Allelopathic Potential of Rhizosphere Powder Amended Soil (LPRS) and Inorganic Profiling of *Eclipta alba* (L.) Hassk. on Growth of Crops and Weeds

A. Gulzar*, M.B. Siddiqui and Shazia Bi

*Department of Botany, Aligarh Muslim University, Aligarh, 202002*

*Corresponding author, Email: aasifa4gulzar@gmail.com, aasifa.gulzar@rediffmail.com*

**Abstract**

The experiment was carried out to study the allelopathic and elemental analysis of *Eclipta alba* (L.) Hassk. and physico-chemical characteristics of its rhizosphere soil, and determine the effect on the growth of crops (*Oryza sativa* L., *Phaseolus aureus* L.) and weed (*Cassia sophera* (Roxb.) L., *Cassia tora* L.) plants. Root length, shoot length and dry weight of test plants decreased significantly when plants were grown in rhizosphere amended soil. The pH of rhizosphere soil decreased compared to control whereas the, organic carbon and organic matter increased. Elemental analysis showed the composition of 8 different elements with calcium, iron and Magnesium highest concentration. The presence of significantly high amount of phenolics in rhizosphere soil indicated their possible interaction with soil chemical properties.

**Keywords:** allelopathy, rhizosphere amended soil, pH, electrical conductivity, phenolics and inorganic profiling

**Introduction**

Allelopathy includes the positive and negative effects of chemical compounds produced mainly from the secondary metabolism of plants, microorganisms, viruses and fungi that have an influence upon the growth and development of agricultural and biological ecosystems (excluding mammals) (Kruise et al., 2000, olofsdotter et al., 2002, Rice, 1984, Seigler1996). The term allelopathy was coined by Molish, 1937. The allelopathic effects are achieved due to the release of active biomolecules, commonly called allelochemicals, into the environment by the allelopathic plants (Hussain et al., 2007, Seigler, 1996). These chemicals are largely classified as secondary metabolites (such as alkaloids, isoprenoids, phenolics, flavonoids, terpenoids and gluconolates etc (Nazir et al., 2007). Allelopathic substances released by the plants accumulate in soil to physiologically active level (Samreen et al., 2009). These allelochemicals are found to accumulate and persist for considerable time, thus, significantly interfering with the growth of neighbouring plants and weeds (Putnam and Duke, 1974). Integrated weed management is one of such approaches where allelopathy can play its ecofriendly role in weed management (Hussain et al., 2007). The allelopathic properties of plants can be exploited successfully as tool for pathogens and weed reduction (Xaun et al., 2005). Allelochemicals may be involved in plant-plant, plant-insect or plant-herbivore chemical communication (Weir et al., 2004) as well as micro-organism-derived allelochemicals that may be involved in microbe-microbe or microbe-plant interactions (e.g., colonisation process of a new environment) (Singh et al., 2003).

*Eclipta alba* belonging to the family Asteraceae is considered to be one of the world’s worst weeds in 17 crops in 35 countries and can reduce yields more than 75% in pea nut (Prostko, 2012) and in rice and mung bean (Gulzar and siddiqui, 2014). Its invasive nature is due to its fast growth rate, high reproductive and vegetative potential, adaptable to changing environmental conditions, wide ecological amplitude and allelopathy. Several workers have demonstrated
the allelopathic properties of the weed (Pawinde et al., 2008, Yonli et al., 2010, Gulzar and Siddiqui, 2014). The present study was conducted to assess phytotoxicity of rhizosphere soil amended with leaf powder and to find out the role of phenolics and various elements in this. For the study, we selected four test species, two crops namely *Oryza sativa* L. and *Vigna radiate* L. and two weeds namely *Cassia tora* L. and *Cassia sophera* L. (Roxb.).

**Materials and Methods**

**Collection of Soil and Evaluation of Its Physico-Chemical Characteristics**

Rhizosphere soil that is, soil in and around the root system (approximately at 5 to 15 cm depth and 10 cm radius) was collected from *E. alba* invaded area in the month of August, 2010 from the campus of Aligarh Muslim University, Aligarh (27º 29' to 28º, 100º N.L and 77º 29' to 78º, 38 E.L). Collection of soil was made from the upper 0 to 15 cm soil profile since 80% of the root system of plant is present in this zone. Soil samples were analyzed for pH, conductivity, phenolics, organic carbon, organic matter, and nutrients. The pH and conductivity were measured in a 1: 5 soil water (w/v) paste with the help of digital pH and conductivity meter, respectively. Organic carbon and organic matter were estimated (Walkey and Black, 1934), total phenolics (Swain and Hillis, 1959). Available nitrogen from soil was estimated using alkaline potassium permanganate solution as per the method of Association of Official Agricultural Chemists (AOAC), 1960; available phosphorus (Olson et al. 1954), potassium and sodium (Bower and Gschwend, 1952) and available iron, manganese and zinc (using an atomic absorption spectrophotometer) was measured. At least four replicates were maintained for each analysis.

**Preparation of Rhizosphere Amended Soil (RLPS)**

The experiment were conducted in September 2010 in a completely randomized block design in the net house, Department of Botany, Aligarh Muslim University with average temperature of (22/14±3°C), constant supply of photosynthetically active radiation (PAR) (400-700nm) and relative humidity maintained at (62±5%). Fresh green leaves of *Eclipta alba* (Figure 1) were collected and dried separately under shade, powdered and labeled separately. The powdered part were mixed into the soil at the rate of 5, 10, 20 and 40g kg⁻¹ soil and labeled as LPRS (leaf powder amended rhizosphere soil) and unamended soil as US, respectively. Each of the respective amended or unamended (control) soil was taken in 250 mL capacity plastic cups.

**Growth Studies**

Fresh seeds of crops (*oryza sativa, Phaseolus aureus*) and weeds (*Cassia tora, Cassia sophera*) were collected from the agricultural department and road sides of the Aligarh Muslim University for growth studies. The seeds of the *C. tora* and *C. sophera* were rubbed with sand paper for breaking the dormancy and dipped in water for 12 h. *O. sativa* and *P. aureus* seeds were soaked in water for 12 h. They were subjected to growth studies in pots filled with soil samples (rhizosphere amended soil as well as control). For each tested plant species and treatment, five replicates were used. After one month, seedlings were uprooted carefully, keeping the root system intact. Their root and shoot lengths were measured and biomass quantified after oven drying.

![Figure 1](image)

*Figure 1 Eclipta alba, its profuse growth (A); Eclipta alba plant (B); Eclipta alba root (C).*
Potential of LPRS and eclipta alba on growth of crops and weeds

Elemental Analysis of Plant
The plant samples for the determination of nutrient elements like K, Na, Ca, Mg, Cu, Zn, Fe, Mn, Mo and B which do not volatilize at high temperature can be digested by dry ashing in furnace using suitable silica, porcelain or platinum crucible and extracting them in dilute HNO₃ (Brahma et al., 2014).

Statistical Analysis
The data were subjected to ANOVA followed by Duncan’s Multiple Range Test (DMRT) (Duncan, 1955) and 2 sample t-test, wherever applicable.

Results

Elemental Contents
The content of various elements in the mature E. alba are presented in Figure 2.

Elemental Analysis of Rhizosphere Soil
The pH and electrical conductivity was significantly higher in the rhizosphere soil of E. alba than in the control soil (Table 1). The amount of phenolics in the rhizosphere soil of E. alba was as about four times as in control. The differences were also statistically significant and similar differences in regards to organic carbon and organic matter were observed (Table 1). Thus, the amount of organic carbon was maximum in soil of E. alba invaded site followed by control. Amount of macro and micro nutrient was also observed in the rhizosphere soil and control soil. In general, maximum amount of nutrients was calculated in the soil of E. alba invaded soil followed by control.

Table 1 Soil characteristics in control soil and rhizosphere soil.

<table>
<thead>
<tr>
<th>Soil character</th>
<th>Control</th>
<th>Rhizosphere soil</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH</td>
<td>7.63</td>
<td>7.24</td>
</tr>
<tr>
<td>Conductivity</td>
<td>132.1</td>
<td>187.5</td>
</tr>
<tr>
<td>Phenolic content (mg 100 g⁻¹)</td>
<td>0.21</td>
<td>0.64</td>
</tr>
<tr>
<td>OC (%)</td>
<td>1.08</td>
<td>1.72</td>
</tr>
<tr>
<td>OM (%)</td>
<td>1.86</td>
<td>2.80</td>
</tr>
<tr>
<td>N (kg ha⁻¹)</td>
<td>175</td>
<td>242</td>
</tr>
<tr>
<td>P (kg ha⁻¹)</td>
<td>162.4</td>
<td>182</td>
</tr>
<tr>
<td>K (mg kg⁻¹)</td>
<td>104</td>
<td>149</td>
</tr>
<tr>
<td>Na (mg kg⁻¹)</td>
<td>37.4</td>
<td>71.1</td>
</tr>
<tr>
<td>Ca (g 100 g⁻¹)</td>
<td>2.31</td>
<td>4.18</td>
</tr>
<tr>
<td>Mg (g 100 g⁻¹)</td>
<td>1.51</td>
<td>2.38</td>
</tr>
<tr>
<td>Cl (g 100 g⁻¹)</td>
<td>3.74</td>
<td>2.10</td>
</tr>
<tr>
<td>HCO₃ (g 100 g⁻¹)</td>
<td>13.74</td>
<td>24.12</td>
</tr>
<tr>
<td>Zn (mg kg⁻¹)</td>
<td>2.4b</td>
<td>5.1a</td>
</tr>
<tr>
<td>Fe (mg kg⁻¹)</td>
<td>5.4b</td>
<td>9.11</td>
</tr>
<tr>
<td>Mn (mg kg⁻¹)</td>
<td>10.2b</td>
<td>10.76</td>
</tr>
<tr>
<td>Cu (mg kg⁻¹)</td>
<td>0.24b</td>
<td>0.76</td>
</tr>
</tbody>
</table>

Different superscript symbols in a row represent significant difference at P<0.05 applying DMRT.

Figure 2 The contents of various elements in mature E. alb
Exception, however, were observed in the content of Cl, it was found maximum in control soil (3.74 g 100 g⁻¹) as compared to rhizosphere soil (2.10 g 100 g⁻¹). In the case of K, Ca, Mg and Na maximum amount of the respective element was found in rhizosphere soil. The differences in the amount of all macro- and micronutrients among the control and rhizosphere soil were found to be statistically significant (Table 1).

Seedling Growth and Dry Biomass

Growth of test species reduced significantly in the rhizosphere soil amended with leaf powder of *Eclipta alba* (Figure 3). Both root and shoot lengths, and seedling weight were severely affected and the effect was more on root length than on shoot length. When grown in rhizosphere amended soil, root length reduced by 90.48% in *C. tora*, followed by *C. sophera* (80.63%) and minimum was in *O. sativa* (23.55%) at 4% concentration, hence the root length decreased with the increasing concentrations i.e. 0.5 to 4% as compared to control. The maximum reduction in shoot length was observed in *C. tora* nearly (82.73%), followed by *C. sophera* nearly (70.14%) in rhizosphere amended soil in comparison to control. In all these test plants maximum retardatory effect was observed at 4% concentration and it was (83.68%) in *C. sophera*, (75.47%) in *C. tora*, (58.41%) in *O. sativa* and nearly (52.66%) in *P. aureus* in LPRS as compared to control.

![Figure 3](image-url)
Discussion

The bioassay studies conducted in *E. alba* rhizosphere amended soil indicates a retardatory effect on growth, the magnitude of which varied from species to species. It is clear from the experiments that growth of the tested plant species that is, *O. sativa*, *P. aureus*, *C. tora*, and *C. sophera* was significantly affected when grown in the rhizosphere amended soil compared to control. Their height and biomass accumulations were significantly reduced in the rhizosphere amended soil. On the basis of root length of the tested plant species, the retardatory effect was in an order *C. tora* > *C. sophera* > *P. aureus* > *O. sativa*. On the basis of shoot length the decreasing order of test plants follows the trend *C. tora* < *C. sophera* < *P. aureus* < *O. sativa*. In the case of dry weight, the decreasing order of the test plants occurs as *C. sophera* < *C. tora* < *O. sativa* < *P. aureus*.

The reduction in seedling growth and dry biomass by rhizosphere soil and aqueous extracts of plants parts of *Eclipta alba* has also been investigated by (Gulzar and Siddiqui, 2013, Gulzar and Siddiqui, 2014). The pronounced alteration in rhizosphere soil nutrient dynamics might be due to the incorporation of powdered elements in addition to releasing putative phytotoxins into the soil medium, alters the soil nutrient dynamics and thus affects the plant growth (DeJong and Klinkhamer, 1985, Facelli and Pickett, 1991, Brady and Weil, 2002, Castells et al., 2005). Xuan et al. (2005) have also reported a similar increase in electrical conductivity of the soil incorporated with residues of allelopathic plants. It ruled out the possibility of any resource depletion and/or competition by addition of root residues into soil medium. Such a root mediated allelopathy has been reported since 1800s when de Candolle (1832) suggested that some crop plants release phytotoxins through their roots and it results in soil sickness. Mahall and Callaway (1991) demonstrated that root exudates of *Larrea tridentate* deleteriously affect the growth of nearby *Ambrosia* plants. A number of studies have earlier demonstrated that root exudation is one of the major modes of release of potential allelochemicals into the soil rhizosphere (Rice 1984, Schreiner and Reed 1907, Bertin et al., 2003). Root exudates comprise a variety of compounds including amino acids, organic acids, sugars, phenolics, and other secondary metabolites, and serve as an important medium of root-based interactions with other organisms (bacteria, actinomycetes, pathogens, fungi, and insects) in the soil (Walker et al., 2003). (±)-Catechin is a potent root secreted allelochemical of *Centaurea maculosa* that exhibits allelopathy, affects soil microbial activity and even imparts invasiveness to the weed (Bais et al., 2002). Recent studies with catechin have demonstrated the importance of root exudates in regulating the rhizosphere interactions and thus plant communities (Walker et al., 2003, Bais et al., 2004). This study indicates that some inhibitors are present in the soil contributed by both rhizosphere soil and powder amended in it that adversely affects the early growth of tested plant species compared to the control. Several studies have indicated that these phenolics are responsible for growth retardatory effect on other plants including crops thus, causing appreciable injury in the growing plants (Rice, 1984, Qasem and Foy, 2000, Weston and Duke, 2003; Sisodia and Siddiqui, 2009). This indicates that phenolics could be the substances depressing the growth of the other plants grown in their rhizosphere soil. Plants release a number of low (phenolics) and high (polysaccharides, proteins) that suppress the growth of neighbouring vegetation has been reported by (Verma and Rao, 2006, Walker et al., 2003). Besides, the plant material upon death and decay undergo decomposition by microbial activity, which in turn lead to release of elements affecting plant growth known as elemental allelopathy. It has been widely reported that accumulation of various heavy metals can cause plant toxicity and affect their growth, for example Cd, Cr, Co, Ni, and Co, etc (Jamal et al., 2006, Liu et al., 2009).

The presence of phenolic allelochemicals in rhizosphere soil and plant elemental composition indicates that these might have been released from the plants through any of the mode that induce the growth retardatory effects.

References


Molish, H. 1937. Der Einfluss einer Pflanze auf die andere- Allelopathic. G. Fischer, Jene, Germany, p. 106.


Manuscript received 26 January 2014, accepted 20 November 2014