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Phytotoxicity of *Parthenium hysterophorus* L. residues towards growth of *Zea mays*

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Abstract: ***Parthenium hysterophorus*** **L. a noxious weed has spread in all states of India. It is spreading in agroecosystem and affecting the biodiversity and productivity of the agroecosystems. The present study was conducted in Department of Botany, J.P.University in laboratory condition to evaluate the phytotoxicity levels of different concentrations of aqueous extracts of leaves, stems and roots of *Parthenium* on the rate of seed germination, root and shoot length and Seed Vigour Index in *Zea mays*. The rate of seed germination, root length, shoot length and Seed Vigour Index in *Z.mays* decreased by 53 to 100%; 42.6 to 76.03%; 45.15 to 74.56% and 77.74 to 96.54%, respectively. In stem extract seed germination, root length, shoot length and SVI were inhibited which ranged from 3.33 to 96.67%; 6.30 to 95.22%; 37.40 to 77.38%; and 56.78% to 99.61%, respectively, whereas in root aqueous extract these values decreased by 5 to 28.75%; 1.39 to 27.91%; 27.74 to 66.93%; and 24.06 to 56.565. On the basis of phytotoxicity levels of the plant parts of *Parthenium* for *Z.mays* can be arranged as leaves > stems > roots. The phytotoxic impacts of leaves, stem and roots for seed germination, root and shoot length and SVI were significantly different at p < 0.000. Similarly the impact of treatments i.e. different concentrations of aqueous extracts of leaves, stems and roots also differed significantly for seed germination and growth parameters at p < 0.000. The interaction of plant parts and treatments were significantly different for germination (p < 0.000), for root length (p < 0.001) but for shoot length no significant differences occurred (p < 0.334).**

Keywords: ***Parthenium hysterophorus*****, Phytotoxicity, Root length and shoot length, Seed germination, Seed Vigour Index.**

1. INTRODUCTION

In nature there are many weed species which show phytotoxic activities. Among such weeds *Parthenium hysterophorus* L. is an aggressive weed native to Southern North America, Central America, the West Indies and Central South America [1]. *Parthenium* shows allelopathic effect and inhibits the growth of many species. *Parthenium* is a noxious, aggressive, invasive exotic weed. It has spread in all states of India [2] and is harmful for plants, animals and human beings. The successful spread of *Parthenium* is due to its allelopathic properties. It affects the plant diversity, dominance, succession of natural vegetation and the productivity of agro-ecosystems. The allelochemicals released by *Parthenium* in environment are sesquiterpene lactones and phenolics. Parthenin is the major Sesquiterpene lactone which is an allelochemicals causing allelopathy. The rapid expansion and widespread distribution of *Parthenium* has become a challenging threat to the productivity and sustainability of agroecosystems. *Parthenium* contains allelochemicals in almost all parts including stems,leaves, flowers, buds, pollengrains, seeds, fruits, roots etc. However, differences were observed regarding allelopathic potential and abilities to produce toxins in various plant parts f *Parthenium*. [3] have evaluated the phytotoxic potential of sequentially extracted solvent (hexane, ethyle-acetate, methanol) extracts of *P.hysterophorus* (aerial parts) on seed germination in *Vigna radiata* L. and reported that germination, growth and vigour was significantly reduced by ethyl-acetate and methanol extracts. They suggested that phytotoxicity of ethylacetate and methanolic crude extracts of *P.hysterophorus* could be exploited as potential herbicide for weed management.

[4] have suggested that bioassays can be used widely to demonstrate allelopathy due to their usefulness as an early proof of allelopathic activity, involvement of low cost, easy execution and replication. *P.hysterophorus* shows allelopathic effects on *Phaseolus mungo*, *Cajanus cajan*, *Pisum sativum*, *Triticum aestivum*, *Oriza sativa*, *Zea mays*, *Brassica*

oleracea, *Brassica campestris*, *Rhaphanus sativus*, *Acacia catechu*, *Cassia tora*, *Vigna mungo*, *Vigna radiate*, *Cicer aeritinum*, *Vigna unguiculata*, *Artemisia dubia*, *Ageratina adenophora*, *A. conyzoides*, *Helianthus annus*, *Phaseolus vulgaris*, *Abelmoschus esculentus*, *Capsicum annum*, *Trifolium repens*, *Macrotyloma uniflorum* etc.[5], [6], [7]; [8], [9], [10], [11], [12], [13], [14], [15], [16], [17].

Maize (*Zea mays*) is the third most important crop in India after rice and wheat and is an impartant staple food in many countries of the world. It is not only used for human food and animal feed but it has wide individual applications. The demand for maize is expected to go up due to a growing population. Maize is a poultry feed.

The Jai Prakash University campus spread in 240 ha was ten years ago a cropland. After abandonment of cropping and establishment of the University campus *Parthenium hysterophorus* L. has covered the whole campus of the University. Thus the present study was aimed at to know the phytotoxicity levels of different concentrations of aqueous extracts of leaf, stem and root of *Parthenium hysterophorus* L. on the rate of seed germination and growth of *Zea mays* in laboratory condition.

2. MATERIALS 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, stem and leaves were separated and 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 whatman's filter paper. For each treatment ten replicates were maintained and each petridish ten seeds of *Zea mays* was placed. Distilled water was added when needed in petridishes. 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 Pearsons Correlation Coefficient, and Tukey HSD and Post Hoc Tests

3. RESULTS

Seed Germination Rate (%): In leaf extract of *Parthenium* the germination rate of seed of maize in control condition was recorded 100% whereas in different treatments it varied from 0% to 47% only. In 100% treatment seed germination was completely inhibited. In 15%, 25% 50% and 75% treatments the seed germination rate was 47%, 41%, 34% and 14%, respectively. Thus with increase in the concentration of leaf extract of *Parthenium* the rate of inhibition in seed germination decreased 53% in 15% treatment to 100% in 100% treatment. No seed germination occurred in 100% treatment. The per cent decrease in seed germination values in stem extract of *Parthenium* in *Z. mays* ranged from 3.33% to 96.67% in different concentrations and 100% in control condition. Inhibitory effect in germination was observed for *Zea mays* in all concentrations when compared to control treatment.The seed germination in *Z.mays* in 15, 25, 50, 75 and 100% *Parthenium* root extract values were 70, 57, 59, 60 and 76%, respectively (Table 1). The per cent decrease in seed germination was minimum 5% in 100% treatment and maximum 28.75% in 25% treatment (Table 2).

Root Length (cm): The root length in control condition in leaf extract of *Parthenium* was recorded 7.51 cm while in different treatments i.e. from 15% to 75% the root length values ranged from 1.8 cm to 4.31cm. Minimum value (1.8 cm) was observed in 75% treatment and maximum value (4.31cm) in 15% treatment. The growth in length of root decreased with increase in the concentration of leaf extract of *P.hysterophorus*. The per cent decrease in root length varied from 42.6% to 100% in different concentrations of leaf extract. The per cent decrease in root length compared to control condition was 42.6%, 58.5%, 72.0%, 76% and 100%, respectively in 15%, 25%, 50%, 75% and 100% concentrations of leaf extract of *Parthenium*. The values of radicle growth of *Z.mays* ranged from 0.50 to 9.81 in different concentrations

compared to 10.47 in control treatment in stem extract of *Parthenium*. The per cent decrease varied from 6.30% to 95.22% in root length of *Z.mays*. The root length value was was minimum 8.81 cm in 75% treatment and maximum 12.05 cm in 15% treatment among different treatments in root extract of *Parthenium*. The per cent decrease in root length in 15, 25, 50, 75 and 100% treatments were 1.39, 20.21, 7.20, 27.91 and 27.25%, respectively. The root length values decreased in all treatments compared to control condition.

Shoot Length (cm): In leaf extract of *Parthenium* the length of shoot in control condition was recorded 6.80 cm and this value was nil in 100% treatment. In other treatments this value ranged from 1.73cm to 3.73cm. In 15%, 25%, 50% and 75% treatments the shoot length values were 3.73 cm, 3.65 cm, 3.56 cm and 1.73 cm respectively. The shoot length values decreased with increase in the concentrations of leaf extract of *Parthenium*. The inhibition values in shoot length in 15%, 25%, 50%, 75% and 100% treatments were 45.1%, 46.3%, 47.6%, 74.6% and 100%, respectively. The values of plumule length ranged from 1.5 to 4.15cm in different concentrations and 6.63 in control condition in *Zea mays* in stem extract of *Parthenium*.

The shoot length values were 7.19, 5.51, 4.60, 4.03 and 3.29 cm, respectively, in 15, 25, 50, 75 and 100% treatments in root extract of *Parthenium*. The length of shoot decreased with the increase in concentration of root extract. The per cent decrease in 15, 25, 50, 75 and 100% treatments were 27.74, 44.62, 53.77, 59.50 and 66.93%, respectively (table 2).

SVI: In leaf extract of *Parthenium* control condition the seed vigour index value was maximum 1431, which decreased in different treatments. In 15%, 25%, 50%, 75% and 100% treatment the SVI values were 377.88, 318.57, 192.44, 49.42 and 0.0, respectively. The per cent decrease in SVI values in comparison to control condition in 15%, 25%, 50%, 75% and 100% treatments were 73.6%, 77.7% 86.6%, 96.5% and 100% treatments, respectively. The SVI values ranged from 6.66 to 738.98 in 15% to 100% treatments and 1710 for control condition in stem extract of *Parthenium*; and the per cent in decrease value ranged from 56.78% to 99.61% in stem extract of *Parthenium*. In root extract of *Parthenium* the SVI values in *Z.mays* ranged from 770.4 to 1346.8 in different treatments. The per cent decrease in SVI value ranged from 24.06% to 56.56% (table 2).

The Tukey HSD and Post HOC Tests indicated that the effects of different plant parts i.e. leaf, stem and root extract of *Parthenium hysterophorus* showed significant differences in the rate of seed germination, length of root and shoot in *Zea mays*. Similarly the effect of different concentrations of leaf, stem and root extracts of *Parthenium* also showed significant differences in the rate of seed germination and root length and shoot length in *Z.mays*. The interactions of plant parts and treatments were significantly different for seed germination and root length values. However the shoot length values were not significantly different (Table 3).

4. DISCUSSION

In the present study the seed germination rate in 100% concentration of leaf extract was completely inhibited. However in 15% to 75% leaf extract the rate of seed germination decreased by 53% to 86%; root length decreased by 42.6% to 76.03%; shoot length 45.15% to 74.56%; abd SVI decreased by 77.74% to 96.54%. Thus the leaf extract of different concentrations affected the rate of seed germination and SVI values more than the length of root and shoot. It was observed that with the increase in concentration of leaf extract the rate of seed germination, root length, shoot length and SVI values in *Z.mays* decreased.

In the different concentrations of stem extract of *Parthenium* decreased in the rate of seed germination, root length, shoot length and SVI values ranged from 3.33% to 96.67%; 6.30% to 95.22%; 37.40% to 77.38%; and 56.78% to 99.61%, respectively. The stem extract of *Parthenium* affected more the rate of seed germination root length and SVI values than the shoot length in *Z.mays*. In the different concentrations of root extract of *Parthenium* the rate of seed germination, root length, shoot length and SVI values decreased from 5 to 28.75%; 1.39% to 27.91%; 27.74 to 66.93% and 24.06 to 56.565, respectively. It indicated that shoot length and SVI values were more affected than the rate of seed germination and root length in *Z.mays* by the different extracts of root extract of *Parthenium*. The leaf extract of *Parthenium* showed greater phytotoxicity than stem and root extract of *Parthenium*. Root extract showed minimum inhibitory effect compared to leaf and stem extract of *Parthenium* in *Z.mays*.

Several workers have reported that all parts of *Parthenium* (leaves, stem, leaf hairs, flowers, pollengrains etc.) contain toxic and inhibitory constituents, terpenoids, Sesquiterpene lactones, volatile oils, amino sugars, phenolic derivatives, flavonoids etc. [18]. Parthenin present in the *Parthenium* has been reported as the main cause of allelopathy. Different

concentrations of parthenin have been reported in different plant parts such as leaf (3.40%), stem (0.12%), flower (1.08%), trichomes (1.20%) etc. It has been reported that the leaves, stems and roots of *Parthenium* contain different concentrations of parthenin, which is the main cause for different levels of phytotoxicity of leaves, stems and root. Although the phytotoxic effects of *Parthenium* is species specific. In the present study the indifferent concentrations of leaf, root and stem extracts of *Parthenium*. The rate of seed germination, root length and shoot length in *Z.mays* differed significantly at $p < 0.000$. The values for seed germination, root length and shoot length in different concentrations (treatments) were significantly different at $p < 0.000$. The interactions of plant parts and treatments were also significantly different for seed germination at $p < 0.000$ and root length at $p < 0.001$ however the shoot length values were not significantly different ($p < 0.344$). This indicated that the impact of plant parts and treatments were more for seed germination and root length in *Z.mays*.

[19] have evaluated the phytotoxic effect of whole plant residue of *Parthenium* and rhizospheric soil of 15cm depth and of collar distance of 15cm on seedling emergence and growth of wheat, canola, wild oat and canary grass. The phytotoxic effect of whole plant residue of *Parthenium* reduced the emergence of canola (11-20%), wild oat (20-29%) and canary grass (20-27%) whereas emergence in wheat was not affected. The biomass of seedling was reduced in wheat (41-48%), canola (53-61%), wild oat (31-45%) and canary grass (30-45%). The rhizospheric soil of 15cm depth reduced the emergence of seedlings by 15% and collar distance of 15cm soil 40%. Shi et al. (2018) have reported that introduced biotypes of *Parthenium* were more phytotoxic to lettuce than *Parthenium* biotypes of native range. No significant differences was reported in seedling growth of lettuce when two Australian biotype species of *Parthenium*, one invasive and other non-invasive, were compared. They reported that invasiveness of *Parthenium* was not associated with litter phytotoxicity. The residue of invasive species biotype had greater phytotoxic upon Australian native pasture grass species relative to the introduced pasture grass species with *Cenchrus ciliaris* and *Astreable sequrrosa*. They suggested that phytotoxicity of *Parthenium* may not be the main reason for plants invasive trait.

5. CONCLUSION

The leaf, stem and root aqueous extracts of different concentrations of *P.hysterophorus* showed phytotoxicity to the rate of seed germination, root length, shoot length and seed vigour index in *Zea mays*. Leaf and stem extracts were more toxic for *Z.mays* than the root exract of *Parthenium*. The impact of plant parts and treatments were significantly and negatively different for seed germination and growth parameters. The phytotoxicity levels of different parts of *Parthenium* can be arranged as leaves > stem > root for Z.mays.

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TABLE 1: Seed Germination rate, Length of root & shoot and Seed Vigour Index in *Z.mays* in Different Concentrations of Leaf, Stem and Root Extract of *P.hysterophorus*.

Extract	Growth parameters	Control	15%	25%	50%	75%	100%
	Seed Germination (%)	100	47	41	34	14	0
Leaf Extract	Root Length (cm)	7.51	4.31	3.12	2.1	1.8	0
	Shoot Length (cm)	6.8	3.73	3.65	3.56	1.73	0
	SVI	1431	377.88	318.57	192.44	49.42	0
	Seed Germination (%)	100	96.67	56.67	56.67	33.33	3.33
Stem Extract	Root Length (cm)	10.47	8.45	9.81	7.19	8.88	0.5
	Shoot Length (cm)	6.63	4.15	3.23	3.51	3.13	1.5
	SVI	1710	601.29	738.98	606.37	400.29	6.66
	Seed Germination (%)	80	70	57	59	60	76
Root Extract	Root Length (cm)	12.22	12.05	9.75	11.34	8.81	8.89
	Shoot Length (cm)	9.95	7.19	5.51	4.6	4.03	3.29
	SVI	1773.6	1346.8	869.82	940.46	770.4	925.68

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

Extract	Growth parameters	15%	25%	50%	75%	100%
	Seed Germination (%)	-53	-59	-66	-86	-100
Leaf Extract	Root Length (cm)	-42.6	-58.46	-72.04	-76.03	-100
	Shoot Length (cm)	-45.15	-46.32	-47.65	-74.56	-100
	SVI	-73.59	-77.74	-86.55	-96.54	-100
	Seed Germination (%)	-3.33	-43.33	-43.33	-6.67	-96.67
Stem Extract	Root Length (cm)	-19.29	-6.30	-31.33	-15.19	-95.22
	Shoot Length (cm)	-37.40	-51.28	-47.06	-52.79	-77.38
	SVI	-64.84	-56.78	-64.54	-76.59	-99.61
	Seed Germination (%)	-12.5	-28.75	-26.25	-25	-5
Root Extract	Root Length (cm)	-1.39	-20.21	-7.2	-27.91	-27.25
	Shoot Length (cm)	-27.74	-44.62	-53.77	-59.5	-66.93
	SVI	-24.06	-50.96	-46.97	-56.56	-47.84

Table 3: Significance levels of plant parts (leaf, stem and root extract) of *P.hysterophorus* and their different concentrations (treatments) on seed germination and length of root and shoot in *Z.mays* after Tukey HSD and Pst 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*	0.001*	0.344
4	**Leaves × Stem**	0.000*	0.000*	0.752
5	**Leaves × Root**	0.000*	0.000*	0.000*
6	**Stem × Root**	0.039*	0.000*	0.000*
7	**Control / 15%**	0.000*	0.113	0.000*
8	**Control / 25%**	0.000*	0.000*	0.000*
9	**Control / 50%**	0.000*	0.000*	0.000*
10	**Control / 75%**	0.000*	0.000*	0.000*
11	**Control / 100%**	0.000*	0.000*	0.000*
12	**15% /25%**	0.016*	0.353	0.431
13	**15% /50%**	0.003*	0.279	0.083
14	**15% /75%**	0.000*	0.001*	0.000*
15	**15% /100%**	0.000*	0.000*	0.000*
16	**25% /50%**	0.995	1.000	0.960
17	**25% / 75%**	0.016*	0.293	0.016*
18	**25% / 100%**	0.001*	0.000*	0.000*
19	**50% / 75%**	0.070	0.370	0.146
20	**50% / 100%**	0.008*	0.000*	0.000*
21	**75% / 100%**	0.976	0.187	0.064

*Significantly different

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