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Phytotoxic effects of sweet basil (*Ocimum basilicum* L.) extracts on germination and seedling growth of commercial crop plants

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ABSTRACT

The study pertains to the exploration of the phytotoxic (allelopathic) potential of aqueous extracts derived from leaf, root and seeds of Ocimum on some commercially important agricultural crops like wheat, gram lentil, mustard, barley ,okra and pea, in terms of seed germination, root and shoot elongation. The inhibitory effect was exhibited by all the extracts with maximum in leaf followed by root and seed extract. In barley, the germination inhibition was 100%, 80% and 60% respectively by leaf, root and seed. Further, Ocimum extracts significantly affect the root and shoot elongation of all the test crops. The maximum root and shoot growth was retarded by leaf extracts. The trends was okra > barley > mustard > maize > wheat > pea > lentil > gram and okra > maize > barley > Gram > wheat > lentil > mustard > pea, respectively in leaf extract. These results provide evidence of differential allelopathic effects as well as providing preliminary evidence of some allelopathic potential of Ocimum plant.

Key words: Allelopathy, extracts, Germination, Root growth, Shoot growth

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INTRODUCTION

The genus *Ocimum*, of the family Lamiaceae (Labiatae), includes at least 60 species and numerous varieties [28]. Some of the *Ocimum* sp. is used in the traditional medicine for different ailments, especially in many Asian and African countries [33], sweet basil (*O. basilicum*) being one of the most important species. The essential oil is extensively utilized in several European countries and USA for flavoring food, confectionery, condiments and toiletry products such as mouth washes and dental creams [8], [15].

Allelopathy appears to be an important component of plant interference capability in a variety of natural and managed ecosystems [32]. Allelopathy is a phenomenon where a plant species chemically interferes with the germination, growth or development of other plant species and has been known for over 2000 years. Early reference of 300 BC, suggests the involvement of this phenomenon, where many crop plants viz., gram (*Cicer arietinum*) and barley (*Hordeum vulgare*) inhibited growth of some weeds and crop plants [22]. Allelochemicals can be present in any parts of plant viz., roots, rhizomes, leaves, stems, pollen, seeds and flowers which may be released into the environment by root exudation, leaching from over the ground parts, volatilization and decomposed plant material [10], [19], [20], [25].

The occurrence of natural allelopathic activity in crops has significant positive and negative implications for cropping systems. The relevance of the allelopathic properties of some crops has been suggested for weed management owing to the possibility of reduction in usage of expensive, pollutant synthetic herbicides [2], [14]. Aqueous extract of plants may interfere with test crop germination and seedling growth by (i) causing plant growth inhibition (allelopathy), (ii) causing nutrient transformation, and/or (iii) by influencing the microbial population that can affect the crop seedlings [11], [12], [24]. Molloy et al. [17] and Perry et al. [18] also observed the allelopathic potential in aqueous extracts of *Dacrycarpus dacrydioides*, *Prumnopitys taxifolia*, and *Podocarpus totara* on *D. dacrydioides* and *L. sativa* for germination and seedling elongation, respectively. *Ocimum* as a crop is commercially cultivated for essential oil production in Kharif season (rainy season, June –September) during which least weed intensity has been observed. The observation prompted us to explore the phenomenon through (i) different plants parts (seed, root and leaves) (ii) concentration of phytotoxic material (iii) involvement of organic molecules through (iv) different assay crops on parameters like germination, root and shoot growth.

MATERIALS AND METHODS

Plant material

Plant material of sweet basil (*O. basilicum* var. CIM-Saumya) like leaf, root and seed were obtained from the research farm of Central Institute of Medicinal and Aromatic Plants, Lucknow, India. Test crop seeds *viz.* wheat (*Triticum aestivum* L.), maize (*Zea mays* L.), gram (*Cicer arietinum* L.), lentil (*Lens esculenta* L.), mustard (*Brassica campestris* Linn.), barley (*Hordeum vulgare* L.), okra (*Abelmoschus esculentus* L.) and pea (*Pisum sativum* L.) for the bioassays were procured from an authorized seed store.

Extract preparation

Aqueous extracts were prepared for bioassays. For this, leaf and root were shade dried in the month of August 2010 and coarsely ground. The seeds used for extract preparation were harvested and processed in October 2010. The seed were also reduced to coarsely ground material. The coarsely ground material (20g) was prepared in distill water (200ml) for 24hrs in a rotary shaker. The suspension was filtered and the filtrate was considered as extract for the bioassay.

Bioassays

Germination and root shoot length of all the eight test crops presence of three extracts of basil were tested in petri-dishes (9.0 cm d × 1.5 cm ht) under aseptic conditions with four replication. Ten surface sterilized seeds of wheat, maize, gram, lentil, mustard, barley, okra and pea were placed separately in a sterilized bioassay system. The filter paper in each petri-dish was moistened with 5 ml of extract or 5 ml of distilled water as control. All the treatments were considered in triplicate. The germination data and root, shoot length were measured after 10 days of starting the experiment.

Statistical analysis

All experiments in this study were arranged in completely randomized design (CRD) to enable statistical evaluation using SPSS version (17) and Duncan's multiple range test was used as a post-hoc analysis to compare the mean. Least significant differences (LSD) were calculated using test of significance at 5% level of significance [27].

RESULTS

Effect of *Ocimum* plant extracts on seed germination

The germination of all the tested crop seeds were significantly inhibited by the *Ocimum* extracts (leaf, root and seed). The maximum germination inhibition was observed in leaf extract (42%) and the minimum in seed extract (15%) (Fig.1a). Barley seed exhibited maximum reduction in germination by leaf extract, while okra by root and seed extracts. The seed of gram, lentil and pea germinated well, but showed inhibition of germination to a higher extent as compared to control (Fig.1b). The germination reduction trend of different extracts is represented in Table 1. However, germination of wheat, lentil and gram seed was least affected by leaf extract. The germination reduction trend in root and seed extracts was found to be almost similar and lentil, pea and gram seed germination was least affected by both the extracts.

Effect of *Ocimum* plant extracts on root elongation

Root elongation of all the test crop seeds was significantly influenced by different *Ocimum* plant extracts (leaf, root and seed) (Fig.2, a & b; Table 1). The most effective reduction among all extract was observed in leaf extracts. Okra and barley seeds did not show root growth by leaf extracts. The root development of mustard seeds was least affected by *Ocimum* plant extracts followed by lentil and pea. Overall, the okra seed showed minimum root length (0.25 cm) while the maximum was in gram crop seeds (1.63 cm) through treatment with different *Ocimum* plant extracts. Overall reduction of root length was 59%, 40% and 16% by leaf, root and seed extracts, respectively when compared to control (without extracts) (Fig.2,a). The trend of root elongation pattern was not consistent among the extracts.

Effect of *Ocimum* plant extracts on shoot development

Extracts of leaves, root and seed of *Ocimum* significantly inhibited the growth of the radical of the tested crop seeds (Fig.3,a& b). On average, radical elongation decreased by 64%, 43% and 40% in leaves root and seed extracts respectively, compared to control treatment (Fig.2,a). Barley and okra did not show radical elongation by *Ocimum* extracts treatment. However, the shoot length of the lentil seed by leaf extract and mustard seed by both root and seed extract was less affected. Effects on radical elongation were variable among test crop seeds. The shoot growth inhibition pattern in all test crop seed was similar by root and seed extracts, while, leaf extract had different pattern (Table 1). The shoot growth of okra and barley, and okra and maize was most affected by leaf and, root and seed extracts, respectively.

DISCUSSION

This study demonstrates the allelopathic activity of *Ocimum* in terms of seed germination and seedling growth of some agriculturally important crops. Inhibition of germination, root and shoot elongation of tested crop seeds with plant extracts could be due to water-soluble organic acids, chemical decomposition or microbial degradation of organic compounds [9], [13]. The effects varied depending on the tissue and extract types, the target species and the growth attributes measured. Germination was less sensitive than seedling growth to allelopathy, as also observed in other species [23], [26], [29]. *Ocimum* plant extracts slight delay in germination and maximum germination rate was affected by leaf extracts followed by root and seed extracts. In this study, the effect of *Ocimum* seed extract on germination and root development was less as compared to the leaf and root extracts [4]. These results are in accordance with other studies which reported that allelopathicity may vary among plant parts [1], [5], [7], [29]. Barley leaves extract showed the highest inhibitory effect on lentil [31].

Ocimum plant extracts inhibited over all shoot growth of test crops seed by 37% compared to water control. In this study, radical growth appeared more sensitive to extracts than the hypocotyls length. This may be attributed to the fact that radical is the first to come in contact with the allelochemicals. Similar findings were reported on the water extracts of allelopathic plants generally having more pronounced effects on shoot growth, rather than root growth [1], [6], [31].

The leaf extract of plants showed most prominent allelopathicity than root and seed extract. These results are in agreement with findings of other plants [16], [29]. Extracts of different plant species may contain phytotoxic compounds; the present extracts were either slightly phytotoxic or non-phytotoxic. The interactions of crop species with extracts indicate that phytotoxic effects may be due to more than one chemical component present in the different extracts and the crop species that reacted differently to these compounds. Inhibition might have been due to the presence of allelochemicals as reported by [3]. Swaminathan et al. [30] reported that the potential compounds which are able to induce inhibitory effect and seed germination are identified as phenolic acids [21].

It may be concluded that the *Ocimum* plants can reduce germination and alter root/shoot developments of many commercial crops. Isolation, identification and its effects on soil properties of *Ocimum* phytotoxic molecules (allelopathic) would be needed to support this hypothesis and also useful for management of cropping systems/crop rotation involving *Ocimum* plants as a crop. Further, plans are to conduct field experiments to assess allelopathic effects on test crops by *Ocimum* plants.

Table 1. Trends of % germination reduction root and shoot elongation due to the *Ocimum* extracts

Extracts	**% Germination reduction**		
Leaf	Barley > okra > maize > mustard > pea > wheat > lentil > gram		
Root	Okra > barley > maize > mustard > wheat > lentil > pea > gram		
Seed	Okra > barley > mustard > wheat > maize > lentil > pea > gram		
	Root growth		
Leaf	Okra > barley > mustard > maize > wheat > pea > lentil > gram		
Root	Okra > barley > maize > wheat > lentil > gram > mustard > pea		
Seed	Okra > barley > maize > lentil > gram > pea > wheat > mustard		
	Shoot growth		
Leaf	Okra > maize > barley > Gram > wheat > lentil > mustard > pea		
Root	Okra > barley > maize > gram > wheat > lentil > mustard > pea		
Seed	Okra > barley > maize > gram > wheat > lentil > mustard > pea		
LSD (P <0.05)	**Germination (%)**	**Root growth**	**Shoot growth**
Extracts	5.25	0.18	0.07
Test crops	7.43	0.25	0.11
Extracts× Test crops	14.86	0.52	0.22

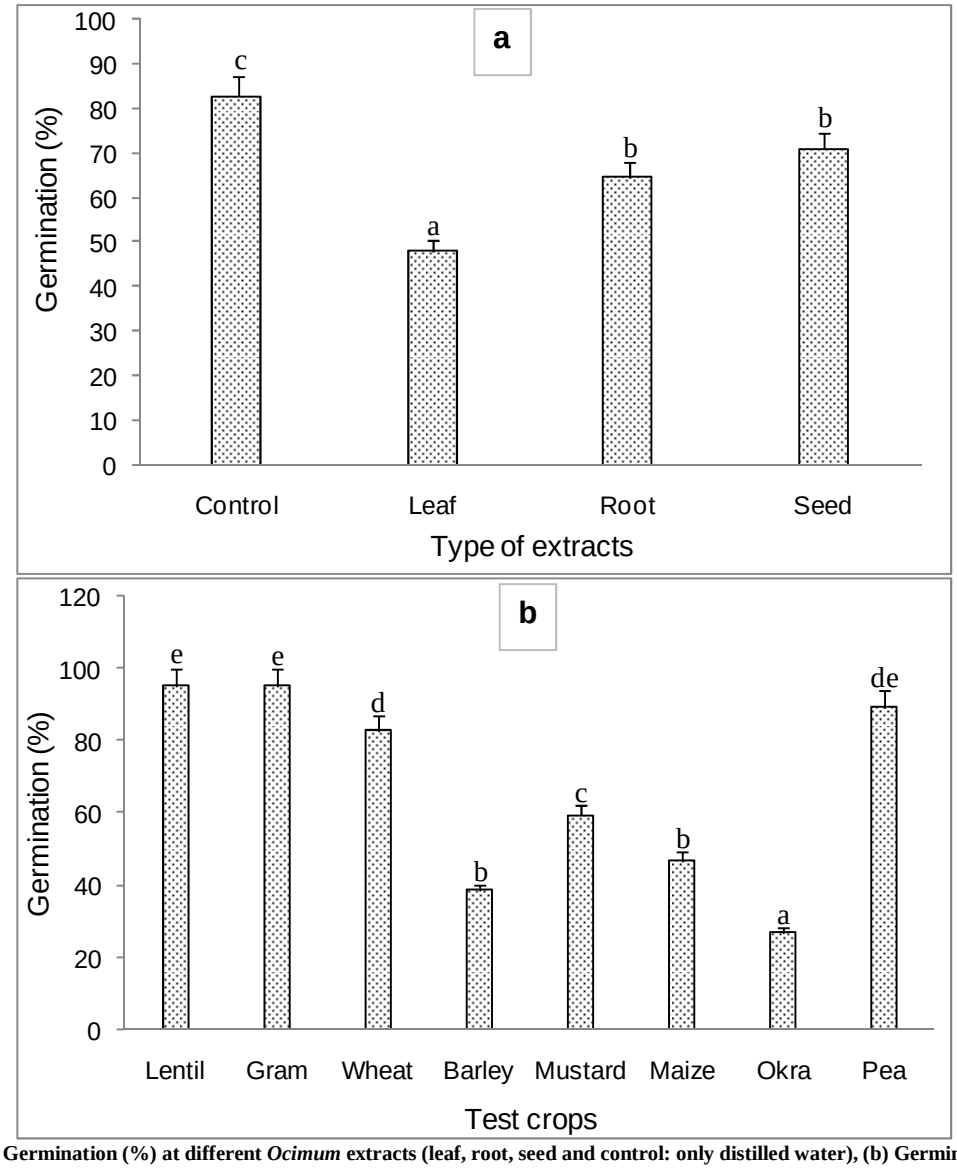

Figure1. (a) Germination (%) at different *Ocimum* extracts (leaf, root, seed and control: only distilled water), (b) Germination (%) of different test crop seeds. (Bar denotemean; Bar diagrams followed by the same letter do not differ significantly at p<0.05 by Duncan's multiple range test).

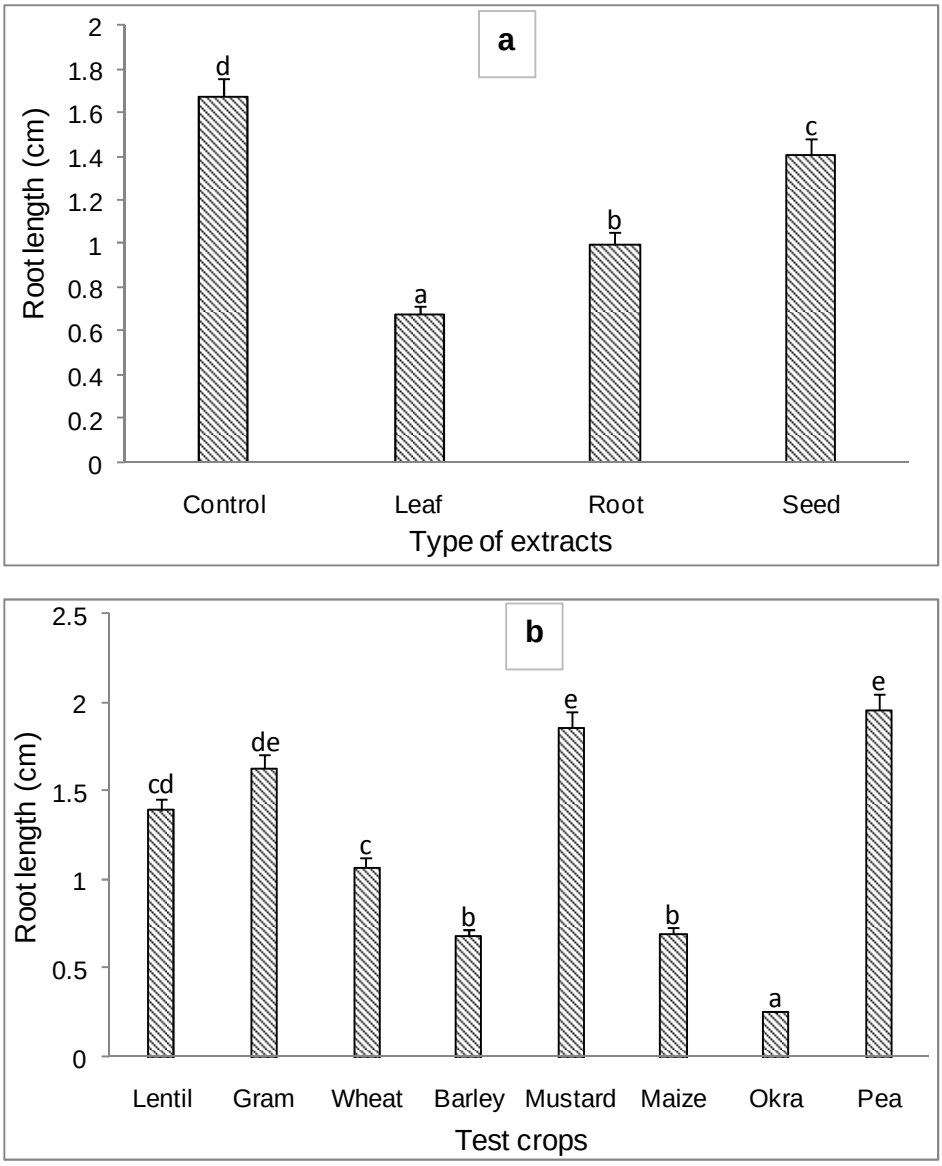

Figure 2. (a) Root elongation (cm) at different *Ocimum* extracts (leaf, root, seed and control: only distilled water), (b) Root elongation (cm) of different test crop seeds. (Bar denotes ± mean; Bar diagrams followed by the same letter do not differ significantly at p<0.05 by Duncan's multiple range test).

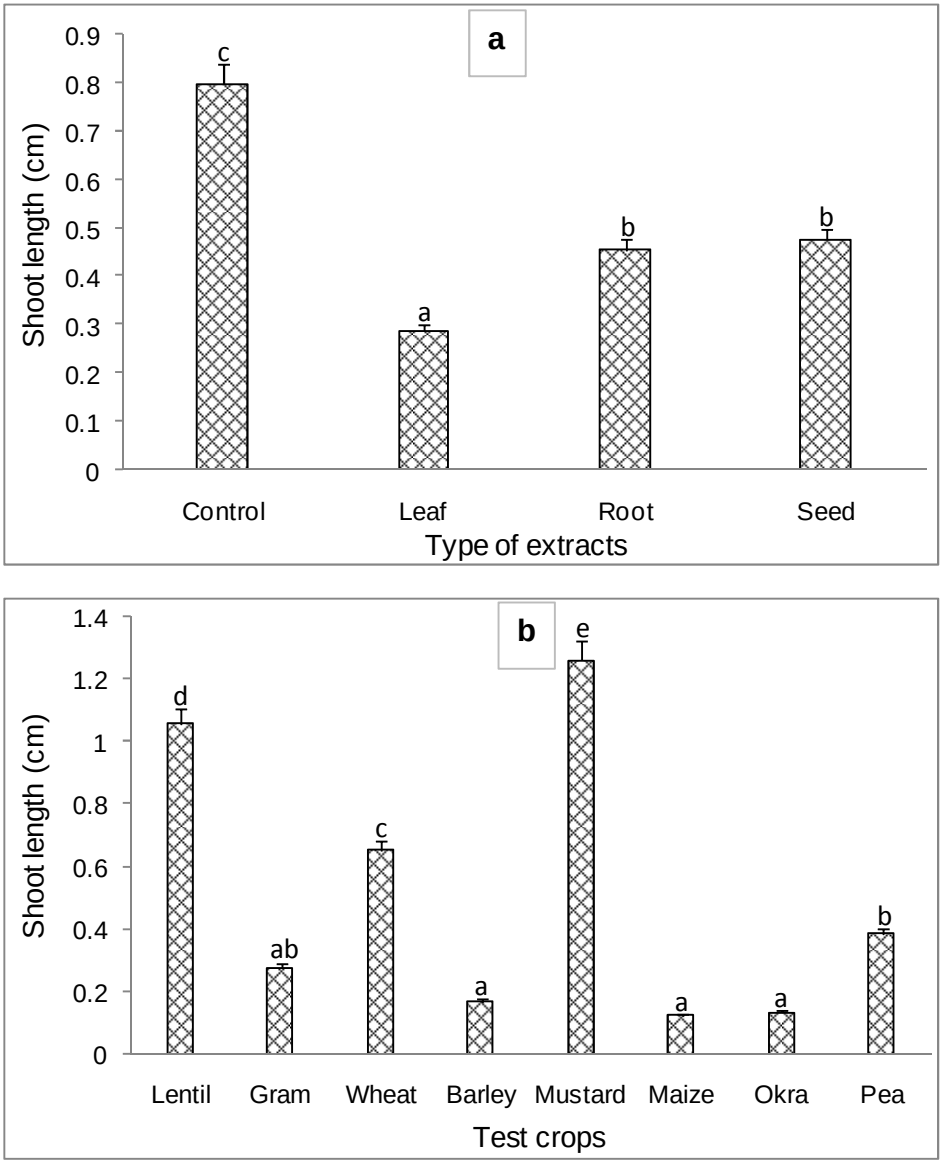

Figure 3. (a) Shoot growth (cm) at different *Ocimum* extracts (leaf, root, seed and control: only distilled water), (b) Root elongation (cm) of different test crop seeds. (Bar denotes ± mean; Bar diagrams followed by the same letter do not differ significantly at p<0.05 by Duncan's multiple range test).

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