



## Soil seed bank studies on a riparian habitat invaded by *Parthenium*

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*Parthenium* weed (*Parthenium hysterophorus* L.) is an annual herb of the Asteraceae family, originating from the tropical Americas and now a weed of global significance in many countries around the world (Adkins and Shabbir 2014). It reduces crop and pasture productivity, reduces native plant community biodiversity and negatively affects human and animal health (Shabbir and Bajwa, 2006). In Pakistan, *Parthenium* weed was first reported from the Gujarat district of Punjab Province in 1980 (Razaq *et al.* 1994) and since then it is rapidly spreading throughout the Province of the Punjab, the Islamabad Capital Territory (ICT) and the Khyber Pukhtunkhwa (KPK) Province (Shabbir *et al.* 2012).

Several aspects contribute to the invasiveness of *Parthenium* weed. These include its very large viable seed production, its large and persistent soil seed banks (Navie *et al.* 2004, Nguyen 2011) the longevity of its seeds when buried (Navie *et al.* 1998), its fast germination and quick flowering time, its ability to flower over a long period of time, its allelopathic interactions with neighboring plants and its ability to adapt to many different environments (Adkins and Shabbir 2014). A single plant of *Parthenium* weed can produce as much as 156,000 seeds (Dhileepan 2012) and result in huge soil seed bank.

Soil seed banks are very important for the regeneration and future composition of plant communities especially for those that are reproduced only by seeds. Variation in the size of soil seed banks may depend upon several factors including the rainfall intensity of the region, the time of year when sampled and the presence or absence of seed predators (McIvor *et al.* 2004, Navie *et al.* 2004). In Australia, Navie *et al.* (2004) determined the size of the viable soil seed bank of *Parthenium* weed invaded pasture where weed seed bank accounted for up to 87% of the total seed bank present. Nguyen (2011) has recently reported that a *Parthenium* weed seed bank still exists at these field sites in the range of 5,000 to 6,000 seed/m<sup>2</sup>.

In Pakistan, there has not been any systematic study on the soil seed bank in natural areas invaded by *Parthenium* weed. Hence, in this study, we attempted to quantify and compare the soil seed banks of *Parthenium* weed invaded and non-invaded sites along a riparian habitat near the district Lahore.

Two sites were selected along the Lahore branch canal, first site was selected on the basis of its even infestation *Parthenium* weed (*c.* 5-10 weed plants/m<sup>2</sup>) while the second site was free of *Parthenium* weed. Both sites were located in riparian area along the canal (extending between the section of EME sector and Izmir Town). The distance between these two sites was approximately 5 km. The annual mean temperature of Lahore is 24.3 °C and total annual rainfall averages 628.8 mm. The vegetation of the area mainly consists of herbs but few shrubs trees were also present. At each site, three large plots of 5 × 5 m dimensions were selected.

At each site, collection of soil samples from each plot at both sites was made in May 2014. At each site, 5 quadrats (each 1 × 1 m) were thrown randomly within all three larger plots and five soil cores were removed from the individual quadrat (one from each of the four corners and one from the centre of the quadrat), using a brass ring soil corer (7.2 cm diameter and 10 cm deep), and pooled to make a single sample. The samples were placed individually into zip-lock plastic bags, sealed and stored at *ca.* 25 ± 5 °C for between 2 to 3 days while they were being transferred from the field to the glasshouse.

These soil samples were then spread thinly over a 2 cm layer of a sterilized soil contained in shallow trays (20 × 25 × 6 cm; w/l/h) that were distributed randomly on a bench in a glasshouse. All the trays were watered daily to maintain their soil moisture content close to field capacity. The trays were observed regularly for newly emerging seedlings recorded. All identified seedlings were removed while in the cases where identification was not possible, representative individuals were planted into small pots of soil and grown on to maturity, to allow for later taxonomic identification.

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Life-history characteristics, such as plant longevity, life form, weed status and origin of all species present were also obtained from the literature. After 4 months, when seedling emergence was almost entirely ceased, the experiment was terminated and a final record of seedling emergence was taken. The data from all samples was used to determine the size of the seed bank and compared between the invaded and non-invaded sites.

A total 28 plant species were found in the soil seed bank community from both invaded and non-invaded sites (Table 1). These species belonged to Poaceae, Asteraceae, Amaranthaceae, Cyperaceae, Malvaceae and 9 other plant families as shown in Table 1. At invaded site, the density of all species in the seed bank was 7,713 seeds/m<sup>2</sup> while it was 6,954 seeds/m<sup>2</sup> at non-invaded site. At invaded site, *Parthenium* weed was represented with the highest seed density (4,438/m<sup>2</sup>) followed by *Cynodon dactylon* (650/m<sup>2</sup>) and *Calotropis procera* (650/m<sup>2</sup>; Table 1). At non-invaded site, *Saccharum spontanem*

was represented with the highest seed density (1,126/m<sup>2</sup>) followed by *Cynodon dactylon* (1,112/m<sup>2</sup>) and *Abutilon indicum* (776/m<sup>2</sup> Table 1). It was interesting to note a native grass, *Saccharum spontanem* being the most dominant species of the non-invaded site was altogether absent in the invaded site. *Parthenium* weed was found to be the most dominant and abundant broad-leaved species in the seed bank with 4,438 seeds/m<sup>2</sup> present in soil (Table 1). In Australia, Navie *et al.* (2004) determined the size of the viable soil seed bank of *Parthenium* weed up to 44,700 seed/m<sup>2</sup> in a sandy-loam soil close to a creek. Nguyen (2011) has recently reported that a *Parthenium* weed seed bank still exists at this field site, but now, 10 years later in the range of 5,000 to 6,000 seed/m<sup>2</sup>.

More number of plant Families (14) and taxa (25) were represented in *Parthenium* weed-free site as compared to the invaded site where 2 plant families and 8 taxa were absent in soil seed bank (Table 1). Nguyen (2010) found that the diversity of a pasture plant community in Queensland was significantly

**Table 1. Comparison of the germinable soil seed bank of a *Parthenium* invaded and non-invaded riparian habitat near Lahore**

Plant species	Family	Weed status	Seeds/m <sup>2</sup>	
			Invaded sites	Non-invaded site
<i>Abutilon indicum</i> Link. (Sweet)	Malvaceae	Perennial, Shrub	244	776
<i>Cenchrus ciliaris</i> L.	Poaceae	Perennial, Graminoid	110	368
<i>Alternanthera pungens</i> Kunth	Amaranthaceae	Perennial, Forb, Weed	234	198
<i>Calotropis procera</i> (Aiton)	Apocynaceae	Perennial, Shrub	645	46
<i>Convolvulus arvensis</i> L.	Convolvulaceae	Annual, Forb	34	398
<i>Senna occidentalis</i> L. (Link)	Fabaceae	Perennial, Shrub, Weed	398	35
<i>Coryza canadensis</i> (L.) Conq.	Asteraceae	Annual, Forb, Weed	-	27
<i>Cynodon dactylon</i> L.	Poaceae	Perennial, Graminoid	650	1,112
<i>Cyperus rotundus</i> L.	Cyperaceae	Perennial, Graminoid, Weed	88	48
<i>Datura innoxia</i> Mill.	Solanaceae	Annual, Shrub, Weed	-	26
<i>Desmostachya bipinnata</i> (L.) Stapf.	Poaceae	Perennial, Graminoid	-	188
<i>Eleusine indica</i> (L.) Gaertn.	Poaceae	Annual, Graminoid	-	78
<i>Amaranthus viridis</i> L.	Amaranthaceae	Annual, Forb	42	-
<i>Lantana camara</i> L.	Verbenaceae	Perennial, Shrub, Weed	34	-
<i>Malvastrum coromandelianum</i> (Linn.) Garcke.	Malvaceae	Annual, Forb	46	562
<i>Parthenium hysterophorus</i> L.	Asteraceae	Annual, Forb, Weed	4,438	-
<i>Sida cordata</i>	Malvaceae	Perennial, Shrub	-	134
<i>Solanum nigrum</i> L.	Solanaceae	Annual, Forb	48	198
<i>Eragrostis</i> sp.	Poaceae	Annual, Graminoid	-	28
<i>Setaria</i> sp.	Poaceae	Annual, Graminoid	-	188
<i>Cannabis sativa</i> L.	Cannabiaceae	Annual, Shrub	-	26
<i>Heteropogon contortus</i> (L.) P. Beauv.	Poaceae	Perennial, Graminoid	366	882
<i>Saccharum spontanem</i> L.	Poaceae	Perennial, Graminoid	232	1,126
<i>Achyranthes aspera</i> L.	Amaranthaceae	Perennial, Shrub, Weed	46	146
<i>Ipomoea cornea</i> Jace.	Convolvulaceae	perennial, Shrub, Weed	58	28
<i>Tribulus terrestris</i> L.	Zygophyllaceae	Annual, Forb, Weed	-	78
<i>Acacia nilotica</i> L.	Fabaceae	Perennial, Tree	-	182
<i>Dalbergia sissoo</i> Roxb.	Fabaceae	Perennial, Tree	-	76
Total			7,713	6,954

reduced by the presence of *Parthenium*, even when the weed was present in relatively low densities (*i.e.* 2 plants/m<sup>2</sup>) and this trend was seen in both the above-ground plant community and the soil seed bank.

It was also observed that many grasses (*D. bipinnata*, *Ellusine indica*, *Eragrostis* sp. and *Setaria* sp.) were absent in the *Parthenium* invaded site as compared to weed-free site. It was also found that another alien invasive plant, *Lantana camara*, was only found in the *Parthenium* invaded site with a soil seed bank of 34 seeds/m<sup>2</sup> (Table 1). Similarly, the total seed number of other weeds, such as *Senna occidentalis*, *Alternanthera pungens*, *Cyperus rotundus* and *Ipomoea carnea* present in soil was 61% higher in invaded site as compared to non-invaded site.

The domination by *Parthenium* weed of the seed banks of this site suggests that the weed is having a substantial negative impact on the ecology of these plant communities. This study has demonstrated that *Parthenium* weed can significantly reduce the plant diversity in the below ground species present in the form of seed banks. Many valuable medicinal herbs, adapted to a wide range of environments, are being significantly affected by *Parthenium* weed. Riparian habitats are rich repository of natural herbs used in folk medicines and hence there is now concern for these important biological resources. It is recommended that *Parthenium* weed should be controlled in natural vegetation to protect the native plant populations.

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#### SUMMARY

*Parthenium* is an invasive weed in many parts of the world. In Pakistan, this has now become dominant weed in wastelands, forests and other natural areas and is also becoming a problematic weed in other situations such as irrigated and rain-fed cropping systems, pasture lands. In this preliminary study we investigated the impact of this weed on the soil seed bank of a riparian habitat. The impact of *Parthenium* weed upon below ground soil seed bank

was assessed in the invaded and non-invaded sites along the canal near district Lahore, Pakistan. In the invaded site, the average number of *Parthenium* weed seeds in the soil was found to be 4,434/m<sup>2</sup>. The average numbers of seed/m<sup>2</sup> and species diversity were lowest in the invaded site while it was highest in weed-free sites. A number of important native plant species such as, *Saccharum spontaneum*, *Eleusine indica* and *Solanum nigrum* were found to be declining in the invaded sites. The long-term presence of *Parthenium* weed at these sites poses a serious threat to native plant diversity in these habitats.

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