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RELATIVE PHYTOTOXICITY OF STEM AND ROOT AQUEOUS EXTRACTS OF *PARTHENIUM HYSTEROPHORUS* L. ON PHASEOLUS MUNGO

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ABSTRACT

The productivity of agroecosystem and loss of biodiversity are caused by phytotoxic activities of an invasive exotic weed *Parthenium hysterophorus*. The present study was conducted to assess the relative phytotoxicity of 15, 25, 50, 75 and 100% aqueous extracts of stem and root of *Parthenium* on the rate of seed germination and seedling growth of *Phaseolus mungo* a pulse crop, in laboratory condition. The rate of seed germination in *P.mungo* in stem and root aqueous extracts of *Parthenium* decreased from 1 to 2% and 9 to 100%, respectively. The inhibition in root length in stem extract varied from 4.23% to 73.41% and in root extract from 7.62% to 100%. The inhibition in shoot length in stem extract varied from 9.45% to 18.15% and in root extract from 9.45% to 100% compared to control condition. The Seed Vigour Index (SVI) value decreased from 14.59 to 28.14% in stem extract and 8.78% to 100% in root extract. The root extract of *Parthenium* was more phytotoxic than the stem extract in *Phaseolus mungo*. The phytotoxic impacts of plant parts (stem and root), treatments (15%, 25%, 50%, 75% and 100% concentrations) and interactions between plant parts and treatments were highly significantly different at $p < 0.000$. Thus the present study indicated that the aqueous extract of root of *Parthenium* was recorded more phytotoxic than stem extract on *Phaseolus mungo*.

INTRODUCTION

Parthenium hysterophorus L. is an exotic, invasive alien species which has spread in all States of India and more than 40 countries around the world.When alien species are introduced unintentionally or deliberately they may spread and grow vigorously (Raghubanshi *et al*. 2005); and biodiversity, ecosystems, economy and human health are threatened (Evans 1997 and Levine *et al*. 2003). Invasive species significantly affects the diversity and structure of plant communities (Chippendale and Panneta 1994; Heida and Pysek 2006; Levine *et al*. 2003; Shabbir and Bajwa 2006). Invasive species are generalists, survive in wide range of climatic conditions and possess a broad habitat compatibility. These species rank second as a threat to biodiversity (McGinley and Duffy 2011). They can tolerate a wide range of edaphic and climatic conditions than native species. Invasive species have wide genetic pool which enhances invasive potential. When populations of invasive species increase the populations of native species decrease and after establishment of invasive species it is irreversible. All exotic species are not harmful. Exotic species lack natural predators and diseases in new habitats. Areas disturbed by human activities become problematic due to invasive species (Sheley *et al*.1999) such as road building (Trombulak and Frissell 2000), residential developments, forest clearing, logging, grazing, mining, ditching,mowing, erosion control, and fire control activities (Simberloff 2000). Disturbance occurring naturally such as fires, tornadoes, landslides and tree falls also pave the passage for invasion of exotic species.

Parthenium hysterophorus a noxious weed has attained a global significance and is a major weed in all States of India and other parts of the world. It is also called as "scourge of India". *P.hysterophorus* L. is distributed worldwide such as Africa (Madagascar, Mozambique, SouthAfrica), America (Bahamas, Bermuda Cuba, Halti, Jamaica, Puerto Rico, USA, Argentina, Barbados, Belize, Bolivia, Dominica, Guatemala, Guyana, Honduras, Paraguay, Tahiti, Trinidad and Tobago, Venezuela, China, all states of India, Nepal, Pakistan, Taiwan, Vietnam, Australia etc. (Lakshmi and Srinivas 2017). It mainly affects the production and biodiversity of agricultural and

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natural ecosystems and on animal and human health. Its management is very difficult. Not a single method alone can be effective in its management although integrated management approaches have been recommended (O'Donnell and Adkins 2005). In India *Parthenium* was transported through wheat seeds under PL480 scheme.

Parthenium grows luxuriantly in wastelands, vacant lands, orchards, forest lands, flood plains, agricultural lands, shrub lands, urban areas, overgrazed pasture lands, along road sides, railway tracks etc. Reduced pasture cover and drought are favourable conditions for establishment of *Parthenium*. It can grow upto 2200 m above sea level (Sankaran 2008). *Parthenium* grows on all types of soils but luxuriant growth takes place in black soil compared to laterite soil (Mahadevappa *et al*. 2001). However, Dale (1981) reported that *Parthenium* prefers to grow from alkaline to neutral clay soil or sandy to heavy clay soil (ARMCA, 2000). *Parthenium* cannot grow luxuriantly in saline soil near seashore (Lakshmi and Srinivas, 2007). In acidic soil the growth of *Parthenium* is reduced (ARMCA, 2000).

A single plant of *P.hysterophorus* produces up to 100,000 seeds in one life cycle. Sankaran (2008) recorded more than 340 million seeds/ha in the surface soil. Sankaran(2008) reported that more than 70% seeds of *Parthenium* in 5cm soil surface were viable for 2 years. However seed viability may be upto 20 years. Adkins and Sowerby (1996) have experimentally proved that *Parthenium* has allelopathic effect that reduces the growth and germination of other associated species. Timsina *et al*. (2011) have reported that *Parthenium* invasion has affected the growth of other species such as *Trifoliumrepens*, *Imperata*, *Chrysopoganaciculatum*, *Sporobolium* and *Dactylocteniumaegypticum*. Mahadevappa *et al*. (2001) have reported that *Parthenium* invasion reduced 90% forage production. *Parthenium* has two potential causes to inhibit the growth of other species such as efficient extraction of nutrient from deficient soils and its allelopathic effect.

The ecology of natural ecosystem is disrupted by invasive exotic plants. The native plant and animal species are displaced. Thus the biological resources are degraded. These invasive species reduce the amount of light, water, nutrients and space available for native species (Randall and Marinelli 1996; Hobbs and Huenneke 1992; Huenneke 1996). Such changes cause increased rate of erosion. Changes in population's genetic makeup, harbour plant pathogens, contains toxins which may be lethal to humans and other animals.

Parthenium is an aggressive colonizer, production of large amount of seeds; shows allelopathic effects; induces changes in the physical, chemical and biological properties of soil; replaces palatable grasses in rangelands and its manual removal is difficult (Tamado and Milberg 2000; Pandey *et al*. 2003; Tiwari *et al*. 2005; Oudhia 2000 a; Oudhia 2000 b; Batish *et al*. 2002 a; Batish *et al*. 2002 b; Singh *et al*. 2003; Singh *et al*. 2005; Batish *et al*. 2002 c; Bhowmik *et al*. 2007; Tudor *et al*. 1982; Kohli and Rani 1994; Anonymous 2000; Ayele 2007; Wegari 2008; Odhia (2001). Tamado and Milberg (2000) have showed that *Parthenium* was the most major problem in rangeland and cropland in the Eastern Ethiopia. Monaco *et al*. (2001) have reported that the spread of seeds and their ability to remain viable in the soil for many years pose one of the most complex problems for control and this fact makes eradication difficult for many seed producing *Parthenium*. *Parthenium* secrets certain allelochemicals such as: phenolic acids, caffeic acid, vanillic acid, ferruclic acid, chlorogenic acid, para caumeric acid, para hydroxyl benzoic acid (Kanchan and Jayachandra 1980; Das and Das 1995) and other important chemicals such as pseudoguaionolides, parthenin, anhydroparthenin, ambrosin, coronopilin and damsin which have adverse effect on the growth of plants which grow in its vicinity. Khalaj *et al*. (2013) reported that secondary metabolites are released through volatilization, leaching, root exudation and decomposition of plant residues in the soil. Dogra *et al*. (2011) have reported two life cycles in one year in *Parthenium* from March to June and from July to November in North-Western Indian Himalayas (H.P.). They produce enormous number of seeds which are very small in size and also light in weight and can survive as seed bank in soil for years. *Parthenium* is an annual plant with a deep tap-root and an erect much- branched stem. It usually grows 1-2 m. tall. Mature stems are greenish and longitudinally grooved, covered with small stiff hairs (trichomes). Leaves are simple, pale green, lobed, sessile and irregularly dissected. The number of leaves per plant is 6 to 55. The flowers are arranged in capitulam, creamy white in colour, borne in profusion at the tips of the stem. Small flower heads are arranged in clusters and its colour changes to light brown, when seeds are mature. Flowering can occur at any time of the year, but is most common during the rainy season. Each flower contains five seeds, which are wedge-shaped, black, 2mm long with thin white scales.

Phaseolus mungo a pulse crop is widely cultivated in India. India is the largest producer with more than 50% of world production. Green gram or mung similar to other pulses is grown primarily for its protein rice seeds. It contains about 20-25% protein. The plants are sometimes cut and ploughed into the soil to enrich soil nitrogen.

The present study was aimed to assess the relative phytotoxicity levels of different concentrations of aqueous extracts of stem and root of *Parthenium hysterophorus* on the rate of seed germination; length of root and shoot; and Seed Vigour Index (SVI) of *Phaseolus mungo* in laboratory condition.

MATERIAL AND METHODS

Parthenium hysterophorus has invaded the Jai Prakash University campus of about 240 ha area in just ten years. Earlier the whole area was a cropland. The study site is situated between 25^0 36'-26^0 15' N latitude and 84^0 25'-85^0 15' E longitude in the southern part of the newly - created Saran Division of North Bihar. Total area of the Saran district is 2641 sq. km.

After abandonment of cropping *P.hysterophorus* invaded the whole area. Plant samples were collected from the University campus from vegetative phase of *P.hysterophorus* during the period 2017. Root and stem were separated and were air dried in shade and crushed with the help of laboratory blender. Dried samples were powdered and were used in the conduction of the experiment. 15%, 25%, 50%, 75% and 100% concentrations were prepared. A separate control condition was set up by using only distilled water. Experiments were set up in petri

dishes covered with what man's filter paper. For each treatment ten replicates were maintained and in each petridish ten seeds of *P.mungo* was placed. Distilled water was added when needed in petridisesh. The rate of seed germination, length of root and shoot were determined after seven days of setting up of the experiment. Seed Vigour Index (SVI) was calculated by using the following formula:

SVI = (Length of root + Length of shoot) × Seed germination %

Data collected were statistically analysed by using the SPSS programme through Pearson's Correlation Coefficient, and Tukey HSD and Post Hoc Tests.

RESULTS

The data recorded on the rate of seed germination, root length, shoot length and Seed Vigour Index (SVI) are presented in Table 1. The per cent decrease or increase in parameters studied in different concentrations of aqueous extracts of stem and root of *Parthenium* compared to control condition are presented in Table 2; and summary of significance levels of plant parts, treatments and their interactions are presented in Table 3.

Table 1 Seed Germination rate, length of root & shoot and Seed Vigour Index in *P.mungo* in different concentrations of stem and root extract of *P.hysterophorus*.

Extracts	Growth parameters	Control	15%	25%	50%	75%	100%
Stem Extract	Seed Germination (%)	100%	100%	100%	98%	99%	100%
	Root Length (cm)	3.31	0.88	1.53	2.17	1.51	3.17
	Shoot Length (cm)	14.99	12.27	13.56	12.92	12.39	12.46
	SVI	1830	1315	1509	1480.78	1376.1	1563
Root Extract	Seed Germination (%)	100%	100%	91%	89	55	0
	Root Length (cm)	7.09	6.55	6.34	4.37	1.97	0
	Shoot Length (cm)	12.28	11.12	8.99	6.35	3.3	0
	SVI	1937	1767	1395.03	954.08	289.85	0

Table 2 Per cent increase (+) or decrease (-) in seed germination rate and growth parameters in *P.mungo* in different concentrations of stem and root extract of *P.hysterophorus*.

Extracts	Growth Parameters	15%	25%	50%	75%	100%
Stem Extract	Seed Germination (%)	0.0	0.0	-2	-1	-100
	Root Length (cm)	-73.41	-53.78	-34.44	-54.38	-4.23
	Shoot Length (cm)	-18.15	-9.54	-15.84	-17.34	-16.88
	SVI	-28.14	-17.54	-19.08	-24.8	-14.59
Root Extract	Seed Germination (%)	-100	-9	-11	-45	-100
	Root Length (cm)	-7.62	-10.58	-38.36	-72.21	-100
	Shoot Length (cm)	-9.45	-26.79	-48.29	-73.13	-100
	SVI	-8.78	-27.98	-50.75	-85.04	-100

Seed Germination Rate (%): In case of *Phaseolus mungo* when seeds were treated with different concentrations of stem extract such as 15%, 25%, 50%, 75%, 100% of *P.hysterophorus*, the seed germination rate was 100% in control condition. In case of 50% and 75% treatments the rate of seed germination decreased by only 2% and 1%, respectively. Thus the effect of different concentrations of stem extract on seed germination was very negligible**.** In case of root extract of *Parthenium* in control condition and 15% treatment the rate of seed germination was 100% whereas in 25%, 50% and 75%, it was 91%, 89% and 55%, respectively. In 100% treatment the rate of seed germination was nil. Thus the per cent decrease in rate of seed germination values in 25%, 50% and 75% were 9%, 11% and 45%, respectively compared to control condition. In 15% treatment there was no difference in seed germination compared to control condition but in 100% treatment seed germination was completely inhibited.

Root Length (cm): In case of stem extract of *Parthenium* the root length value in control condition was 3.31cm and in different treatments it varied from 0.88cm to 3.17cm. It was minimum 0.88cm in 15% treatment and maximum 3.17cm in 100% treatment. The per cent decrease in the value of length of root varied from 4.23% to 73.41%. It indicated that lower concentration of stem extract affected more the root length than the higher concentrations. In case of root extract of *Parthenium* it was recorded 7.09cm in control condition and in 15%, 25%, 50%, and 75% treatments root length values were 6.55cm, 6.34cm, 4.37cm and 1.97cm, respectively. The per cent decrease in root length values were 7.62%, 10.58%, 38.36% and 72.21%, respectively in 15%, 25%, 50% and 75% treatments, respectively.

Shoot Length (cm): In stem extract of *Parthenium* the shoot length value in control condition was 14.99cm and in different treatments it ranged from 12.27cm in 15% treatment to 13.56cm in 25% treatment. The per cent decrease in length of shoot varied from 9.45% in 25% to 18.15% in 15% treatment. In 50%, 75% and 100% treatments the per cent decrease in shoot length compared to control condition was 15.84%, 17.34% and 16.88%, respectively. In root extract of *Parthenium* it was recorded 12.28cm in control condition whereas it varied from 3.3cm in 75% treatment to 11.12cm in 15% treatment. In comparison to control condition the shoot length values decreased by 9.45%, 26.79%, 48.29% and 73.13% in 15%, 25%, 50% and 75% treatments, respectively.

Seed Vigour Index (SVI): In stem extract of *Parthenium* the SVI value was highest 1830 in control condition, however in different treatments these values ranged from 1315 to 1563. The per cent decrease in SVI values in 15%, 25%, 50%, 75% and 100% treatments were 28.14%, 17.54%, 19.08%, 24.80% and 14.59%, respectively. In root extract of *Parthenium* in control condition the SVI value was recorded 1937 whereas these values ranged from 289.85 in 75% treatment to 1767 in 15% treatment. The decrease in SVI values in 15%, 25%, 50% and 75% treatments were 8.78, 27.98, 50.75 and 85.04%, respectively, compared to control condition.

The Tukey HSD and Post HOC Tests indicated that the effects of plant parts i.e. stem and root extract of *Parthenium* showed significant differences in the rate of seed germination, root length and shoot length in *P.mungo*. Similarly the effects of different concentrations of stem and root extracts of *Parthenium* showed significant differences in the rate of seed germination, root length and shoot length values in *P.mungo*. The interactions of plant parts i.e. stem and root extracts and treatments i.e. 15%, 25%, 50%, 75% and 100% concentrations were significantly different for seed germination, root length and shoot length of *P.mungo* (Table 3).

Table 3 Significance levels of plant parts i.e. stem and root extract of *P.hysterophorus* and their different concentrations i.e. 15, 25, 50, 75 and 100% (treatments) on seed germination and length of root and shoot in *P.mungo* after Tukey HSD and Post HOC Tests.

Sl no.		Seed Germination Rate (%)	Root Length (cm)	Shoot length (cm)
1	Plant Parts	0.000*	0.000*	0.000*
2	Treatments	0.000*	0.000*	0.000*
3	Plant Parts × Treatments	0.000*	0.000*	0.000*
4	Stem× Root	0.000*	0.000*	0.000*
5	Control / 15%	1.000	0.005*	0.041*
6	Control / 25%	0.390	0.295	0.001*
7	Control / 50%	0.130	0.000*	0.000*
8	Control / 75%	0.000*	0.000*	0.000*
9	Control / 100%	0.000*	0.000*	0.000*
10	15% /25%	0.511	0.613	0.823
11	15% /50%	0.196	0.761	0.000*
12	15% /75%	0.000*	0.000*	0.000*
13	15% /100%	0.000*	0.000*	0.000*
14	25% /50%	0.992	0.047*	0.001*
15	25% / 75%	0.000*	0.000*	0.000*
16	25% / 100%	0.000*	0.000*	0.000*
17	50% / 75%	0.000*	0.000*	0.041*
18	50% / 100%	0.000*	0.000*	0.000*
19	75% / 100%	0.000*	0.847	0.000*

*Significantly different

DISCUSSION

In the present study the rate of seed germination in stem and root aqueous extract of *Parthenium* varied from 98% to 100%; and 0.0% to 100%, respectively in *Phaseolus mungo*. In stem extract the rate of seed germination in *P.mungo* was affected negligibly whereas in root extract of higher concentration (100% concentration) not a single seed germinated. The phytotoxicity impact on seed germination increased with increase in the root extract concentration. The per cent decrease in root length in stem extract varied from 4.23% to 73.41%, whereas in root extract it varied from 7.62% to 100%. The per cent decrease in shoot length in stem and root extracts varied from 9.54% to 18.15% and 9.45% to 100%; and decrease in SVI value ranged from 17.54% to 28.14%; and 8.78% to 100%, respectively in stem and root extracts of *Parthenium.*

In earlier studies we have recorded the phytotoxic impacts of aqueous extracts of leaves, stem and roots of *P.hysterophorus* on the rate of seed germination and growth of seedlings of *Cicer aeritinum*, *Pisum sativum*, *Cajanus cajan, Macrotylomauniflorum*, *Triticumaestivum*, *Zea mays* and *Brassica nigra* (Shikha 2018; Shikha and Jha 2016 a, b, c, d; 2017 a, b; 2018 a, b, c, d). The impact of plant parts, treatments and their interactions were highly significantly different at $p < 0.000$. In the present study the root extract of *Parthenium* was more toxic than the stem extract in *P.mungo* on the rate of seed germination, length of root and shoot; and seed vigour index (SVI). However in *C.cajan* stem extract was more phytotoxic than the root extract of *Parthenium* (Shikha 2018).

Kohli and Batish (1994) has reported that allelochemicals are produced by all plants and plant parts although root and leaves were mainly responsible for their production and release. *Parthenium* has allelopathic effects on neighbouring plants (Kumbhar and Dabgar 2012) and strong competitiveness with crop plants (Kohli and Rani 1994). In case of invasion of *Parthenium*allelopathy has been found as a mechanism of invasion (Lamarqe *et al*. 2011; Lavine and D'Antonio 1999; Lavine *et al*. 2003; Mack 1996; Mack *et al*. 2000; Maharajan *et al*. 2007; Mallik and Prescott 2001). *P. hysterophorus* contains parthenin an active chemical which is a terpenoid (Sesquiterpene). Leaching, volatilization, root exudation and decay of the fallen parts are some processes of release of allelochemicals from *P.hysterophorus* either by biotic or abiotic means (Mew *et al*. 1982). Nath (1988) and Netsere (2015) stated that allelopathy has many effects either positive or negative on many plant species by stimulating or inhibiting the surrounding herbaceous vegetation. Positive and negative allelopathic effects have been reported of *Parthenium* on many agricultural crops and other plant species (Oudhia *et al*. 1997; Aggarwal and Kohli 1992). Einhelling (2002) has reported that there are hundreds of secondary metabolites in the plant kingdom and many are known to be phytotoxic.

The present study indicated that the aqueous extract of root of *Parthenium hysterophorus* was more phytotoxic to the rate of seed germination, length of root and stem; and Seed Vigour Index (SVI) in *Phaseolus mungo* than the stem extract of *Parthenium*. The impact of different parts, treatments and their interactions differed significantly at $p < 0.000$.

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