



PREVALENCE AND ALLELOPATHIC EFFECT OF *PARTHENIUM HYSTEROPHORUS* ON CROPS IN SOUTHWEST REGIONS OF BANGLADESH

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ABSTRACT

Periodical weed surveys were conducted during 2020-21 in Jashore, Jhenaidah, Chuadanga, Meherpur and Khustia districts of Bangladesh to observe the severity and allelopathic effect of *Parthenium hysterophorus* on field crops. *Parthenium* infected the crops differently as observed in rice (8.75%), maize (11.45%), lentil (12.45%), chickpea (32.40%), field pea (57.63%), jute (57.63%), cotton (13.45%), mustard (63.85%), sesame (17.50%), groundnut (28.35%), pointed gourd (11.50%), pumpkin (8.45%), onion (30.47%), garlic (26.25%), turmeric (17.50%), potato (38.75%), banana (24.33%), sugarcane (60.25%), napiergrass (55.00%) and marigold (11.25%). Allelopathic effect was examined using 5% aqueous leaf extract of *P. hysterophorus* in germination test and results showed complete failure of germination in seeds of sesame, jute, pumpkin, red amaranth, chili, radish and tomato. Seeds of other crops germinated poorly in aqueous solution of parthenium with reduced radicle and plumule growth. Among the different crops, wheat had the highest reduction in radicle (96%) and plumule (94%) length compared to their control.

Keywords: Parthenium, infestation, allelopathy, aqueous extract, germination, seedling growth

Introduction

Parthenium hysterophorus L., known as Congress Weed, Carrot Weed, or White Top, is an alien invasive herbaceous weed that was once only found in the tropical and subtropical Americas but is now found across the tropics (Adkins and Shabbir 2014). In every instance, the weed has been unintentionally introduced and spreads quickly and forms mono-specific thickets that endanger cropland, rangeland, and the diversity of natural ecosystems. For instance, introduction of parthenium in India took place in the 1950s, and within a few years, it spread to almost the whole nation (Bajwa *et al.* 2016). Recently, it has been introduced to Bangladesh, presumably from India, as the weed populations are found mostly in the border districts specially on the road systems connecting the two countries. The weed has also been identified in Jashore, Narail, Magura, Kushtia, Meherpur, Chuadanga, Faridpur, Rajbari, Rajshahi, Natore, Pabna, Sirajgonj, Manikgonj, Gazipur, Dhaka and Mymensingh districts which supported the findings of other authors (Masum *et al.* 2013, Masum *et al.* 2022). This weed severely impacts

on human health, agriculture, forestry, fisheries, wetlands, roadsides, natural areas, and animal productivity.

Globally and specifically in Bangladesh, climate change is currently a reality. There has been a noticeable increase in global temperature and changes in rainfall patterns. Such changes in temperature and rainfall are likely to modify the distribution and adaptation of plants including weeds. *Parthenium* weed is considered physiologically adaptable to climate change and it has been hypothesized that parthenium weed will become more vigorous and prolific in near future (Navie *et al.* 2005).

Although several studies on the effect of parthenium weed have been undertaken in many countries, very little work has been done in Bangladesh. Further, a few accounts of parthenium weed are available although most of the people never know anything about the emerging problem. Investigation on parthenium weed by assessing the severity of infestation and their effects on crop production is necessary to address this issue effectively. Therefore, the current research was conducted to identify the crops with parthenium

populations, to measure their number and level of infestation, and to determine the allelopathic effect of parthenium on crop productivity.

Materials and Methods

Crop infestation: Field surveys of parthenium weed infestations were conducted during April 2020 to March 2021 in 27 administrative regions (Upazila) within Jashore hub which encompasses Jashore, Jhenaidah, Chuadanga, Meherpur, and Khustia districts of Bangladesh. Jashore hub includes the western portion of the Ganges River floodplain with primarily high and medium elevations. This area is primarily calcareous dark grey and brown floodplain soils that are moderately alkaline. The organic matter content is high in dark grey soils but low in brown ridge soils. In this study, crop fields were measured using the list quadrat method. Photographs were taken by handheld GPS to integrate topography when parthenium at a density of at least one plant per 10 m² (Maszura *et al.* 2018).

The following equations were used to compute the percent prevalence and infestation of parthenium:

$$\text{Occurrence (\%)} = \frac{\text{No. of field having parthenium}}{\text{Total number of fields surveyed}} \times 100$$

$$\text{Infestation (\%)} = \frac{\text{Total no. of quadrates in which parthenium weed occurred}}{\text{Total number of quadrates used}} \times 100$$

The crop fields were chosen based on local crop production patterns and the seasons. The number of fields inspected for the various crops ranged from 20 to 200. Twenty quadrates measuring 50 × 50 cm² were randomly placed along each 50-meter length to count the amount of parthenium in each of the selected fields.

Allelopathic effects: For determination of allelopathic effect of parthenium, germination test of crop seeds was conducted with aqueous extract of parthenium.

Fresh parthenium samples were collected from different infested parts of the country at their maximum vegetative stage. Leaf samples of parthenium were oven-dried at 60°C until they reached a constant dry weight. The dried samples were blended into a fine homogeneous powder and preserved in glass jars. After being separated, the leaves were finely chopped by a sharp knife, weighed for

an equal amount, crushed in a sterile mortar and pestle, and combined with sterilized water for 48 hours at room temperature. The aqueous stock extract was prepared by soaking 50 g of air-dried plant material for 24 hours at room temperature in 1000 mL of cold distilled water for making 5% concentration. Aqueous stock extract was filtrated firstly by three layers of muslin fabric to remove particles from aqueous leachate. The filtrate was re-filtered using one layer of Whatman No. 1 filter paper to get the final aqueous solution and preserve it in a dark and cool place. It was used for the plant aqueous extract bioassay. pH of the extracts was adjusted to 5.74 and used within a week.

Germination test was carried out in 2021 at the Central Laboratory, Department of Agronomy, Sher-e-Bangla Agricultural University, Dhaka. In this experiment, 5% aqueous leaf extracts of parthenium and control were followed with three replications of each crop seed in a completely randomized design. Ten seeds of each test crop were sown on Whatman 2 MM paper in a 9 cm Petri plate, and 6 mL of the aqueous extract or control solution was added to the Petri plate in a 48-hour interval. Germination was examined every 12 hours until no more seeds were germinated which was indicated by the appearance of the radicle and expressed in percentage.

Data analysis: Statistix 10 data analysis software was used and for each statistical comparison, the Type I error was set to 0.01. Microsoft Excel was used to compute the standard errors.

Results and Discussion

Crop fields were analyzed and the results revealed that cereal, pulse, fibre, oil, sugar, narcotic, spices, vegetables, fodder, fruit crops and flowering ornamental crop were infested by parthenium weed with the exception of cereal crop *aman* rice (Table 1). Only *aus* rice (upland rice) crop fields were infested although the infestation was lower (8.75%). Similarly, lower infestation was noticed on the vegetable crop pumpkin (8.45%). A severe infestation of parthenium weed (>50%) was recorded in pulse crop pea (57.85%), fiber crop tossa jute (57.63%), oil crop mustard (63.85%), sugar crop sugarcane (60.35%), and fodder crop napier grass (55.0%) fields. A moderate parthenium infestation was observed (10-40%) in cereal crops (wheat

Table 1. *Parthenium* prevalence and infestation percentages in various crops

Common name	Scientific name	No. of fields investigated	No. of infested fields	Occurrence (%)	Infestation (%)
Cereal crops					
Aus rice	<i>Oryza sativa</i>	180	6	3	8.75
Aman rice	<i>Oryza sativa</i>	50	3	sporadic	-
Maize	<i>Zea mays</i>	60	3	5	11.45
Wheat	<i>Triticum aestivum</i>	45	2	4	22.32
Pulse crops					
Lentil	<i>Lens culinaris</i>	20	1	5	12.45
Pea	<i>Pisum sativum</i>	25	6	24	57.85
Chickpea	<i>Cicer arietinum</i>	20	2	10	32.4
Fibre crops					
Tossa jute	<i>Chorchorus olitorius</i>	35	15	43	57.63
Cotton	<i>Gossipium hirsutum</i>	12	1	8	13.45
Oil crops					
Mustard	<i>Brassica campestris</i>	37	9	24	63.85
Peanuts	<i>Arachis hypogaea</i>	3	1	33	28.35
Sesame	<i>Sesamum indicum</i>	10	1	10	17.5
Sunflower	<i>Helianthus annuus</i>	6	1	16	10
Tuber crops					
Potato	<i>Solanum tuberosum</i>	20	7	35	38.75
Sugar crop					
Sugarcane	<i>Saccharum officinarum</i>	70	45	64	60.35
Narcotic Crops					
Tobacco	<i>Nicotiana tabacum</i>	16	1	6	13.45
Spices crops					
Onion	<i>Allium cepa</i>	28	4	14	30.47
Garlic	<i>Allium sativum</i>	26	2	8	26.35
Turmeric	<i>Curcuma longa</i>	14	3	21	17.5
Vegetables crops					
Bottle gourd	<i>Lagenaria siceraria</i>	22	3	14	11.5
Pumpkin	<i>Cucurbita maxima</i>	14	2	14	8.45
Hyacinth bean	<i>Lablab purpureus</i>	5	1	20	10.5
Tomato	<i>Solanum lycopersicum</i>	20	4	20	17.75
Fodder crops					
Napier grass	<i>Pennisetum purpureum</i>	15	8	53	55
Fruit crops					
Banana	<i>Musa acuminata</i>	33	2	6	24.33
Mango	<i>Mangifera indica</i>	20	11	55	12.45
Flowering ornamental crops					
Marigold	<i>Tagetes erecta</i>	6	1	16	11.25

– 22.32%, and maize – 11.45%), pulse crops (chickpea – 32.40%, and lentil – 12.5%), fibre crop cotton (13.45%), oil crops (peanuts – 28.35%, sesame – 18.5%, sunflowers – 10%), tuber crop potato (38.75%), narcotic crop tobacco (13.45%), spice crops (onion – 30.47%, turmeric – 17.5%, garlic – 26.35%), vegetable crops (bottle gourd – 11.5%, hyacinth bean – 10.5%, and tomato – 17.75%), fruit crop (banana – 24.33%, mango – 12.45%), and flowering ornamental crop marigold (11.25%) fields. Additionally, in various locations throughout the examined region, parthenium weed is a severe problem in pastures and rangelands (data not shown). Parthenium weed has been documented to harm agricultural output through resource competition and allelopathy in many Asian countries, Africa and Australia. In most of these countries, the weed has already infested susceptible crops, while in other countries, it is still moving from the areas it originally colonized into cropping lands. Parthenium infestations were recorded in rice, millet, soybean, sugarcane, maize, cotton, sorghum, onions, and citrus orchards. Compared to other crops, sugarcane had a substantially greater parthenium infestation. There is substantial evidence that parthenium can reduce sorghum and sunflower production. It can reduce pasture production by up to 90% and crop yield losses by up to 40%. It interferes with nodulation in legumes by inhibiting the activities of the nitrifying and nitrogen-fixing bacteria *Rhizobium*, *Actinomycetes*, *Azotobacter*, and *Azospirillum* (Gnanavel 2013). Due to parthenium weed infestations, Tamil Nadu lost almost 300 kg ha⁻¹ of cotton seed. In contrast, rice had minimal parthenium infestation (Khan and Aneja 2016). Grain yield and the harvest index of maize were also dropped due to parthenium weed (Safdar *et al.* 2016).

Allelopathy activity of leaf extract of *P. hysterophorus* was examined against seed germination including radicle and plumule growth of twenty field crops. Crops included three major kinds of cereal (rice, wheat, maize), six pulse crops (chickpea, cowpea, green gram, blackgram, field pea, lentil), two oilseed crops (mustard, sesame), one fiber crop (tossa jute), two spice crops (onion, chilli), and six vegetable crops (bean, cucumber, pumpkin, red amaranth, radish, tomato). Leaf extract used for germination test had a more substantial inhibitory allelopathic effect than other vegetative parts of parthenium. Allelopathic effects of parthenium on crops were assessed by germination

test, radicle and plumule length of seedlings (Anwar *et al.* 2016).

The osmotic and imbibitional absorption of water, which activates enzymes and increases metabolic activity is the first step of germination. Germination rates were lower in all seeds treated with 5% parthenium leaf extract than the control (Table 2). The failure of germination (0%) was observed in sesame, jute, pumpkin, red amaranth, chili, radish and tomato seeds due to allelopathic effect of parthenium extract, similarly, aqueous parthenium leaf extract completely prevented seed germination in *Eragostis tef* (Tefera 2002). Among the major cereals, wheat had the minimum germination (21.33%), followed by maize (33.33%) and rice (44.33%). Phenols, alkaloids and other allelochemicals of parthenium may cause failure or lower germination crop seeds. An imbalance in metabolism controlled by different enzyme activities may also cause the inhibitory impact of parthenium leaf extracts on seed germination. However, flavonoid compounds' herbicidal activity may contribute to the further decline in the germination percentage (Sorecha and Birhanu 2017).

All the species in germinated test showed significantly shorter radicle and plumule length when treated with aqueous parthenium extract (Table 2). Of the cereal species, the radicle and plumule of wheat decreased considerably due to parthenium extract. The results showed that the radicle and plumule length of rice became 75 and 74% shorter than that of the control. Similarly, radicle and plumule length of wheat were 96 and 94% shorter respectively than the control. Whereas in maize, radicle length was 43% and plumule length was 44% shorter from the control. Among pulses, the radicle and plumule length of lentil were reduced to 87 and 90%, respectively as compared to the control. The radicle and plumule length of mustard seedlings reduced to 45 and 66% the mustard seedlings in control condition. Similarly, the onion seedlings had 76 and 72% reduced radicle and plumule respectively, compared to seedlings of onion in control. Among the vegetables, cucumber had the higher reduction seedling growth (58 and 59% radicle and plumule, respectively, as compared to control seedling. Contrary, been had 45 and 43% reduced radicle and plumule, respectively than from control seedlings.

Table 2. Allelopathic effects of parthenium on germination, radicle and plumule length of various field crops

Name of the Crops	Germination (%)		Radicle length (cm)		Plumule length (cm)	
	Control	Aqueous extract	Control	Aqueous extract	Control	Aqueous extract
Cereal crops						
Rice	96.33 ± 0.88	44.33 ± 4.70	3.37 ± 0.11	0.85 ± 0.03	4.27 ± 0.15	1.04 ± 0.01
Wheat	97.43 ± 0.69	21.33 ± 2.03	4.47 ± 0.33	0.20 ± 0.06	8.83 ± 0.45	0.57 ± 0.17
Maize	94.57 ± 0.88	33.33 ± 3.28	12.42 ± 0.65	7.09 ± 0.21	12.72 ± 0.46	7.13 ± 0.51
Pulse crops						
Chickpea	87.33 ± 7.06	27.33 ± 4.67	10.46 ± 0.48	5.53 ± 0.70	3.54 ± 0.25	1.75 ± 0.19
Cowpea	92.00 ± 2.19	38.33 ± 4.41	6.68 ± 0.34	3.68 ± 0.26	9.32 ± 0.45	6.66 ± 0.29
Greengram	95.00 ± 1.15	70.60 ± 4.63	9.10 ± 0.35	4.33 ± 0.97	18.13 ± 0.64	13.33 ± 0.94
Blackgram	95.00 ± 1.82	81.33 ± 2.89	7.73 ± 0.33	5.13 ± 0.43	18.40 ± 0.36	15.60 ± 0.93
Fieldpea	94.20 ± 0.67	34.00 ± 3.21	63.78 ± 1.40	9.48 ± 0.52	59.00 ± 3.88	7.39 ± 0.66
Lentil	93.17 ± 1.73	37.00 ± 1.53	51.95 ± 8.50	6.54 ± 0.10	64.31 ± 3.12	6.43 ± 1.03
Oilseed crops						
Mustard	87.83 ± 4.04	38.96 ± 4.87	3.78 ± 0.12	2.08 ± 0.30	3.56 ± 0.81	1.21 ± 0.09
Sesame	85.33 ± 0.88	0.00 ± 0.00	3.22 ± 0.14	0.00 ± 0.00	3.64 ± 0.10	0.00 ± 0.00
Fiber crop						
Jute	80.67 ± 3.53	0.00 ± 0.00	1.32 ± 0.05	0.00 ± 0.00	2.64 ± 0.10	0.00 ± 0.00
Spices crops						
Onion	77.50 ± 1.73	14.67 ± 2.03	2.80 ± 0.70	0.67 ± 0.17	3.56 ± 0.80	0.98 ± 0.12
Chilli	76.33 ± 4.41	0.00 ± 0.00	3.12 ± 0.29	0.00 ± 0.00	3.38 ± 0.13	0.00 ± 0.00
Vegetables crops						
Bean	79.33 ± 0.58	42.33 ± 2.96	18.33 ± 0.24	10.04 ± 0.88	33.45 ± 0.16	19.15 ± 2.29
Cucumber	86.00 ± 1.76	41.67 ± 2.03	46.79 ± 2.98	19.79 ± 0.63	62.77 ± 1.20	25.82 ± 1.57
Pumpkin	75.67 ± 2.40	0.00 ± 0.00	17.72 ± 0.40	0.00 ± 0.00	10.37 ± 1.12	0.00 ± 0.00
Amaranth	74.33 ± 0.58	0.00 ± 0.00	11.42 ± 0.66	0.00 ± 0.00	20.43 ± 1.42	0.00 ± 0.00
Radish	92.33 ± 0.33	0.00 ± 0.00	8.33 ± 0.24	0.00 ± 0.00	16.45 ± 1.64	0.00 ± 0.00
Tomato	96.00 ± 1.73	0.00 ± 0.00	0.35 ± 0.03	0.00 ± 0.00	0.89 ± 0.03	0.00 ± 0.00

Radicle appeared more sensitive to allelopathic effect than plumule in most cases of test species. Similar findings have been reported for tomato (Mersie and Singh 1987), chickpea and sesame (Ashebir *et al.* 2012), maize, soybean, and cotton (Masum *et al.* 2012), blackgram and green gram (Parthasarathi *et al.* 2012), onion and bean (Demissie *et al.* 2013), bean (Tahseen *et al.* 2015), maize (Anwar *et al.* 2016), wheat, chickpea and mustard (Hassan *et al.* 2018), rice and wheat (Shrestha and Thapa 2018), cowpea and rice (Bhuvaneshwari *et al.* 2019). In this study,

dicotyledonous plants showed more growth inhibitory effects than monocotyledonous plants. Khanh *et al.* (2006) also observed that *Passiflora edulis* aqueous extracts significantly inhibited the growth of dicot plants while having less of an impact on the growth of monocot plants.

Conclusion

Parthenium weed is identified in different field crops of southeast region of Bangladesh although degree of infestation varied significantly depending upon the

nature of crop growth. It also showed allelopathic effect on germination and seedling growth of crops. However, detailed study is necessary with crops in other regions of Bangladesh so that comprehensive management may be adopted to control the devastating weed. Further, appropriate laws, policy, and management options are required to reduce parthenium weed in Bangladesh.

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