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Morphological and elements constituent effects of allelopathic Activity of some medicinal plants extracts on Zea mays

Areej Ali Baeshen*

Department of Biological Sciences, Faculty of Science, King Abdulaziz University, Jeddah, Saudi Arabia

***Corresponding author**

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A B S T R A C T

Allelopathy is a complex phenomenon that depends on the concentration of allelochemicals. It has both inhibitory and stimulatory effects, which may be decide by concentration of allelochemicals present in extraction. In the present study, the allelopathic effects of *Eruca sativa*, *Mentha peperina*,, and *Coriandrum sativum* water extract prepared by grinding fresh leaves of the medicinal plants in distilled water and three concentrations were taken from the crude extracts (100%, 50% and 25% in addition to 0% as control), were tested for their effects on seed germination and some growth parameters of *Zea mays* . the experiment was conducted in sterilizes Petri dishes under the natural laboratory conditions at temperature of 25° C, with a 24 h, 48 h, 72 h, 96 h and 120 h time interval for seed germination and 24 h, 48 h and 72 h for radicle length. The effects of different concentrations of aqueous extract were compared to distilled water (Control, 0%). In maize, germination percentage was suppressed when plants was treated with 100% extracts, however, 50% an 25% of *M.peprina* increased germination percentage by 4 times more than the control. Moreover, 50% and 25% extracts of M. peperina and 50% of C. sativum increased maize radicle and plumule length by 3 to 4 times that of the control .. Results of plumule fresh and dry weights revealed that, concentrations of water extracts of *100% and 50% M. peperina* , *E. sativa* 100% and *E. sativa* 50% reported almost similar plumule fresh weight as in control plants. The most interesting finding is the reduction in harmful salts and TDS which could be a good factor in saline soils of Saudi Arabia.

Introduction

Allelopathy is a phenomenon involving either direct or indirect and either beneficial or adverse effects of a plant (including microorganisms) on another plant through the release of chemicals in the environment (Singh, et al. 2001). For over 2,000 years, allelopathy has been reported in the literature with respect to plant interference (Weston and Duke, 2003). Allelochmicals which inhibited the growth of some species at certain concentrations may stimulate the growth of same or different species at lower concentrations (Zhung, et al., 2005). According to the different structures and properties of these compounds, allelochemicals can be classified into the following categories: (1) water-soluble organic acids, straight-chain alcohols, aliphatic aldehydes, and ketones; (2) simple unsaturated lactones; (3) long-chain fatty acids and polyacetylenes; (4) quinines (benzoquinone, anthraquinone and complex quinines); (5) phenolics; (6) cinnamic acid and its derivatives; (7) coumarins; (8) flavonoids; (9) tannins; (10) steroids and terpenoids (sesquiterpene lactones, diterpenes, and triterpenoids) (Zhao et al., 2010).

Dongre *et al*., 2004 studied two black gram varieties that were treated with different concentration of aqueous leaf leachates of eight dominant weeds (*Ageratum conyzoides, Anagelis arvensis, Eclipta alba, Lippia nodiflora, Parthenium hysterophorus, Phylanthus niruri, Pluchea lanceolata* and *Polygonumm plebejum)* to asses their allelopathic effects on seed germination. Leachates of all weed species inhibited both seed germination and seedling growth of both test varieties at 10 per cent concentration. Increase in concentration of leachates was invariably associated with decrease in germination of test cultivars irrespective of weed species.
In addition, The aqueous extracts from fresh and dry leaves of *Lantana camera* inhibited the growth of water hyacinth and killed the plant within six days because of salicylic acid which is major allelochmicals in lantana (Zhung *et al*., 2005).

Bioassay studies of aqueous extract of inflorescence, stems and leaves of *Parthenium hysterophorus* on germination and seedling establishment of *Cassia occidentalis* showed that all concentration from plant parts had inhibitory effect on seed germination and seedling growth. Leaf extract appeared to be more potent compare to extracts from stems and inflorescence (Rahaman and Acharia.1998).

Medicinal Plants used in the study

E. sativa

Belongs to the family *Brassicaceae*. One of the famous plants that almost used daily in salads in addition to its use as medicinal plants in many Arabic countries including Saudi Arabia. The essential oil from the leaves of *Eruca sativa* was found to contain 67 volatile components, representing 96.52% of the oil, which were characterized. The main constituents were 4-methylthiobutylisothiocyanate (60.13%) and 5-methylthiopentanonitrile (11.25%). The essential oil from the leaves of*E. sativa* was characterized by a high content of sulfur- and nitrogen-containing compounds (Mitsuo et al. 2002). In addition leaves are used for their antimicrobial activity (Alaraidh et al., 2014).

M. peperina

From the family Lamiaceae. Peppermint has a high menthol content. The oil also contains menthone and menthyl esters, particularly menthyl acetate. Dried peppermint typically has 0.3-0.4% of volatile oil containing menthol (7-48%), menthone (20-46%), menthyl acetate (3-10%), menthofuran (1-17%) and 1,8-cineol (3-6%).

Peppermint oil also contains small amounts of many additional compounds including limonene, pulegone, caryophyllene and pinene. It is the oldest and most popular flavour of mint-flavoured confectionery and is often used in tea and for flavouring ice cream, confectionery, chewing gum, and toothpaste. Peppermint can also be found in some shampoos, soaps and skin care products. (Herro and Jacob, 2010). Peppermint can also be found in some shampoos, soaps and skin care products (Herro and Jacob, 2010).

C.Sativum

From the family Apiaceae. All parts of the plant are edible, but the fresh leaves and the dried seeds are the parts most traditionally used in cooking. The leaves have a different taste from the seeds, with citrus overtones.

However, many people experience an unpleasant soapy taste or a rank smell and avoid the leaves. The flavours have also been compared to those of the stink bug, and similar chemical groups are involved (aldehydes). The different perceptions of the coriander leaves' taste is likely genetic, with some people having no response to the aromatic chemical that most find pleasant, while simultaneously being sensitive to certain offending unsaturated aldehydes (Sathyavathi et al., 2010).

Zea mays

From the family Poaceae. Maize is the most widely grown grain crop throughout the Americas,] with 332 million metric tons grown annually in the United States alone. Approximately 40% of the crop - 130 million tons - is used for corn ethanol. Genetically modified maize made up 85% of the maize planted in the United States in 2009 (Karl, 2013).

Material and Methods

Preparation of aqueous extracts

Fresh leaves of Salad Rocket (*Eruca sativa*), *Mentha peperina* and *Coriandrum sativum* were extracted with distilled water using ground blender. The resulting solution was filtered through four layers of cheesecloth to remove debris, and centrifuged for 30 minutes. The supernatant was then filtered through one layer filter paper (Whattman NO .1). Three concentrations were prepared from the crude extract *Viz*, 100%, 50 , 25%, and 0% (pure distilled water, control).

Treatments and Measurements

Ten uniform and surface sterilized seeds (2% sodium hypochlorite for 15 min) of *Zea mays* were kept for germination in sterilized Petri-dishes lined double with blotting paper. The seeds of *Zea mays* were treated with 3 concentrations of the extracts of the three plants (100%, (crude extract) 50%, 25% and 0% (distilled water). Each treatment had three replicates The Petri-dishes were maintained under laboratory conditions (room temperature 25°C at mid day, and diffused light during day).Some growth parameters were taken. These include, germination rate, radicle and plumule length, fresh and dry weight and elements content of radicle and plumule of *Zea mays* at the end of the experimental period.

Statistical analysis

The experiment was designed as Completely Randomized Block Design (CRBD) and the mean values were analyzed at $P < 0.05$ using one way analysis of variance (ANOVA).

Result and Discussion

Germination Rates

Aqueous extracts of all medicinal plants increased percentage of germination of *Z.mays* more than distilled water. However, Z. mays treated with 100% crude extract of the three plants reported low germination rates (Fig.1). The concentration of 50 % and 25% of *M. peprina* caused 4 times increase in *Z. mays* germination rate compared to control. On the other hand, *Z. mays* treated with 25% and 50 % *E. sativa* and *Coriandrum* achieved from 3 to 3.5 times of germination rate of the control. Noteworthy is that, Z. mays treated with the three tested extracts at all concentrations increased germination rate of *Z.mays* more than distilled water (control).

Radical and Plumule lengths

In general, Z. mays radicle were taller than the Plumule in all treatments. *Z. mays* radicle length showed different responses to the medicinal plants extracts used. 50% and 25% extracts of *M. peperina* and 50% of *C.sativum* , increased maize radicle length by almost three times that of distilled water (9.2, 9.0 and 8.6 cm, respectively compared to 3.8 cm of the control) . On the other hand, 25% of *C.sativum* and 25% of *E. sativa* extracts enhanced the radical growth of mays plants by two folds than the control (6.4 cm compared to 3,8 cm) (Fig.2). These findings are in consistence with those of Ebrahimi *et al*., (2011), Cerdeira, *et al*., (2012) and De Bertoldi, *et* al., (2012). Kimberly *et al*., (2002) reported that *E. sativa* contains Glucosinolates originate from a group of amino acids, including alanine, leucine, methionine, phenylalanine and tryptophan which may be responsible for this increase. Worth mentioning is that 100% crude extract of *E. sativa* and *C.sativum* suppressed radicle length compared to control, while 50% of *E.sativa* caused similar radicle length of the control(Fig.2). Sang et al., (2002) reported root and biomass suppression when Alfalfa (*Medicago sativa* L.) extract was used.

Regarding plumule length, 25% concentration of *M. peperina*, *25% of E. sativa* and 50% *M. peperina* extracts enhanced the growth of maize Plumule by 5 to 4 times of the control (5.8, 4.9 and 4.2 cm) respectively compared to 1.7 cm in the control (Fig. 2). Moreover, 100% of *M. peperina*, 25% and 50% *C. sativum* extracts increased the plumule length by three to two times of the control (3.6, 3.4, 2.4 cm respectively, compared to 1.7 cm of the control). On the other hand, 100% of *C. sativum*, 100% and 50% of *E. sativa* reduced Plumule length by almost half that of the control (0.9 cm compared to 1.7 cm of the control). .

Radicle and Plumule Fresh and Dry Weights

Results of plumule fresh and dry weights (Fig. 3, Table, 1) revealed that, concentrations of water extracts of *100% and 50% M. peperina* , *E. sativa* 100% and *E .sativa* 50% reported almost similar plumule fresh weight as in control plants (0.38 gm, 0.46 gm, 0.41 gm and 0.39 gm, respectively, compared to 0.49 gm in the control). There are no significant differences were observed (Table, 1). Alternatively, plumule fresh weight of maize treated with 50% C. sativum, 25% *M. peperina* and 25% E. sativa reported reduction compared to the control ($P \leq 0.05$, Table 1). These findings are in consistent with those of Hesammi and Farshidi (2012) and Khan *et al*., (2012). In contrast, Aasifa and Siddiqui (2014), have reported that

Aqueous extract of *Eclipta alba* (L.) leaves shows the maximum inhibition seedling growth and dry biomass.

TDS and Essential Elements

Results in Table 2 elucidate the effect of aqueous extract of the three plants on TDS(%) and the essential elements (mg/g dry wt.) on maize (*Z. mays*) radicle . In general, all medicinal plants aqueous extracts caused low amount of TDS accumulation compared to control ($P \geq 0.05$, Table, 2). This considered as a good factor. Phyllis, et al. (2007) reported that very high total dissolved solids (TDS) cause toxicity through increases in salinity, changes in the ionic composition of the water and toxicity of individual ions. Nonetheless, Total Dissolved Solids (TDS) are solids in water that can pass through a filter (usually with a pore size of 0.45 micrometers).

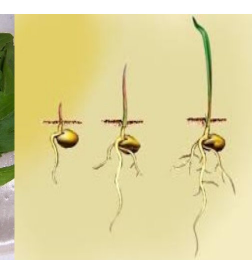
TDS is a measure of the amount of material dissolved in water. This material can include carbonate, bicarbonate, chloride, sulfate, phosphate, nitrate, calcium, magnesium, sodium, organic ions, and other ions. A certain level of these ions in water is necessary for plant life (Phyllis, *et al*., 2007).. Likewise, control plant reported very high amount of sodium (Na^+) and Chlorine (Cl^-) compared to treated plants under all concentrations. This considered as a good factor in the beneficial of plants treated with the aqueous extract as was reported by many authors who concluded that The effects of salt-salinity stress on physiological responses have been observed in several species including not only herbaceous plants and woody plants (Nuran and Hüsnü, 2002; and Huang et al., ,2013). In addition, control plants recorded higher amount of K^+ SO_4^{-2}, Ca^{+2} and Mg^{+2} compared to treated plants at all concentration. Nevertheless, maize treated with these extracts recorded reasonable values of these elements except for Calcium which was low in control plants too. (Table, 2).

Areej and Batoul (2014, personal communication) have found that plants treated with the extracts reported almost twice the values of magnesium and sulfur compared to control in Lentils (*Lens culanaris*, $p<0.05$) shoots. However, due to some technical problem, essential elements were not obtained for maize shoot (plumule). In contrast, accumulation of elements in roots more than shoot is reported by many authors (Nafiseh, *et al*., 2012). However, some authors reported high amount of elements in shoots more than roots (Sêkara, *et al*.,2005) who found that, Red beet accumulated high amounts of cadmium and lead in leaves (2.65 and 8.71 mg kg-1 d. wt, respectively).

C.sativum leaves

M. peperina leaves

.sativa leaves



Z. mays seedlings

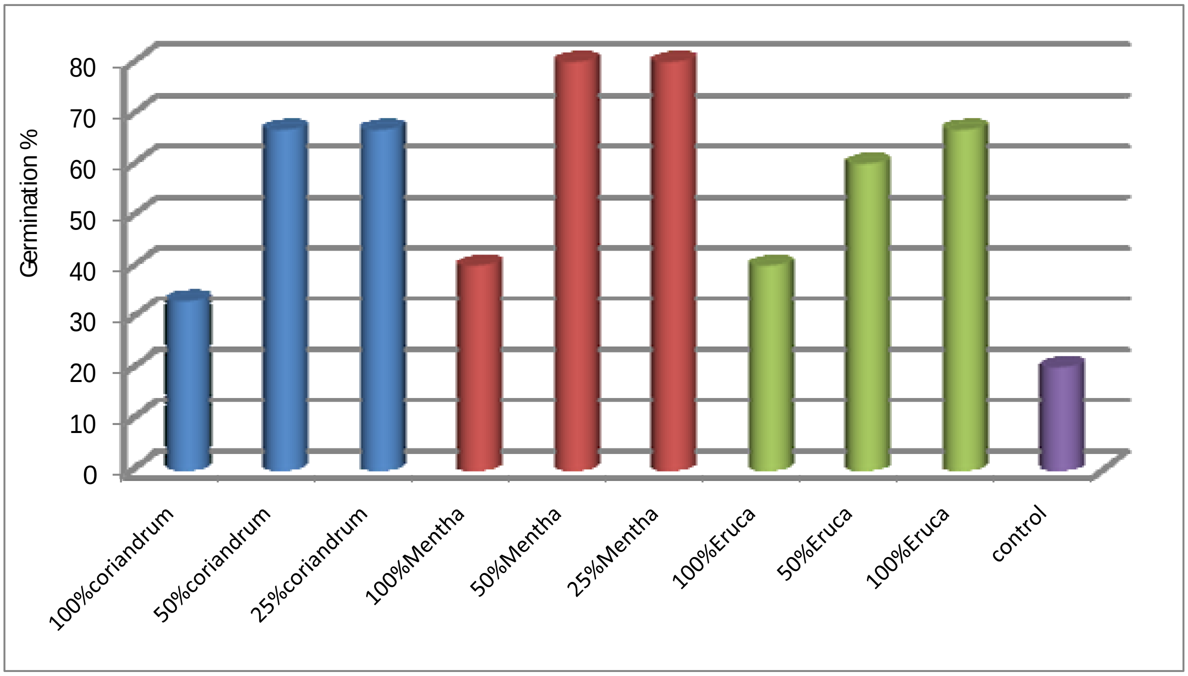


Fig.1 %Germination of (*Zea mays*) grown with different plant extracts.

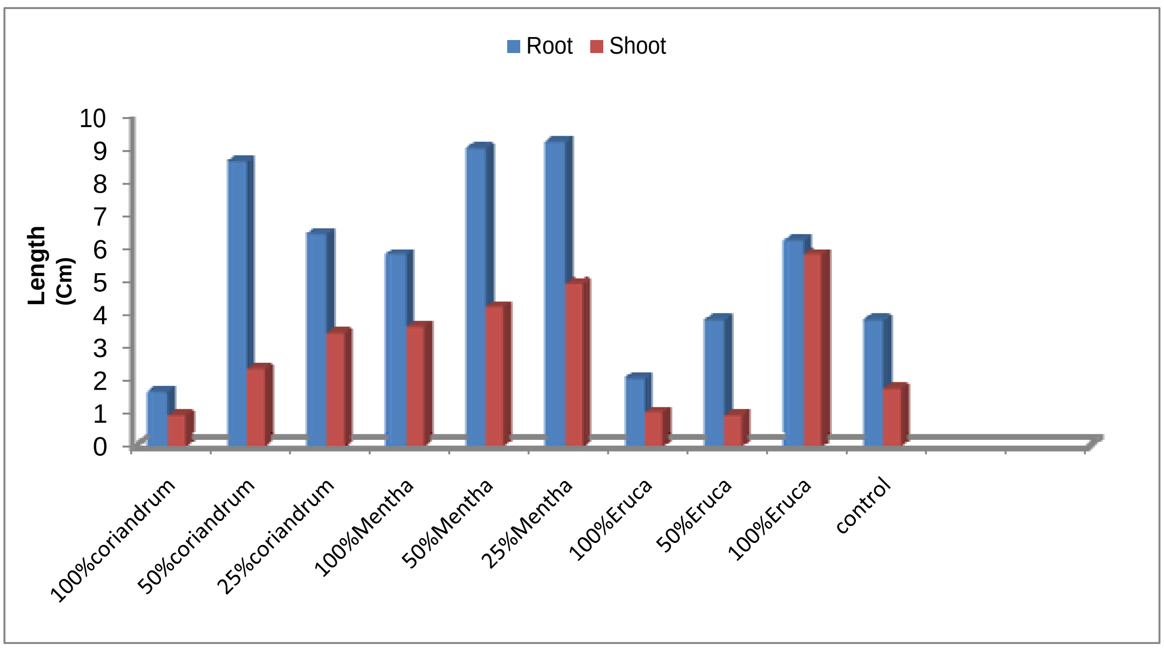


Fig.2 Radicle (root) and Plumule (shoot) length (cm) of Z.mays Treated with different concentrations medicinal plant Extracts

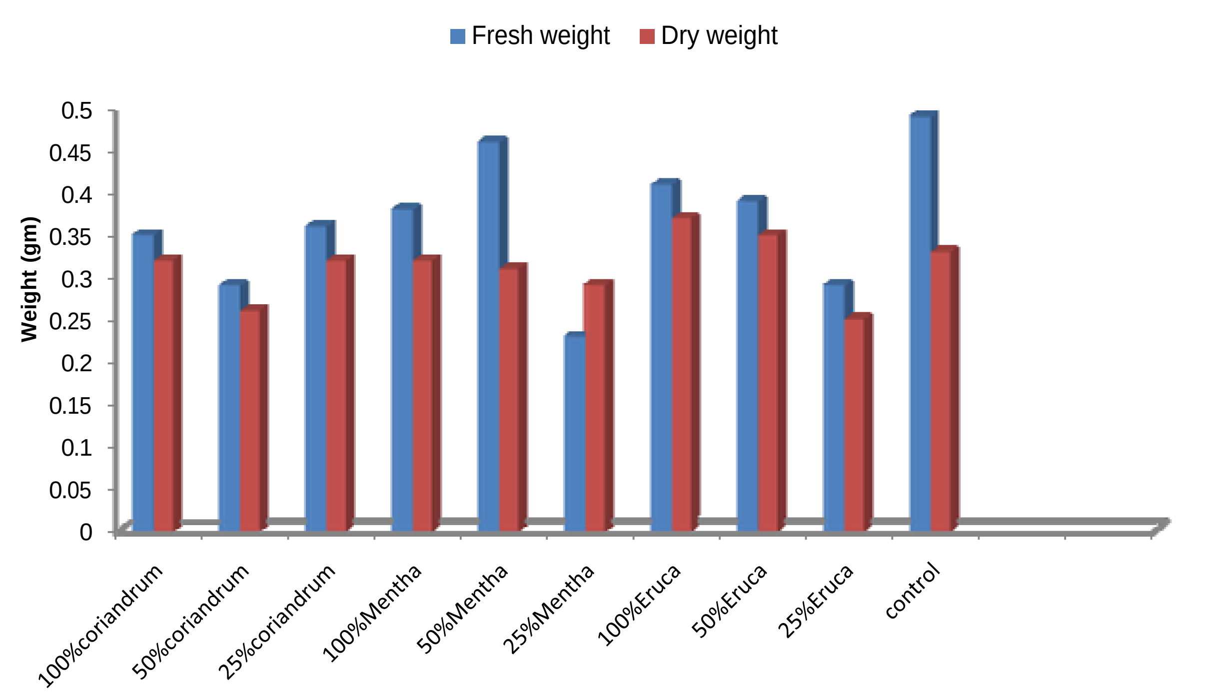


Fig3: Plumule Fresh and Dry weights (gm) of (*Zea mays*) grown with different

Table.1 Plumule Fresh and Dry weights (gm) of (*Zea mays*) grown with different plant extracts

Weight (gm)								
	Fresh weight	Dry weight		Fresh weight	Dry weight		Fresh weight	Dry weight
*C. sativum*100%	0.35a	0.32a	*M. peperina. 100%*	0.38c	0.32a	*E. Sativa. 100%*	0.41c	0.37a
C.sativum. 50%	0.29b	0.26a	*M. peperina. 50%*	0.46c	0.31a	*E. sativa. 50%*	0.39c	0.35a
C.sativum. 25%	0.36a	0.32a	*M. peperina 25%*	0.23b	0.29a	*E. Sativa. 25%*	0.29b	0.25a
Control	0.49c	0.33a						

Numbers with different letters are significantly differ from the control at $P \leq 0.05$

Table.2 Effect of aqueous extract of the three plants on TDS(%) and the essential elements (mg/g dry wt.) on *Zea mays* Root

Plants	TDS	Na^{+}	K^{+}	Cl^{-1}	SO_4^{-2}	Ca^{+2}	Mg^{+2}
Distilled water 0% (control)	62.06a	112.50a	57.83a	2396.25a	30.41a	0.68a	274.50a
*C. sativum*100%	9.30b	7.56b	17.57b	100.58b	3.19b	0.08b	40.32b
C.sativum. 50%	10.25b	6.56b	18.66b	99.84b	2.66c	0.04c	34.31c
C.sativum. 25%	19.58c	40.50c	19.80b	479.25c	5.47d	0.45d	137.25d
M. peperina,. 100%	13.83b	11.38d	25.84c	230.75d	4.61e	0.05c	39.65b
M. peperina,. 50%	10.32b	10.56d	19.84b	149.98e	1.85f	0.02c	25.76e
M. perinta25%	7.65b	6.01b	15.11d	152.40e	4.87e	0.03c	10.47f
E. Sativa. 100%	27.99d	40.50c	28.62c	479.25c	6.08g	0.41d	164.70g
E. sativa. 50%	20.64d	13.50d	27.60c	159.75e	6.08	0.03c	18.30h
E. Sativa. 25%	8.79b	5.63b	14.06d	79.88f	2.58c	0.03c	20.58i

The data are expressed in mean ± SE. n=3 in each group.
Means marked with different letters in the same column are significantly differ at $P < 0.05$.

The present research revealed that aqueous extract of *C.sativa*, *M. peperina* and *E. sativa*, at different concentration levels enhanced the germination percentage, radical length, Plumule length and fresh and dry weights of *Z. mays* seedlings. Their effectiveness on germination and growth suggests that leaves of these medicinal plants may act as a source of beneficial allelochemicals. The most interesting finding is the reduction in harmful salts such as sodium, chlorine and TDS which could be a good factor in saline soils of Saudi Arabia.

There is a need to provide information to farmers about these plants and their allelopathic effects. Further studies are suggested to clarify the possible physiological mechanism related to allelopathic effect on plants especially regarding essential elements accumulation in shoots and roots.

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