Invasive potential of the weed Parthenium hysterophorus – the role of allelopathy

D R Batish, H P Singh, J K Pandher, R K Kohli
Department of Botany, Panjab University, 160014 Chandigarh, India
Email: daizybatish@yahoo.com

INTRODUCTION

Parthenium hysterophorus (hereafter Parthenium: family Asteraceae) is an invasive exotic weed from tropical America that has invaded the plains of India and is also spreading rapidly to hilly tracts in the north-western Himalayas. Upon invasion, it establishes quickly in the alien environment, thereby resulting in changes in the structure and dynamics of native ecosystems. Although the weed is found mostly in wastelands, it also grows well in cultivated fields, pastures and along roadsides. It forms pure stands at the expense of native vegetation, adversely affects the species diversity of the region, and also affects crop yield, animal husbandry and human health (Kohli & Rani, 1994; Evans, 1997). Such dominance may possibly be due to some chemical interference or allelopathy that gives it an additional advantage over native plants. This is further supported by a recently proposed hypothesis that highlights allelopathy as a novel strategy for the invasion of alien environments (Heirro & Callaway, 2003). In Parthenium, most allelopathic studies pertain to the adverse effect on crops (Evans, 1997), and no study is available regarding effects on native or naturalized non-invasive plant species. A study was conducted, therefore, to establish the allelopathic effect of Parthenium on two non-invasive naturalized species (Bidens pilosa and Cassia occidentalis) that seem to be adversely affected by its invasion.

MATERIALS AND METHODS

A Parthenium-infested (PI) or Parthenium-free (PF, control) area was selected and the number of species types and vegetal biomass was determined in both, using quadrats. Further, debris and soil (upper 3–5 cm profile) from PI or PF area were collected. Soils were brought into laboratory, air-dried and sieved (2 mm mesh); Parthenium debris was shade-dried and powdered. Soils and debris powder were then stored in polythene bags for further use. For the laboratory and growth bioassay, seeds of the non-invasive weeds B. pilosa and C. occidentalis were collected locally. Debris (4 g) was soaked in 100 ml of distilled water for 15 h at 24°C, followed by filtration through a double layer of muslin cloth and then Whatman no. 1 filter paper, to obtain full strength extracts (X) that were diluted to obtain half-strength extracts (X/2). The effect of the debris extracts (with distilled water as a control) was studied on early seedling growth (length and weight, after 1 week) of test plants in a laboratory bioassay in Petri dishes kept under controlled conditions in a growth chamber. For growth studies, PI and PF soil (250 g) was placed in 250-ml polystyrene cups (5 replicates), within which were sown 7 seeds each of B. pilosa and C. occidentalis. After 2 weeks, the length (from root tip to shoot tip) of 20 randomly selected seedlings from each treatment was measured; their biomass was also determined. Total water-soluble phenolics in the debris extracts and infested soils were estimated by the method of Swain & Hillis (1959), using Folin-ciocalteu reagent. In each randomized experiment there were 5 replicates/treatment; data were analyzed at \( P < 0.01 \).
RESULTS AND DISCUSSION

Compared with 39 plant types in the PF area, only 14 were present in the PI area, thereby indicating a sharp decline in vegetation diversity. Even vegetal biomass was drastically reduced in PI areas (401 g/m²) compared with PF areas (998g/m²), indicating that, upon invasion by Parthenium, diversity and biomass of the native species are drastically reduced. Allelopathy has recently been proposed as novel mechanism for the spread of invasive species in alien environments (Heirro & Callaway, 2003); therefore, it was explored as an invasive strategy against two non-invasive weeds. Early growth (seedling length and dry weight) of both B. pilosa and C. occidentalis was significantly reduced in PI soil compared with PF soils (Table 1). Growth reductions of test weeds in PI soils indicate the presence of phytotoxins, probably produced by Parthenium. Further, extracts prepared from debris also retarded growth of both weeds (Table 1). This indicated an influx of chemicals, from weed debris into the soil, that interfere with the growth of non-invasive naturalized plants.

Table 1. Effect of Parthenium debris extracts and infested soil on growth of test plants.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>B. pilosa</th>
<th>C. occidentalis</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Seedling length (cm)</td>
<td>Dry weight (mg/plant)</td>
</tr>
<tr>
<td>Parthenium free soil</td>
<td>6.37</td>
<td>3.35</td>
</tr>
<tr>
<td>Parthenium infested soil</td>
<td>4.12*</td>
<td>1.60*</td>
</tr>
<tr>
<td>Distilled water control</td>
<td>5.28</td>
<td>2.40</td>
</tr>
<tr>
<td>Debris extracts X</td>
<td>1.80*</td>
<td>1.70*</td>
</tr>
<tr>
<td>Debris extracts X/2</td>
<td>0.29*</td>
<td>0.66*</td>
</tr>
</tbody>
</table>

* Significantly different from respective control at P < 0.01.

The chemical analysis of infested soils and debris revealed the presence of water-soluble phenolics that play a significant role in allelopathy (Rice, 1984). The PI soil contained a significant amount of water-soluble phenolics (11.82 mg/kg) compared with PF soil (1.67 mg/kg). Even the debris was rich in phenolics (11.87 mg/g). In natural environments, these phenolics (upon release) interfere with the growth of natives that are not naturally adapted to tolerate chemical stress caused by allelochemicals. Presumably, allelopathic interference of Parthenium plays a major role in its successful colonization of alien environments, resulting in a decrease in vegetation density and biomass in infested areas.

REFERENCES


