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Efficacy of different botanical extracts on the management of *Parthenium hysterophorus* (L.)

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ABSTRACT

The present study was carried out to evaluate the efficacy of botanical extracts on the management of *Parthenium hysterophorus* through laboratory experiments. These experiments were carried out at Department of Agronomy, Agricultural College and Research Institute, Madurai during 2013-15. The efficacy of twenty botanicals *viz.*, *Abutilon indicum, Amaranthus spinosus, Amaranthus viridis, Azadirachta indica, Calotropis gigantea, Croton bonplandianum, Cynodon dactylon, Cyperus rotundus*, *Datura metel*, *Echinochloa crusgalli, Helianthus annuus, Lawsonia inermis, Mangifera indica, Prosopis juliflora, Solanum nigrum, Sorghum bicolor, Sorghum halepense, Tagetes erectus, Tamarindus indica, Tephrosia purpurea* were tried at different concentrations under laboratory bioassay. The study reveal that the per cent germination, seedling length, seedling vigor index and seedling biomass of *P.hysterophorus* was reduced significantly due to application of all botanicals, however the effect was more pronounced with botanicals extract in the order of *Datura metel, Mangifera indica, Azadirachta indica, Tagetes erectus, Helianthus annuus* and *Sorghum bicolor* both at 50 and 75 % concentrations. Increased concentration (50 and 75 %) was pronounced more detrimental effects on per cent germination and seedling growth parameters of *P.hysterophorus*.

Introduction

Allelochemicals emancipated as residues, exudates and leachates by many plants from leaves, stem, roots, fruits and seeds reported to interfere with growth of other plants (Asgharipour and Armin, 2010). These chemical products mainly affect plants at seed emergence and seedling levels (Alam and Islam, 2002; Hussain et al. 2007; Mohamadi and Rajaie, 2009; Naseem et al. 2009). Allelopathy plays an important role in agricultural ecosystems and on a large scale, in the plant

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covers among the crop-crop, crop-weed and tree-crop covers. These interactions are detrimental and occasionally are useful and give attention to allelopathy in natural and agricultural ecosystems.

Invasion of exotic species is among the most important global scale problems experienced by natural ecosystem (Sharma et al. 2005). Invasive alien species are such species whose introduction or spread threatens the environment, economy or society including human health. *Parthenium hysterophorus* L. is an annual herb of neo tropical region, now fairly distributed throughout the globe. *P.hysterophorus* L. an abnoxious weed has been reported as a main source of nuisance and health hazard to mankind and animals, threat to bio-diversity and danger to environment (Knox et al. 2011). Today parthenium has got a position among the list of top ten worst weeds of the world and has been listed in the global invasive species database and it has invaded almost all the states of India encroaching about 35 million hectares of land. During the 1980's, parthenium weed used to be considered a weed of rainfed fallow and a waste land, but now it has become a weed of every crop and also into the forested land. It reported to cause yield loss upto 40 % in several crops (Khosla and Sobti, 1979) and reduction in forage production upto 90 % (Nath, 1988). Infestation by parthenium degrades natural eco systems. Its pollen is known to inhibit from fruit set in many crops. The germination and growth of indigenous plants are inhibited by its allelopathic effect. In human beings, the pollen grain, air borne pieces of dried plant material and roots of parthenium can cause allergy type responses like hay fever, asthma, eczema etc., Besides in animals, the plant can cause with external symptoms of pruritis, alopecia, loss of skin pigmentation, facial and body dermatitis, erythematous eruptions and anorexia (Seema, 2011). The milk of cattle, buffalo and sheep may also be tainted by parthenin (Towers and Subba Rao, 1992), which can also affect sheep meat (Tudor et al*.* 1982). Parthenium offers a big challenge to all attempts of control because of its high regeneration capacity, production of huge amount of seeds, high seed germination and extreme adaptability to a wide range of ecosystems.

Preventing the spread of parthenium is the most cost effective management strategy. There is a high risk of spreading parthenium by the movement of vehicle, livestock and crop produces. Eradication of *P.hysterophorus* by manual, chemical and biological control methods such as leaf feeding beetle and fungi have been carried out with variable degree of success. Manual uprooting of parthenium before flowering and seed setting is the most effective method by adopting proper precaution measures. Uprooting the weeds after seed setting will increase the area of infestation. Parthenium is reported to be controlled by foliar spray of some herbicides (Javaid et al. 2006). Although herbicides are the most effective immediate solution to weed management strategies but increased and indiscriminate use of these herbicide resulted in resistance and resurgence in pests. Resistance to specific synthetic herbicides is increasing dramatically in the last two decades leading

to lowering the land values resulting farmers to run out of weed controlling chemicals. Now, it is imperative to concentrate on research to find out some natural extract to control this menace, thereby minimizing or avoiding the frequent use of herbicides in future. Furthermore, increasing public concern on environmental issues requires alternative weed management systems, which are less pesticide dependent or based on naturally occurring compounds (Singh et al., 2003). With increasing societal concern regarding the harmful effects of chemical or synthetic pesticides on humans as well as on environment (Mehdizadeh et al. 2017) have aroused substantial interest to evolve alternate eco-friendly approaches for the control of parthenium. The earlier reports deal with the allelopathic effect of *P.hysterophorus* on the germination and growth of different crops but unfortunately not much work has been done to study the allelopathic effects of different plant species on the control of *P.hysterophorus.* Allelopathy is an ecological approach and allelochemicals as biological herbicides have been a challenge to current approaches (Inderjit and Duke, 2003).

In this regard, allelopathic effect of different plants is drawing attention on many researchers in the recent past. Therefore, keeping this view, studies on exploring the efficacy evaluation of certain botanicals extract on the growth of parthenium was under taken to identify the efficacy potential of different botanicals leaf extract on *Parthenium hysterophorus* L. and effect of identified botanicals with different concentrates on morpho-physical and biochemical properties of this weed.

Materials and Methods

The experiment was conducted in Agricultural College and Research Institute, Madurai, which is situated at 9°54' N latitude and 78° 54' 'E' longitude with an altitude of 147 m above mean sea level. Laboratory bioassay study was conducted to find out the effect of aqueous leaf extracts of botanicals on the control of *P. hysterophorus* L. The details of the experiments are presented below. The experiment was carried out during December 2013 by following complete randomized block design (CRBD). The experiment consists of three concentrations (25 %, 50 % and 75 % plant extract) and spray with distilled water as control and twenty botanicals that presented as below.

B_1 *Abutilon indicum*	**B_{11}** *Helianthus annuus*
B_2 *Amaranthus spinosus*	**B_{12}** *Lawsonia inermis*
B_3 *Amaranthus viridis*	**B_{13}** *Mangifera indica*
B_4 *Azadirachta indica*	**B_{14}** *Prosopis juliflora*
B_5 *Calotropis gigantea*	**B_{15}** *Solanum nigrum*
B_6 *Croton bonplandianum*	**B_{16}** *Sorghum bicolor*
B_7 *Cynodon dactylon*	**B_{17}** *Sorghum halepense*
B_8 *Cyperus rotundus*	**B_{18}** *Tagetes erectus*
B_9 *Datura metel*	**B_{19}** *Tamarindus indica*
B_{10} *Echinochloa crusgalli*	**B_{20}** *Tephrosia purpurea*

Collection of Parthenium hysterophorus L. seeds

Seeds of *Parthenium hysterophorus* L. were collected near Agricultural College and Research Institute, experimental farm during December 2013 and dried in shade for about a week. Air dried seeds with moisture content below 12 % managed through repeated weighing and drying was used for these experiments (Jawahar et al. 2013).

Collection of botanicals

Botanicals of twenty different plant species leaves at vegetative stage were collected and the leaves were washed gently with tap water only a few seconds for removing contaminants like dust etc.

Preparation of aqueous leaf extracts

The collected fresh leaves of each botanical species were cut into small pieces, soaked in alcohol and water at 1:1 proportion, and kept for overnight. After 12 hours, soaked leaves were ground with the help of mixer grinder. From the paste, the leaf extract of each botanical species was prepared by filtration which represented 100 per cent stock solution (Sripunitha, 2009). Further dilution of 25, 50 and 75 per cent (w/v) concentrations were prepared by adding appropriate quantity of distilled water to the 100 per cent stock solution and used as per the treatment schedule.

Sowing

In a laboratory bioassay, the effect of different concentrations of leaf extracts on germination and early seedling growth of *P. hysterophorus* was studied. For this, 10 seeds of *P. hysterophorus* were placed in a 9-cm diameter petri plate lined with a filter paper and moistened with 3 ml of different concentrations of leaf extracts. Treatment with distilled water served as control. Each treatment was replicated thrice. The petri plates were incubated at 25°C and 12 hours light period daily for 10 days. This bioassay study was conducted twice and means values were taken for the study.

Germination percentage

Germination/emergence was measured on 7 days after sowing seeds and was calculated following the procedure of seedling evaluation in the Handbook of Association of Official Seed Analysts (AOSA, 1990) by using the equation 1:

Equation 1: $$Germination\ (\%) = \frac{No.of\ germinated\ seeds}{Total\ No.of\ seeds} \times 100$$

Root and Shoot length

Root length was measured on 10 DAS and mean value was calculated and expressed in millimetre. Shoot length was also measured by using the same seedlings and expressed in millimetre.

Seedling vigor index

The seedling vigor index was calculated as suggested by using Abdul –Baki and Anderson (1973) equation (2).

Equation 2: $$SVI = (Shoot\ length\ +\ Root\ length) \times Germination\ percentage$$

Fresh weight

The seedlings measured for root and shoot length were also used for recording fresh weight and expressed in milligrams.

Statistical analysis

The experimental data collected from three replications were subjected to statistical scrutiny by the method suggested by Gomez and Gomez (1984) and whenever the results were found significant critical differences were worked out at five per cent probability level.

Results and discussion

Percent germination

Data on aqueous leaf extract of botanicals with different concentration on germination percentage are presented in table (1). Among the botanicals, the maximum inhibition was observed with *Datura metel* where only 4.44 % seeds were germinated followed by *Mangifera indica* (8.89%) Similarly, *Azadirachta indica*, *Tagetes erectus, Helianthus annuus and Sorghum bicolor* were also differ significantly in reducing the germination percentage from other plant extracts as well as control. Therefore the order of severity was observed as *Datura metel* > *Mangifera indica* > *Azadirachta indica* > *Tagetes erectus* > *Helianthus annuus* > *Sorghum bicolor.* Though, *Solanum nigrum* and *Amaranthus viridis* with 50 and 75% concentrations registered lesser germination percentage at lower concentration, but the inhibition was very less as compared to *Datura metel,*

Mangifera indica, *Azadirachta indica*, *Tagetes erectus*, *Helianthus annuus* and *Sorghum bicolor.* The adverse effect of 25 to 75 % concentration was significant on the germination of *P.hysterophorus* seeds. The highest concentration of 75 % extract reduced the germination percentage to the level of 24.50 that was on par with 50 % concentration (26.33).Whereas control recorded the highest germination percentage of 100. The interaction effects between concentrations and botanicals were found significant. Among the interactions, *Datura metel, Mangifera indica, Azadirachta indica, Tagetes erectus*, *Helianthus annuus*, *Sorghum bicolor* and *Solanum nigrum* and *Amaranthus viridis* with 50 and 75 % concentration completely inhibited the germination percent and were on par with each other as compared to other plant extracts and control.

Table 1. Efficacy of botanicals on per cent germination of *Parthenium hysterophorus* L.

Botanicals	Per cent germination			Mean
	Concentration			
	25%	50%	75%	
B_1	76.66 (66.05)*	16.66 (23.85)	13.33 (21.14)	35.55 (37.01)
B_2	73.33 (60.00)	6.60 (12.38)	3.33 (6.33)	27.75 (26.24)
B_3	70.00 (61.91)	0.00 (0.28)	0.00 (0.28)	23.33 (20.82)
B_4	40.00 (39.14)	0.00 (0.08)	0.00 (0.28)	13.33 (13.24)
B_5	50.00 (45.00)	33.33 (35.01)	30.00 (33.00)	37.78 (37.67)
B_6	86.66 (72.19)	43.33 (41.15)	40.00 (39.14)	56.66 (50.83)
B_7	96.66 (83.66)	83.33 (69.98)	80.00 (67.97)	86.66 (73.87)
B_8	96.66 (83.66)	76.66 (61.92)	73.33 (59.21)	82.22 (68.26)
B_9	13.33 (21.14)	0.00 (0.28)	0.00 (0.28)	4.44 (7.23)
B_{10}	96.66 (83.66)	86.66 (68.85)	83.33 (69.98)	88.88 (74.16)
B_{11}	46.66 (43.07)	0.00 (0.28)	0.00 (0.28)	15.55 (14.55)
B_{12}	93.33 (80.95)	70.00 (56.99)	66.66 (55.07)	76.66 (64.34)
B_{13}	26.66 (30.78)	0.00 (0.28)	0.00 (0.28)	8.89 (10.45)
B_{14}	80.00 (63.93)	23.33 (28.78)	20.00 ()26.07	41.11 (39.59)
B_{15}	63.33 (53.06)	0.00 (0.28)	0.00 (0.028)	21.11 (17.88)
B_{16}	50.00 (45.00)	0.00 (0.28)	0.00 (0.28)	16.67 (15.19)
B_{17}	66.66 (54.78)	0.00 (0.28)	0.00 (0.28)	22.22 (18.45)
B_{18}	43.33 (41.07)	0.00 (0.28)	0.00 (0.28)	14.44 (13.88)
B_{19}	90.00 (78.74)	50.00 (45.00)	46.66 (43.07)	62.22 (55.60)
B_{20}	83.33 (69.98)	36.66 (37.14)	33.33 (35.21)	51.11 (47.44)
Mean	67.16 (58.89)	26.33 (24.18)	24.50 (22.94)	
Control	100 (89.71)			
	B	C	B x C	
S.Ed	4.35	1.68	7.54	
CD (P=0.05)	8.61	3.34	14.92	

*Figures in parenthesis are (arc sine) transformed values

Aqueous leaf extracts of all the twenty botanical species exhibited allelopathic potential against the germination of *P. hysterophorus.* However, extracts of all test species were not equally toxic against germination of test weed. Aqueous leaf extracts of *Datura metel, Mangifera indica, Azadirachta indica*, *Tagetes erectus, Helianthus annuus* and *Sorghum bicolor* had more inhibitory effect than extracts of remaining test botanicals. The aqueous leaf extracts of higher concentration of 50 and 75 % of the above six botanicals also significantly retarded the germination of *P.hysterophorus.* The most effective treatment in suppressing the germination of *P.hysterophorus* was 50 and 75 % extracts of *Datura metel Mangifera indica, Azadirachta indica, Tagetes erectus, Helianthus annuus Sorghum bicolor* where germination was found to the zero as compared to control (100.00) (Figure 1). Germination is the resumption of metabolic activities and growth by the seed tissues and initial step in germination is absorption of water which takes place through imbibition and osmosis which causes activation of enzymes and increased in metabolic activity. The seeds imbibed with different aqueous leaf extracts which delayed and inhibited the germination in comparison to control. The inhibitory effect in different concentration of leaf extracts on seed germination might be also due to imbalance in metabolism regulated by various enzyme activities (Oyun, 2006). Further reduction in germination percentage might be also due to herbicidal activity of flavonaids compounds (Javaid et al. 2010). Similar inhibitory effects of aqueous leaf extracts of *Datura metel* and *Mangifera indica* on germination of *P.hysterophorus* was reported by Javaid et al. (2009) and (2010). These results are also in conformity with the findings reported by Sing et al. (2013) where in a laboratory petri dish assays, showed that the highest concentration of leaf leachate of *Cassia occidentalis* L. at vegetative stage resulted in complete failure of seed germination of *P. hysterophorus.*

Root length

Observations recorded on root length (mm) are presented in table 2. The data revealed that significant differences among treatments were observed. Among the aqueous leaf extracts, *Datura metel* caused 91.10 % reduction in root length as compared to control. This was followed by *Mangifera indica, Azadirachta indica, Tagetes erectus, Helianthus annuus* and *Sorghum bicolor* which also showed reduced root length. Though, *Solanum nigrum* and *Amaranthus viridis* with 50 and 75% concentration completely inhibited the root length but the reduction was low at 25 % concentration as compared to *Datura metel, Mangifera indica*, *Azadirachta indica*, *Tagetes erectus*, *Helianthus annuus* and *Sorghum bicolor.*

Table 2. Efficacy of botanicals on root length (mm) of *Parthenium hysterophorus* L.

Botanicals	Root length (mm)			Mean
	Concentration			
	C_1 – 25%	C_2 – 50%	C_3 – 75%	
B_1	11.78 (2.75)*	5.67 (2.26)	5.60 (2.25)	7.68 (2.43)
B_2	11.47 (2.73)	2.16 (1.81)	2.12 (1.80)	5.25 (2.12)
B_3	11.14 (2.71)	0.00 (1.39)	0.00 (1.39)	3.71 (1.82)
B_4	8.04 (2.48)	0.00 (1.39)	0.00 (1.39)	2.68 (1.75)
B_5	8.98 (2.56)	7.58 (2.44)	7.53 (2.43)	8.03 (2.48)
B_6	14.56 (2.92)	8.17 (2.49)	8.13 (2.48)	10.29 (2.64)
B_7	19.29 (3.14)	13.42 (2.85)	13.38 (2.84)	15.36 (2.95)
B_8	18.22 (3.10)	11.78 (2.75)	11.71 (2.74)	13.90 (2.87)
B_9	5.49 (2.25)	0.00 (1.39)	0.00 (1.39)	1.83 (1.67)
B_{10}	20.21 (3.18)	14.56 (2.92)	14.48 (2.91)	16.42 (3.00)
B_{11}	8.26 (2.50)	0.00 (1.39)	0.00 (1.39)	2.75 (1.76)
B_{12}	17.25 (3.05)	11.14 (2.71)	11.10 (2.70)	13.16 (2.82)
B_{13}	7.02 (2.39)	0.00 (1.39)	0.00 (1.39)	2.34 (1.72)
B_{14}	12.59 (2.80)	6.85 (2.38)	6.80 (2.37)	8.75 (2.52)
B_{15}	10.12 (2.64)	0.00 (1.39)	0.00 (1.39)	3.37 (1.80)
B_{16}	8.51 (2.52)	0.00 (1.39)	0.00 (1.39)	2.84 (1.76)
B_{17}	10.55 (2.67)	0.00 (1.39)	0.00 (1.39)	3.52 (1.81)
B_{18}	8.15 (2.49)	0.00 (1.39)	0.00 (1.39)	2.72 (1.75)
B_{19}	15.00 (2.94)	8.55 (2.52)	8.43 (2.51)	10.66 (2.66)
B_{20}	13.42 (2.85)	7.79 (2.46)	7.73 (2.45)	9.65 (2.59)
Mean	12.00 (2.74)	4.88 (2.007)	4.85 (2.003)	
Control	20.58 (3.20)			
	B	C	B x C	
S.Ed	0.01	0.00	0.01	
CD (P=0.05)	0.02	0.01	0.03	

*Figures in parenthesis are log (x+4) transformed values

Seedling root length was decreased significantly with 50 and 75 % concentration (4.88 and 4.85) and they were on par with each other followed by 25 per cent concentration (12.00). Whereas, distilled water (control) recorded higher seedling root length of 20.58. Similarly, interaction effects between concentrations and botanicals were also significant. *Datura metel* with increased concentrations of 50 and 75 % completely inhibited the root length. This was followed by *Mangifera indica, Azadirachta indica, Tagetes erectus, Helianthus annuus*, *Sorghum bicolor, Solanum nigrum* and *Amaranthus viridis* with higher concentration 50 and 75 % as compared to other interactions.

Shoot length

Observations on shoot length (mm) are presented in table 3. Significant variation in shoot length of parthenium among the botanicals was observed. The effect of *Datura metel* was more pronounced and reduced the shoot length by 91.77 % as compared to control. This was followed by in the order of *Mangifera indica> Azadirachta indica> Tagetes erectus> Helianthus annuus> Sorghum bicolor*. All the concentration of aqueous leaf extracts significantly reduced the shoot length by 41.05 to 75.84 % as compared to control. Higher concentrations of 50 and 75 % significantly recorded lower shoot length (3.23 and 3.20) and par with each other. Whereas maximum shoot length was noticed at 25 % concentration and control.

Table 3. Efficacy of botanicals on shoot length (mm) of *Parthenium hysterophorus* L.

Botanicals	Shoot length (mm) Concentration			Mean
	C_1 – 25%	C_2 – 50%	C_3 – 75%	
B_1	8.69 (2.54)*	3.37 (2.00)	3.34 (1.99)	5.13 (2.18)
B_2	8.25 (2.50)	1.28 (1.66)	1.24 (1.65)	3.59 (1.94)
B_3	7.93 (2.48)	0 .00 (1.39)	0.00 (1.39)	2.64 (1.75)
B_4	5.37 (2.24)	0 .00 (1.39)	0.00 (1.39)	1.79 (1.67)
B_5	7.10 (2.39)	4.25 (2.11)	4.21 (2.10)	5.19 (2.20)
B_6	9.23 (2.58)	5.45 (2.25)	5.40 (2.24)	6.69 (2.36)
B_7	10.93 (2.70)	9.13 (2.57)	9.08 (2.56)	9.71 (2.62)
B_8	9.83 (2.63)	8.69 (2.54)	8.64 (2.24)	9.05 (2.57)
B_9	3.26 (1.98)	0.00 (1.39)	0.00 (1.39)	1.09 (1.58)
B_{10}	12.25 (2.79)	9.23 (2.58)	9.19 (2.57)	10.22 (2.64)
B_{11}	5.81 (2.28)	0.00 (1.39)	0.00 (1.39)	1.94 (1.69)
B_{12}	9.69 (2.62)	7.93 (2.48)	7.88 (2.47)	8.50 (2.52)
B_{13}	4.22 (2.10)	0.00 (1.39)	0.00 (1.39)	1.40 (1.63)
B_{14}	8.75 (2.54)	4.01 (2.08)	3.94 (2.07)	5.57 (2.23)
B_{15}	7.16 (2.41)	0.00 (1.39)	0.00 (1.39)	2.37 (1.73)
B_{16}	6.41(2.34)	0.00 (1.39)	0.00 (1.39)	2.14 (1.70)
B_{17}	7.39 (2.443)	0.00 (1.39)	0.00 (1.39)	2.46 (1.74)
B_{18}	5.48 (2.24)	0.00 (1.39)	0.00 (1.39)	1.82 (1.67)
B_{19}	9.46 (2.60)	6.06 (2.30)	5.98 (2.40)	7.17 (2.40)
B_{20}	9.13 (2.57)	5.19 (2.21)	5.11 (2.20)	6.48(2.33)
Mean	7.81 (2.45)	3.23 (1.86)	3.20 (1.86)	
Control	13.25 (2.85)			
	B	C	B x C	
S.Ed	0.01	0.00	0.01	
CD (P=0.05)	0.02	0.01	0.02	

*Figures in parenthesis are log (x+4) transformed values.

Interaction effects between concentrations and botanicals also registered significantly. It was found that complete inhibition of shoot length of *P. hysterophorus* was observed in the order of

Datura metel > *Mangifera indica* > *Azadirachta indica* > *Tagetes erectus* > *Helianthus annuus* > *Sorghum bicolor* > *Solanum nigrum* > *Amaranthus viridis* with higher concentrations of 50 and 75 % as compared to other interactions.

Seedling vigor index

The data on seedling vigor index are presented in table 4. Among the botanicals, *Datura metel* registered the lowest seedling vigor index (98.85 %) followed by *Mangifera indica* (97.04%) and *Azadirachta indica* (94.71 %) as compared to control. In general, a higher concentration of 50 and 75% showed significantly lower seedling vigor index (473.12 and 441.03) which was comparatively 67.99 and 70.16 % less than the lower concentration (25 %). Similarly, the interaction effects between concentrations and botanicals was found significant. *Datura metel, Mangifera indica, Azadirachta indica, Tagetes erectus*, *Helianthus annuus* and *Sorghum bicolor* with 50 and 75 % concentration reduced the seedling vigor index as compared to control. Similarly, though *Solanum nigrum* and *Amaranthus viridis* showed positive effect on reducing seedling vigor index at higher concentration but effect was less pronounced at lower concentration. Aqueous leaf extracts of *Datura metel* proved as the most effective botanicals in reducing both root and shoot length of *P.hysterophorus* seedlings. All the applied concentration of 25 to 75 % aqueous leaf extracts significantly declined the root and shoots length, seedling vigor index and seedling fresh weight. Generally, the toxicity of the extract enhanced by increasing the concentration (Figures 1 and 2). Among the concentration, 50 and 75 % significantly suppressed root, shoot length and seedling vigor index as compared to lower concentration. The botanicals of leaf extracts in the order of *Datura metel* > *Mangifera indica* > *Azadirachta indica* > *Tagetes erectus* > *Helianthus annuus* > *Sorghum bicolor* were very effective in retarding root and shoot length and seedling vigor index. Effect of aqueous leaf extracts of botanicals viz., *Datura metel, Mangifera indica, Azadirachta indica*, *Tagetes erectus, Helianthus annuus* and *Sorghum bicolor* on seedling biomass was similar to that of their effect on root and shoot length. The reduction in seedling root and shoot length, seedling vigor index and seedling fresh weight might be attributed to the reduced rate of cell division and cell elongation due to the presence of allelochemicals present in the aqueous leaf extracts (Buckolova, 1971). The remaining botanicals also showed inhibit effect on the growth of parthenium but the effect was not much pronounced as compared to above treatments.

Fresh weight

The data on seedling fresh weight (mg) of *P. hysterophorus* are presented in table (5). Fresh weight was adversely affected by aqueous leaf extract of various botanicals. *Datura metel* reduced

the fresh weight to the tune of 94.31 % followed by other botanicals in the order of *Mangifera indica* > *Azadirachta indica* > *Tagetes erectus* > *Helianthus annuus* > *Sorghum bicolor* which recorded 92.09, 91.01, 89.34, 88.14 and 86.34 % respectively as compared to control. In general, there was an increase in inhibitory effect with an increase in aqueous leaf extract concentrations. Higher concentration 50 and 75 % registered a significant reduction in fresh weight (1.86 and 1.84) but on par with each other as compared to 25 % extract concentration and control. Among the interaction effects between concentrations and botanicals, *Datura metel* with 50 and 75 % concentrations showed complete reduction in fresh weight followed by *Mangifera indica, Azadirachta indica, Tagetes erectus, Helianthus annuus and Sorghum bicolor* with higher concentrations.

Table 4. Efficacy of botanicals on seedling vigor index of *Parthenium hysterophorus* L.

Botanicals	Seedling vigor index			Mean
	Concentration			
	C_1 – 25%	C_2 – 50%	C_3 – 75%	
B_1	1569.23 (7.36)*	150.6 (5.04)	119.17 (4.81)	613.00 (5.74)
B_2	1784.11 (7.49)	22.70 (3.28)	11.18 (2.71)	606.00 (4.50)
B_3	1334.9 (7.20)	0.00 (1.39)	0.00 (1.39)	444.97 (3.32)
B_4	536.40 (6.29)	0.00 (1.39)	0.00 (1.39)	178.80 (3.02)
B_5	804.00 (6.64)	394.29 (5.99)	352.20 (5.87)	516.83 (6.18)
B_6	2061.64 (7.63)	590.15 (6.39)	541.20 (6.30)	1064.33 (6.77)
B_7	2921.06 (7.98)	1879.09 (7.54)	1796.80 (7.49)	2198.98 (7.67)
B_8	2711.31 (7.90)	1569.23 (7.36)	1492.26 (7.31)	1924.27 (7.52)
B_9	116.63 (4.79)	0.00 (1.39)	0.00 (1.39)	38.88 (2.52)
B_{10}	2845.67 (7.95)	2061.64 (7.63)	1972.42 (7.58)	2293.24 (7.72)
B_{11}	656.50 (6.49)	0.00 (1.39)	0.00 (1.39)	218.83 (3.08)
B_{12}	2514.31 (7.83)	1334.9 (7.19)	1265.20 (7.14)	1704.80 (7.39)
B_{13}	299.65 (5.71)	0.00 (1.39)	0.00 (1.39)	99.88 (2.82)
B_{14}	1707.20 (7.44)	253.36 (5.55)	214.8 (5.38)	725.12 (6.12)
B_{15}	1090.54 (6.99)	0.00 (1.39)	0.00 (1.39)	363.51 (3.25)
B_{16}	746.00 (6.62)	0.00 (1.39)	0.00 (1.39)	248.67 (3.13)
B_{17}	1195.88 (7.08)	0.00 (1.39)	0.00 (1.39)	398.63 (3.28)
B_{18}	590.58 (6.38)	0.00 (1.39)	0.00 (1.39)	196.86 (3.05)
B_{19}	2201.4 (7.69)	730.5 (6.59)	627.37 (6.44)	1186.42 (6.91)
B_{20}	1879.09 (7.54)	475.84 (6.17)	427.95 (6.06)	927.63 (6.59)
Mean	1478.31 (7.05)	473.12 (4.06)	441.03 (3.98)	
Control	3383 (8.12)			
	B	C	B x C	
S.Ed	0.01	0.00	0.02	
CD (P=0.05)	0.02	0.01	0.04	

*Figures in parenthesis are log (x+4) transformed values

From the laboratory bioassay study, it could be inferred that among twenty botanicals screened for the control of *P.hysterophorus,* six botanicals viz., *Datura metel, Mangifera indica, Azadirachta indica, Tagetes erectus, Helianthus annuus* and *Sorghum bicolor* caused a significant deleterious effect on Parthenium seed germination and seedling growth parameters. The present investigation also indicated that concentrations of botanicals extract also have a significant effect in expressing the herbicidal effect on *P.hysterophorus.* Therefore, the above botanicals were chosen along with concentrations for further investigations through pot culture study.

Table 5. Efficacy of botanicals on fresh weight (mg) of *Parthenium hysterophorus* L.

Botanicals	Fresh weight (mg)			Mean
	Concentration			
	C_1 – 25%	C_2 – 50%	C_3 – 75%	
B_1	5.23 (2.22)*	1.51 (1.70)	1.48 (1.69)	2.74 (1.88)
B_2	5.02 (2.20)	0.72 (1.55)	0.69 (1.54)	2.14 (1.76)
B_3	4.98 (2.19)	0.00 (1.39)	0.00 (1.39)	1.66 (1.65)
B_4	2.25 (1.87)	0.00 (1.39)	0.00 (1.39)	0.75 (1.54)
B_5	5.12 (2.21)	3.25 (1.98)	3.21 (1.97)	3.86 (2.05)
B_6	6.15 (2.31)	2.60 (1.88)	2.57 (1.87)	3.77 (2.2)
B_7	7.11 (2.40)	5.98 (2.30)	5.94 (2.29)	6.34 (2.33)
B_8	6.95 (2.39)	5.21 (2.22)	5.18 (2.21)	5.78 (2.27)
B_9	1.42 (1.69)	0.00 (1.39)	0.00 (1.39)	0.47 (1.48)
B_{10}	7.21 (2.41)	6.15 (2.31)	6.11 (2.30)	6.49 (2.35)
B_{11}	2.98 (1.96)	0.00 (1.39)	0.00 (1.39)	0.99 (1.58)
B_{12}	6.74 (2.37)	4.81 (2.17)	4.78 (2.16)	5.44 (2.23)
B_{13}	1.98 (1.78)	0.00 (1.39)	0.00 (1.39)	0.66 (1.51)
B_{14}	5.53 (2.25)	1.80 (1.76)	1.75 (1.74)	3.03 (1.92)
B_{15}	3.87 (2.06)	0.00 (1.39)	0.00 (1.39)	1.29 (1.61)
B_{16}	3.41 (1.91)	0.00 (1.39)	0.00 (1.39)	1.14 (1.59)
B_{17}	4.52 (2.14)	0.00 (1.39)	0.00 (1.39)	1.51 (1.64)
B_{18}	2.68 (1.93)	0.00 (1.39)	0.00 (1.39)	0.89 (1.57)
B_{19}	6.42 (2.34)	2.86 (1.92)	2.81 (1.91)	4.03 (2.06)
B_{20}	5.98 (2.30)	2.36 (1.85)	2.30 (1.84)	3.55 (1.99)
Mean	4.78 (2.15)	1.86 (1.71)	1.84 (1.70)	
Control	8.35 (2.51)			
	B	C	B x C	
S.Ed	0.01	0.00	0.02	
CD (P=0.05)	0.02	0.01	0.04	

*Figures in parenthesis are log (x+4) transformed values

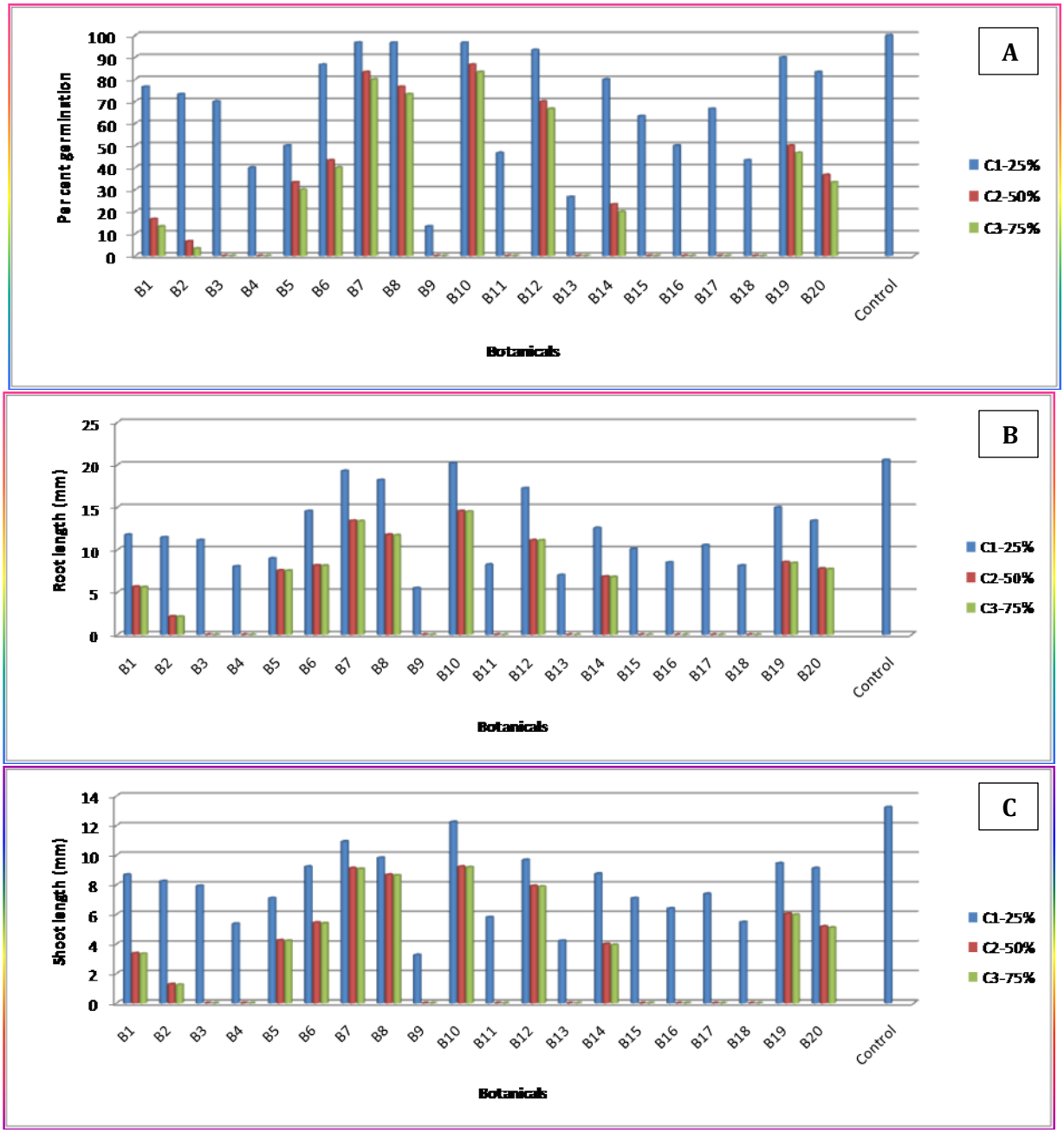

Figure 1. Efficacy of botanicals on per cent seed germination (A), root length (B) and shoot length (C) of *Parthenium hysterophorus* L.

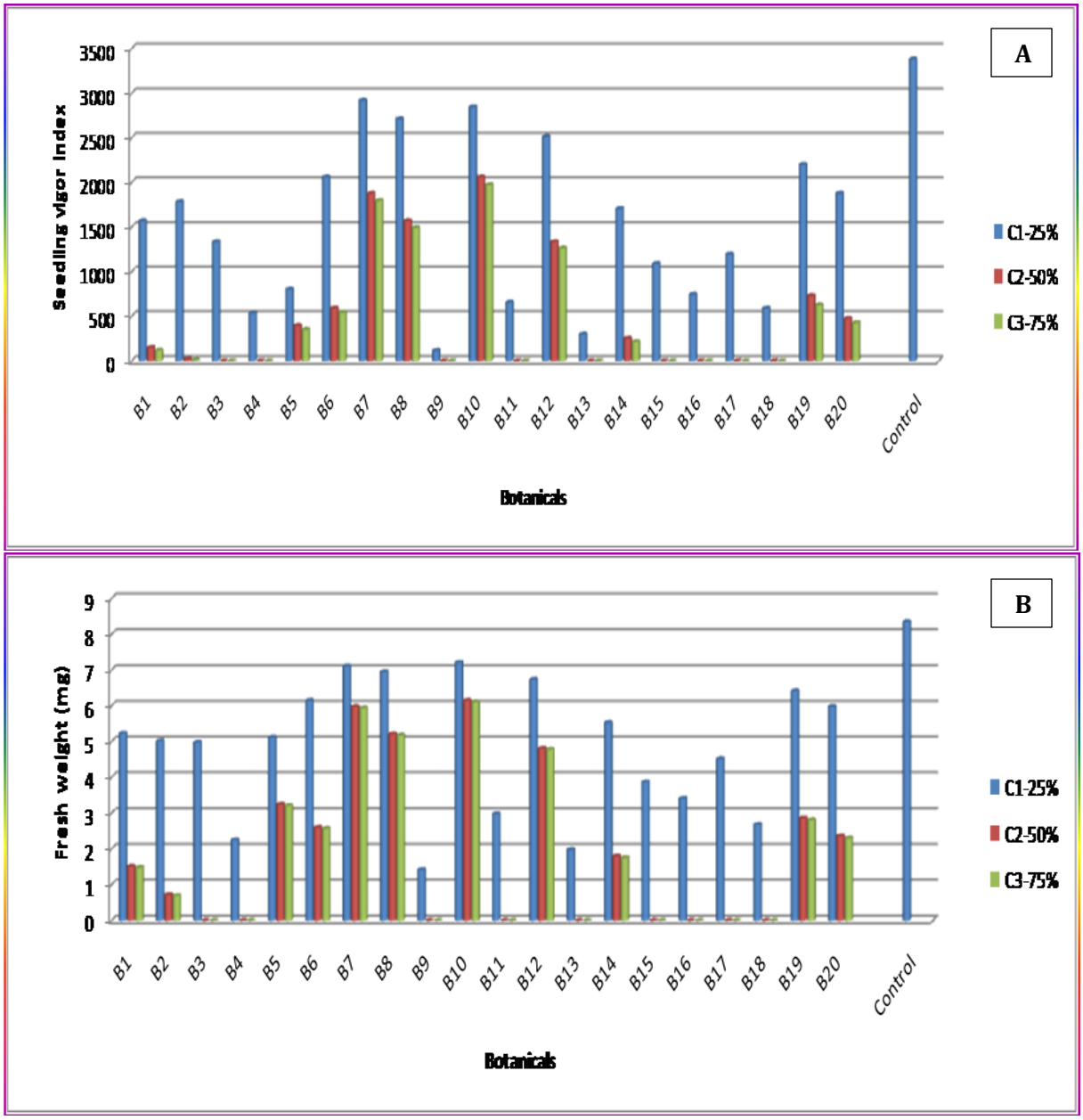

Figure 2- Efficacy of botanicals on seedling vigor index (A) and fresh weight (B) of *Parthenium hysterophorus* L .

In laboratory petri plate bioassay studies, the per cent germination of *P.hysterophorus* seeds was reduced significantly due to application of botanical extract viz., *Datura metel, Mangifera indica, Azadirachta indica, Tagetes erectus, Helianthus annuus* and *Sorghum bicolor* both at 50 and 75 % concentration. Increased concentration (50 and 75 %) pronounced more detrimental effects on per cent germination of *P.hysterophorus*. All the botanicals extracts exhibited a negative impact on germination percent over control. Higher reduction in seedling length and seedling vigor index were also noticed in *P.hysterophorus* with 50 and 75 % concentrations of botanical extract in the

order of *Datura metel> Mangifera indica> Azadirachta indica> Tagetes erectus> Helianthus annuus* > *Sorghum bicolor* as compared to other botanicals. Similarly reduction in growth of parthenium seedlings was observed through seedling biomass due to higher concentration (50 and 75%) of botanical extracts. Among twenty botanicals, the higher inhibition of growth was observed in the order of *Datura metel> Mangifera indica> Azadirachta indica> Tagetes erectus> Helianthus annuus* > *Sorghum bicolor*.

Conclusion

The present study reveals that the Higher reduction in seedling length and seedling vigor index were also noticed in *P.hysterophorus* with 50 and 75 % concentrations of botanical extract in the order of *Datura metel> Mangifera indica> Azadirachta indica> Tagetes erectus> Helianthus annuus* > *Sorghum bicolor* as compared to other botanicals. This needs further studies, to test the efficacy of these crude extract under field conditions. Furthermore, the allelochemicals present in these extracts responsible for germination and growth reduction should be identified and isolated. There is a possibility of using these allelochemicals directly (or) structural leads for discovery and development of environment-friendly herbicides to control one of the world's worst weed (*P.hysterophorus*). Secondly, the movement of allelochemicals, mode of action, selectivity etc. should be broadly studied. Finally, the impact of the use of allelochemicals from the agronomic and environmental point of view needs special attention.

Conflict of interest

Authors declare no conflict of interest.

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