwheat and hairy vetch (Mirsky et al., 2013).

Allelochemicals are released from donor species as volatiles, foliage leachates, root exudates or through decomposed plant residues that yield allelochemicals during decay process or after being modified by microorganisms (from toxic to non-toxic or *vice versa*), mediated

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through the environment and finally reached receiver species (Bertin et al., 2003; Weir et al., 2004; Belz, 2007).

Vegetable crops occupy a large area of the total cultivated land in Jordan. Crops selected for this study are among the main vegetables grown in the country. It has been long observed that weed population infesting these crops is clearly varied in size, density and species composition which may be due to differences in crops competitive abilities, allelopathic influences or both. The crops studied belong to different plant families that include allelopathic species. Selected weeds are also most common and associate with vegetables. They belong to different plant families and some exhibit allelopathic influence on different plant species including crops (Qasem, 1995; Al-Johani et al., 2012; Dmitrovic et al., 2014). Crop rotation, crop residue management, soil cover by living or dead mulch, crop or cultivar selection for certain weed infested fields, selection of a crop species, variety or cultivar of different responses to growth factors from weeds are all usually recommended managements for weed control. Different techniques are usually available to local farmers of no or low cost, eco-friendly and can be easily employed in weed management. However, literature on weed management using phytotoxic/allelopathic vegetable crops in general and broad-leaved in particular are limited. Weed suppression using allelopathic crops or their materials is a new innovative technology aiming at more clean environment and healthy yield at low cost. Therefore, possible management of weeds using phytotoxic vegetable crops or their materials was a focal point for the present work aimed to:

1 Investigate possible phytotoxic effects of selected vegetable crops on germination and growth of some widely spread weed species in Jordan using different experimental techniques.
2 Observe any differences between studied crops in their effects on the tested weed species and weed response to different crop materials and techniques used.
3 Manipulation of the interrelationships between tested vegetables and their associated weeds through specific management practices available to local farmers with no extra cost.
4 Document any possible phytotoxic effects of the selected vegetables against examined weed species, and their possible future use to manage these weed species and may be others in different crops and under different field conditions.

## 2. Materials and methods

### 2.1. Source of plant materials

Plants of bean (*Phaseolus vulgaris* L. cv 'Bronco'), cauliflower (*Brassica oleracea* var. *botrytis* L. cv. 'Sieera'), cabbage (*Brassica oleracea* var. *capitata* cv. 'O-S Cross'), eggplant (*Solanum melongena* L. cv. 'Classic'), pepper (*Capsicum annuum* var. *annuum* L. cv. 'Anaheim Chili'), potato (*Solanum tuberosum* L. cv. 'Diamond'), radish (*Raphanus sativus* cv. 'Shami') and tomato (*Solanum lycopersicum* L. cv. "076") were grown in the field at the University of Jordan Research Station at the campus (except been which collected from the farmers' field). Crops were not treated by any pesticide. Plants were grown for two months (flowering stage) in the spring before harvested and used in laboratory and glasshouse experiments.

### 2.2. Preparation of plant materials

#### 2.2.1. Aqueous extracts of shoots

Fresh shoots of each vegetable crop were washed with tap water, then with distilled water. Shoots were added to distilled water using 300 g/L, blended and homogenized in a Waring blender for five minutes at room temperature. The mixture was allowed to stand for half an hour, and then filtrated through a Whatman no.1 filter paper. The filtrate was placed in dark PVC bottles and stored at −20 °C until used and considered a full strength concentration.

#### 2.2.2. Foliage leachates

Fresh shoots of each crop species were immersed in distilled water at a rate of 1:1 w/v in a wide plastic container for half an hour. Leachates were filtered through a Whatman no. 1 filter paper and immediately tested for their phytotoxic activities.

#### 2.2.3. Dried and decayed residues

Shoots of all crops were harvested at flowering stage, oven-dried at 75 °C for 48 h, ground into a fine powder then stored in plastic bags until used. Decayed residues were obtained by thorough incorporation of crops ground-dried residues in potted soil, pots then were regularly irrigated by tap water for 40 days before planted.

#### 2.2.4. Preparation of weed seeds

Seeds of *Amaranthus retroflexus* L., *Chenopodium murale* L., *Eruca sativa* Mill, *Malva sylvestris* L., and *Solanum nigrum* L. were collected from cultivated fields in the Jordan Valley, while *Portulaca oleracea* L. seeds were obtained from local markets.

All seeds were cleaned, subjected to a preliminary germination test and then stored in glass vials until used.

The following experiments were carried out;

### 2.3. Laboratory experiments

#### 2.3.1. Full strength aqueous extract effects of crop species

Fifty seeds of each of the six weed species were placed on a filter paper in each of four (9 cm diameter) plastic Petri-dishes per treatment. 5 ml of full strength extract concentration of each crop was added to each of four Petri-dishes considered as replicates. Petri-dishes sown with the same number of weed seeds were treated with 5 ml distilled water as control. Dishes were incubated at 25 °C in the dark. Germination percentage was recorded at 14 days after incubation at which the experiment was terminated and stem and roots lengths were determined.

#### 2.3.2. Effect of extract concentration

The same procedure was followed as above but extract of each crop was used at 1, 2, 3 and 4 ml per Petri-dish. The final volume was made up to 5 ml by adding distilled water. Control treatment received only 5 ml of distilled water per dish. Similar data as above were obtained on germination and growth of weed seedlings.

#### 2.3.3. Effect of foliage leachates

Five ml of leachates of each crop species was added per each of four Petri-dishes per treatment and similar volume of distilled water was added per Petri-dish in the control treatment. Experiment duration and data obtained were the same as in previous experiments.

#### 2.3.4. Possible volatile effects

Twenty seeds of each weed species were placed on a filter paper in each of 5 cm diameter plastic Petri-dish. Two ml of distilled water was added per Petri-dish. Dishes were left uncovered (to allow volatile diffusion) and each was placed in a larger plastic container of 11 cm diameter at which 10 ml full strength extract or distilled water (for the control) was added. Containers were closed with parafilm and incubated at 25 °C for a week. The experiment then was terminated and germination percentage, and stem and root lengths were determined.

### 2.4. Glasshouse experiments

Four experiments were carried out in 11 cm diameter PVC pots under glasshouse conditions at the University of Jordan. Soil mixture used was made from clay: sand: peat at 3:1:1 w/w and of pH = 7.6. Plants were grown at 28/15 °C average day/night temperature. Experiments were as follows: