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Allelopathic Potential of *Aloe vera*

Masoomeh Alipoor[1] • Sasan Mohsenzadeh[1*] • Jaime A. Teixeira da Silva[2] • Mehrdad Niakousari[3]

[1] Department Department of Biology, College of Sciences, Shiraz University, Shiraz 71454, Iran
[2] Faculty of Agriculture and Graduate School of Agriculture, Kagawa University, Miki-cho, Kagawa 761-0795, Japan
[3] Department of Food Science and Technology, College of Agriculture, Shiraz University, Shiraz 71454, Iran

Corresponding author: * **mohsenzadeh@susc.ac.ir**

ABSTRACT

The ethanolic extract obtained from dried *Aloe vera* leaves and flowers was evaluated *in vitro* to examine its potential allelopathic effects. The inhibitory effect of the extract at 0, 2.5, 5 and 10% (i.e., g amounts of original extract in 100 ml of distilled water) on germination and seedling growth of wheat (*Triticum aestivum*), cereal rye (*Secale cereale*), garden cress (*Lepidium sativum*), redroot amaranth (*Amaranthus retroflexus*) and dandelion (*Taraxicum officinalis*) plants were tested. All concentrations of *A. vera* leaf and flower extracts suppressed the germination and growth of all tested plants' seedlings significantly ($P \leq 0.05$), except for wheat germination when 2.5% flower extract and epicotyl length when 2.5% leaf or flower extracts were used. The effects of leaf extract on epicotyl and radicle length were greater than when flower extract was used. Garden cress, redroot amaranth and dandelion seed germination and seedling growth were almost completely inhibited in the presence of 2.5% leaf or flower extract.

Keywords: allelopathy, bioherbicide, inhibitory effect

INTRODUCTION

Allelopathy is a biological phenomenon by which an organism produces one or more biochemical that influences the growth, survival, and reproduction of other organisms. These biochemicals are known as allelochemicals and can have beneficial (positive allelopathy) or detrimental (negative allelopathy) effects on the target organisms (Reigosa *et al*. 2006). Allelopathy is an important mechanism of plant interference mediated by the addition of plant-produced phytotoxins to the plant environment and is a competitive strategy of plants (Oussama 2003). Allelochemicals are produced by plants as end products, by-products and metabolites and exist in the stems, leaves, roots, flowers, inflorescences, fruits and seeds of plants (Sisodia and Siddiqui 2010). The release of these chemical compounds into the environment acts on other organisms such as plants, including weeds, animals and microorganisms to either inhibit or stimulate activity (Fujii *et al*. 2003). There is increasing evidence that these plant chemicals can suppress germination and growth of different weed species (Singh *et al*. 2003; Turk and Tawaha 2003; Sampietro and Vattuone 2006; Mohsenzadeh *et al*. 2011). Worldwide, enormous amounts of chemical herbicides are used to manage these weeds. However, synthetic herbicides are often toxic and cause environmental problems (Khanh *et al*. 2004; Sodaeizadeh *et al*. 2009). Moreover, overuse of artificial herbicides has led to the development of weed biotypes with herbicide resistance (Sodaeizadeh *et al*. 2009). In agriculture, there is a worldwide effort to reduce the amount of chemicals used in crop production through modern biological and ecological methods. One of the possible solutions is the use of allelopathy to explore the negative chemical interaction between plants (Azizi and Fujii 2006). The importance of allelopathy in the natural control of weeds and crop productivity is now highly recognized (Khan *et al*. 2009). In recent years, medicinal plants have been increasingly explored for their allelopathic potential (Anjum *et al*. 2010). Medicinal plants may contain bioactive compounds such as ferulic, coumaric, vanillic, caffeic and chlorogenic acid that possess inhibitory activity (Modallal and Al-Charchafchi 2006). Nazir *et al*. (2006) evaluated the allelopathic effects of the aqueous extracts of *Rheum emodi*, *Saussaurea lappa* and *Potentilla fulgens* on some traditional food crops; germination of all crops was significantly reduced by *S. lappa* and *P. fulgens* extracts. Fujii *et al*. (2003) used 239 medicinal plants to evaluate the allelopathic activity on lettuce. They concluded that 223 species were inhibitory.

The genus *Aloe* belongs to the Liliaceae, the family of perennial tropical plants of African origin. More than 360 species are known worldwide. One of the important species of *Aloe* which have been used as folk medicine is Curação aloe (*Aloe barbadensis* or *A. vera*). Records of the use of *A. vera* as folk medicine date to antiquity with the earliest account from around 1500 B.C. The exudates of *A. vera* have been used for numerous medical and cosmetic applications since ancient times (Tanaka *et al*. 2006). *A. vera* gel possesses various biological and physiological activities viz. healing ability of skin burns and cutaneous injuries; prophylactic effect against radiation leucopenia; anti-ulcer; inhibitory action against some bacteria and fungi; inflammation-inhibiting effect; inhibition of the prostaglandin synthesis by anthraquinone-type compounds; and inhibition of the AIDS virus by acemannan (Aiyedun 2004; Moody 2004; Dutta Gupta 2010; Datta *et al*. 2012). Commercial exploitation of *A. vera* gel has been carried out for at least 50 years. Various companies in the US act as primary growers and processors of the plant and manufacture bulk supplies of the gel for domestic and export market. Many other companies are secondary processors of *A. vera* products, and cosmetics firms and chain store often buy the gel for incorporation into their own brand name products (Yusuf *et al*. 2004; Hasanuzzaman *et al*. 2008).

This study aimed to assess the *in vitro* allelopathic potential of the ethanolic extract obtained from dried *A. vera* leaves and flowers on germination and seedling growth of wheat, cereal rye, garden cress, redroot amaranth and dandelion.

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Short Communication

MATERIALS AND METHODS

Plant material

A. vera leaves and flowers were harvested from the Shiraz University greenhouse. The seeds of wheat (*Triticum aestivum*), cereal rye (*Secale cereale*), garden cress (*Lepidium sativum*), redroot amaranth (*Amaranthus retroflexus*) and dandelion (*Taraxicum officinalis*), were prepared by the College of Agriculture, Shiraz University.

Extraction from *A. vera*

A. vera leaves and flowers were dried with a spray dryer and by air, respectively and powdered in a knife mill. Ground sample (20 g) was mixed with 200 ml of 96% ethanol using a shaking water bath for 24 h at room temperature. The extract was separated from solid concentrate by filtering through Whatman No. 1 filter paper. The remaining residue was re-extracted twice and the extracts were pooled. The solvent was removed under vacuum at 40°C using a rotary vacuum evaporator (Laborota 4000, Heidolph, Germany).

Bioassay

In order to detect the allelopathic effect of the *A. vera* leaf and flower extracts, dilutions were made of the original extract to 2.5, 5 and 10% of the stock extract. Twenty seeds of each weed were surface sterilized with a water-bleach solution (95: 5) and were placed on sterilized filter paper in 6-cm diameter Petri dishes. Each solution (3 ml) was added to each Petri dish; distilled water served as the control. Petri dishes were placed in the light (350 µmol m^{-2} s^{-1}) at 25°C for 14 days. They were monitored daily and the evaporated contents were compensated with distilled water. The numbers of germinated and non-germinated seeds were counted and final radicle and epicotyl length were measured at the end of the 14th day. Seeds whose radicals emerged were considered to have germinated.

Statistical analysis

The experimental design was a complete randomized design with four replications for each treatment. Data were analyzed using SPSS v. 17.0 and mean comparisons were made following the LSD test at $P \leq 0.05$.

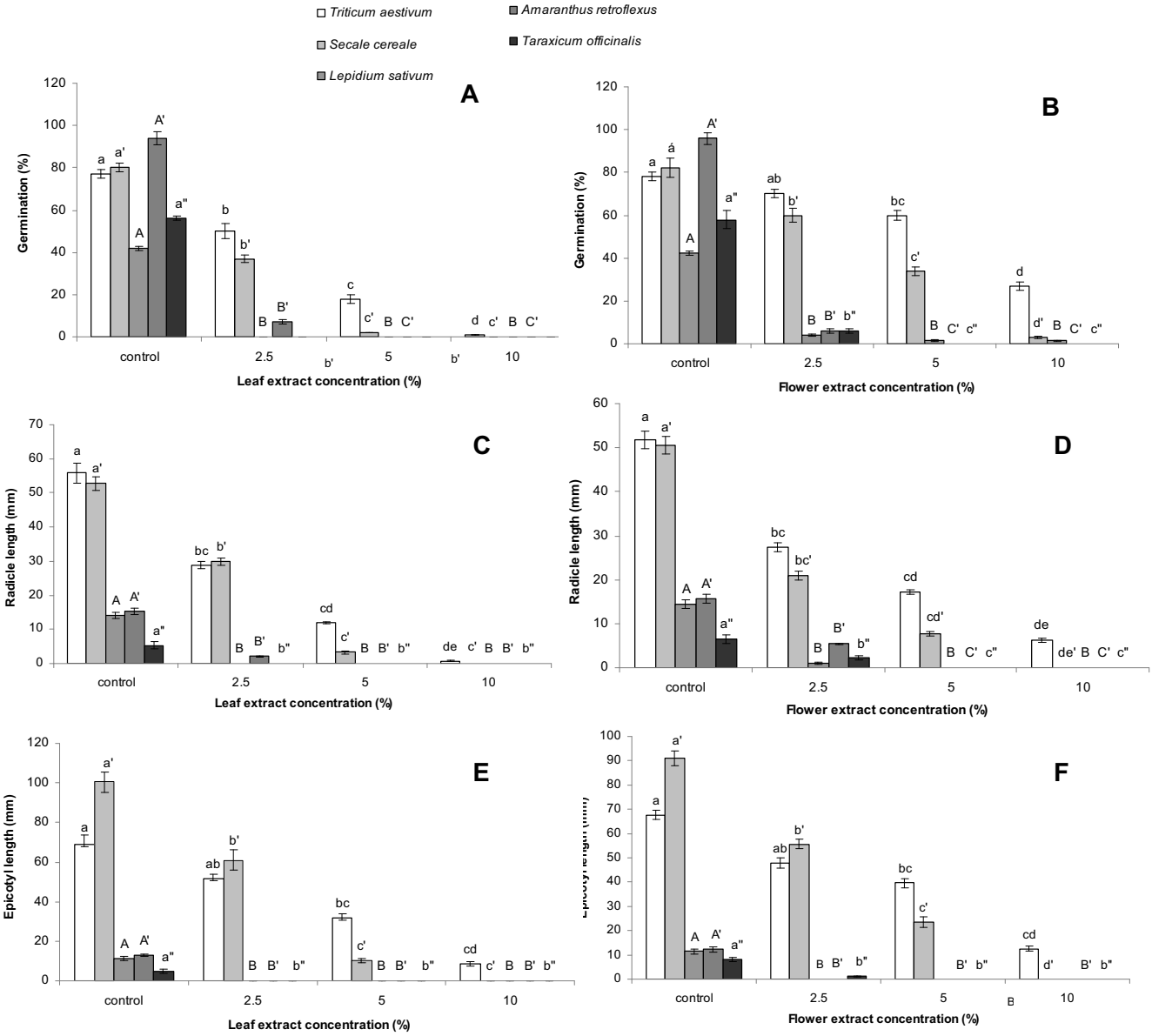

Fig. 1 Effect of different concentrations of *A. vera* leaf (**A, C, E**) or flower (**B, D, F**) extract on wheat (*T. aestivum*), cereal rye (*S. cereale*), garden cress (*L. sativum*), redroot amaranth (*A. retroflexus*) and dandelion (*T. officinalis*), seed germination (**A, B**), radicle length (**C, D**), and epicotyl length (**E, F**). Different small letters and different capital letters show significant differences between means at $P \leq 0.05$).

RESULTS

The allelopathic effect of *A. vera* leaf and flower extracts on the germination and seedling length of the five examined plants was determined. The extract caused a significant ($P \leq 0.05$) decrease or inhibited seed germination and seedling length in all five studied plants.

Different concentrations of extracts exhibited different effects on seed germination. Germination percentage was 42-96% in the control group of the five tested seedlings. All concentrations of *A. vera* leaf and flower extracts inhibited the germination of seedlings. At 2.5%, the germination of all seedlings except for *T. aestivum* by flower extract was significantly decreased although the germination percentage of *T. aestivum* and *S. cereal* was obviously higher than that of the other three tested plants. At 5% of flower extract, only *T. aestivum* and *S. cereal* seeds and at 5% of leaf extract and 10% of flower extract, only *T. aestivum* seeds could germinate, but significantly ($P \leq 0.05$) less than the control (**Figs. 1A, 1B**).

The epicotyl length of all seedlings, except for *T. aestivum*, by leaf and flower extracts, was significantly decreased at 2.5%. Epicotyl growth was completely inhibited in *L. sativum*, *A. retroflexus* and *T. officinalis* at 2.5% and in *S. cereal* at 10% of leaf and flower extracts (**Figs. 1C, 1D**).

Radicle length of all seedlings by 2.5% leaf and flower extracts was significantly decreased. Radicle growth was completely inhibited by leaf extract in *L. sativum* and *T. officinalis* at 2.5% and in *A. retroflexus* at 5% and in *T. aestivum* and *S. cereal* at 10% (**Fig. 1E**). Radicle growth of *L. sativum*, *A. retroflexus* and *T. officinalis* was completely inhibited at 5% of the flower extract and in *S. cereal* at 10% (**Fig. 1F**).

DISCUSSION

In this study, basic research on the allelopathic potential of *A. vera* leaf and flower ethanolic extracts at several concentrations showed that this medicinal plant exhibited a significant inhibitory effect on the seed germination and seedling lengths of all five examined plants. The effects of leaf extract on epicotyl and radicle length was higher than flower extract. Wheat seeds were least affected by the *A. vera* ethanolic extract (leaf and flower). Garden cress, redroot amaranth and dandelion seed germination and seedling growth were almost completely inhibited at 2.5% of leaf or flower extract.

The inhibitory effect of the *A. vera* leaf and flower extracts on seed germination and seedling length of the five tested plants may be related to the presence of allelochemicals, including tannins, wax, flavonoids and phenolic acids. Furthermore, toxicity might be due to a synergistic effect rather than the effect of any one compound or class of secondary metabolite (Saharkhiz *et al*. 2009; Nourimand *et al*. 2011). Several chemical components of *A. vera* are thought to be responsible for its allelopathy. The components of *A. vera* can be divided into the following groups: vitamins, enzymes, minerals, sugars, anthraquinones, lignin, saponins, fatty acids, salicylic acid and amino acids. Anthraquinones are phenolic compounds which are found exclusively in the plant sap. They act as anti-bacterials and anti-virals. In addition, saponins are soapy substances form about 3% of the *A. vera* gel and are capable of cleansing, having antiseptic properties. These act powerfully as antimicrobials against bacteria, viruses, fungi and yeasts (Vazquez *et al*. 1996; Aiyedun 2004; Moody *et al*. 2004; Tanaka *et al*. 2006). These components may act as allelochemicals that may have reduced or completely inhibited seed germination and seedling growth of the tested plants. The lower water availability for seed germination due to binding water by compounds present in an extract might play an effective role in reducing seed germination (Bogatek *et al*. 2006).

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