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The Pharma Innovation

ISSN (E): 2277- 7695
ISSN (P): 2349-8242
NAAS Rating: 5.03
TPI 2019; 8(7): 257-261

www.thepharmajournal.com
Received: 07-05-2019
Accepted: 09-06-2019

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Allelopathic effect of *Parthenium hysterophorus* L. on germination and seedling growth of different field crops

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Abstract
Laboratory experiment was conducted during 2019 at Anbil Dharmalingam Agricultural College and Research Institute, Thiruchirappalli to evaluate the allelopathic effect of *Parthenium hysterophrous* on germination and seedling growth of different field crops. Laboratory experiment was carried out in completely randomized design (CRD) with four replications and six treatments *viz.*, control, 5, 10, 15, 20 and 25 % of *P. hysterophorus* whole plant extract. The results revealed that there was negative correlation observed between concentration of *P. hysterophorus* whole plant extract and germination percentage, seed length, root length, seedling length and seedling vigour index in all treatments. Increasing concentration of *P. hysterophorus* whole plant extract significantly inhibited the germination, shoot length, root length, seedling length and SVI of all tested crops. The highest seedling mortality percentage of various crops *viz.*, sweet corn, groundnut, gingelly, cowpea and rice were registered at 25 % *P. hysterophorus* whole plant extract.

Keywords: Allelopathy, *Parthenium hysterophorus*, seedling length, SVI, seedling mortality

1. Introduction
Allelopathy plays an important role in agricultural ecosystems and in a large scale, in the plant 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) [14]. Invasive alien species are such species whose introduction or spread threatens the environment, economy or society including human health.

Parthenium hysterophorus is an aggressive, noxious and exotic weed. It is commonly known as altamisa, carrot grass, bitter weed, star weed, white top, wild feverfew, the ‘‘Scourge of India’’ and congress grass. *Parthenium hysterophorus* is a prolific weed belonging to Asteraceae family, producing thousands of small white capitula each yielding five seeds on reaching maturity. Within the past century it has found its way to Africa, Australia, Asia and Pacific Islands and has now become one of the world’s seven most devastating and hazardous weeds. This noxious weed is often spotted on abandoned lands, developing residential colonies around the towns, railway tracks, roads, drainage and irrigation canals, etc., This weed grows luxuriantly in established gardens, plantations and vegetable crops. Due to its high fecundity a single plant can produce 10,000 to 15,000 viable seeds and these seeds can disperse and germinate to cover large areas. This alien weed is believed to have been introduced into India as contaminants in PL 480 wheat (Public Law 480 passed in 1954 to give food grains to developing countries for eliminating starvation and malnutrition) imported from the USA in the 1950s.

During the 1980’s, *Parthenium hysterophorus* was considered as a weed of rainfed fallow and a waste land, but now it has become a weed of every crop and also into the forest lands. Khosla and Sobti (1979) [6] stated that it is reported to cause yield loss upto 40 per cent in several crops and reduction in forage production upto 90 per cent. Infestation by *P. hysterophorus* 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. The chemical analysis of parthenium contains coronopilin, tetraneurin A, 2β-hydroxycoronopilin, hysterones A-D, parthenin and acetylated pseudoguaianolides.

These allelochemicals significantly decrease the seed germination and subsequent growth in many crops (Batish *et al*., 2005) [2], by affecting carbohydrate, protein metabolism, physiological changes such as cellular membrane damage, chromosomal aberrations, chlorophyll loss in leaves and loss of dehydrogenase activity in roots of green gram (Rajendiran, 2005) [11].

Parthenium hysterophorus 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. According to Evans (1997) [4], the invasive ability and allelopathic properties of *P. hysterophorus* posses a great risk to disrupt ecosystem.

Hence, the present investigation was carried out with the objective of evaluating the allelopathic effect of *Parthenium hysterophorus* on the germination and seedling growth of various field crops *viz.,* rice (*Oryza sativa*), sweet corn (*Zea mays* L. var. saccharata), cowpea (*Vigna ungiculata* L.), gingelly (*Sesamum indicum) and* groundnut (*Arachis hypogea* L.)

Materials and Methods

I. Preparation of *Parthenium hysterophorus* allelopathic extract

The *Parthenium hysterophorus* whole plant samples were taken and dried at room temperature and it was dried in hot air oven at about 70ºC for 48 hrs. The dried samples were chopped into pieces of 1cm size and grinded. The powder was immersed in distilled water to get different concentration 5, 10, 15, 20 and 25 % of *Parthenium hysterophorus.* The concentrations of 5, 10, 15, 20 and 25 % were prepared by soaking 5, 10, 15, 20 and 25 g powdered samples in 100 ml distilled water for a day. These aqueous leachates were filtered separately using Whattman No. 1 filter paper and centrifuged at 12000 rpm for 5 minutes. The different concentrations of *Parthenium hysterophorus* whole plant extracts of 5%, 10%, 15%, 20% and 25% were prepared and stored in dark cool place for use. The extract was generally used within a week.

II. Treatments and Experimental Design

Laboratory experiment was conducted in Completely Randomized Design (CRD) with four replications. The experiment comprised of six treatments *viz.,* control, 5, 10, 15, 20 and 25 % of *P. hysterophorus* whole plant extract. The different field crops *viz.,* rice, sweet corn, cowpea, gingelly and groundnut were taken under this experiment. Before sowing, the seeds were surface sterilized with 0.1% mercuric chloride for 1 min and then washed in distilled water 3 times for 1 minute each. The petri dishes were wiped with ethanol and then whatman No.10 filter paper was placed. Ten seeds of each crop *viz.,* rice, sweet corn, cowpea, gingelly and groundnut were placed on whatman No. 10 filter paper. Extracts of *Parthenium hysterophorus* were added to the petri dishes according to the nature of treatments along 5, 10, 15, 20 and 25 %. A separate series of control was set up using distilled water. The petri dishes are kept at room temperature in the lab condition.

Treatment Details

T_1 - Control
T_2 - 5% *Parthenium hysterophorus* whole plant extract
T_3 - 10% *Parthenium hysterophorus* whole plant extract
T_4 - 15% *Parthenium hysterophorus* whole plant extract
T_5 - 20% *P. hysterophorus* whole plant extract
T_6 - 25% *Parthenium hysterophorus* whole plant extract

III. Observations recorded

Germination percentage

Germination count was recorded at 10 days after sowing (DAS). The germination percentage was calculated by using formula

Germination percentage = No. of seeds germinate / Total seeds X 100

Growth parameters

The growth parameters such as shoot length and root length were recorded at 10 DAS using a meter scale and expresses as cm. The seedling length was calculated by using formula

Seedling length (cm) = Root length (cm) + Shoot length (cm)

Seedling Vigour Index (SVI)

Seedling vigour index was calculated according to the equation of Abdul-baki and Anderson (1973) [1].

SVI = Germination percentage x Radical length (cm)

Seedling mortality

The seedling mortality was calculated by using formula

$$\text{Seedling mortality} = \frac{\text{No. of seedling emerged} - \text{No. of seedling survived}}{\text{No. of seedling emerged}} \times 100$$

Results and Discussion

Germination percentage

Parthenium hysterophorus whole plant extract significantly affected the germination of rice, sweet corn, cowpea, gingelly and groundnut as compared to control (Fig.1). The treatment of different field crops with 25% *Parthenium hysterophorus* whole plant extract registered minimum germination percentage (47.2, 42.2, 32.5, 30.6 and 41.2 % in rice, sweet corn, cowpea, gingelly and groundnut, respectively). The highest germination percentage (90.1, 100, 100, 80.5 and 90.2 % in rice, sweet corn, cowpea, gingelly and groundnut, respectively) was recorded in control. However, there was decreasing germination percentage with the increasing concentration of *Parthenium hysterophorus* whole plant extract. This might be due to phenols, alkaloids and allelochemicals present in parthenium. This finding agreed with that of Pandey (1997) [9]. 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 metabolic activity. The seeds imbibed with different aqueous leaf extracts delayed and inhibited the germination in comparison to control. The inhibitory effect in different concentration of leaf extracts on seed germination might also be due to imbalance in metabolism regulated by various enzyme activities (Oyun, 2006) [8]. Further reduction in germination percentage might be also due to herbicidal activity of flavonoids compounds (Javaid *et al*., 2010 and Sorecha and Birhanu, 2017) [5, 12].

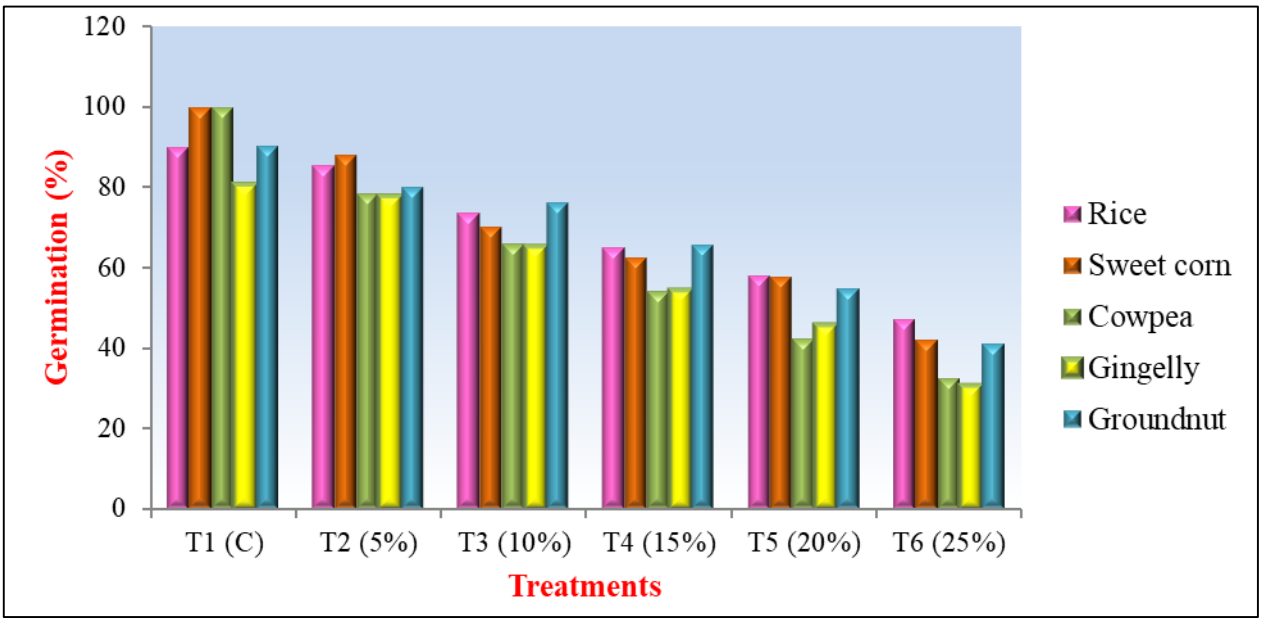

Fig 1: Allelopathic effect of *Parthenium hysterophorous* on germination percentage of different field crops

Shoot length

The shoot length of rice, sweet corn, cowpea, gingelly and groundnut were significantly influenced by the whole plant extract of *Parthenium hysterophorus* (Table 1). The highest shoot length was recorded in control. The treatment of different test crops with 25% *Parthenium hysterophorus* whole plant extract registered minimum shoot length (2.50, 4.28, 6.25, 2.32 and 3.25 in rice, sweet corn, cowpea, gingelly and groundnut, respectively). However, there was decreasing shoot length with the increasing concentration of *Parthenium hysterophorus* whole plant extract. The reduction in shoot length was due to the presence of allelochemical (Parthenin) in leaf extract. This parthenin content present in aqueous extract leads to the inhibition of shoot elongation resulted in reduced shoot length. This is in conformity with the findings of Maharjan *et al.* (2007) [7] and Wakjira (2009) [17].

Table 1: Allelopathic effect of *Parthenium hysterophorous* on shoot length (cm) of different field crops

Treatments	Rice	Sweet corn	Cowpea	Gingelly	Groundnut
T_1 – Control	5.10	9.11	9.02	5.22	5.02
T_2 - 5% *P. hysterophorous* Whole plant extract	4.80	8.50	8.50	4.45	4.50
T_3 - 10% *P. hysterophorous* Whole plant extract	4.21	7.75	8.32	4.34	4.32
T_4 - 15% *P. hysterophorous* Whole plant extract	3.15	6.25	7.22	3.27	4.19
T_5 - 20% *P. hysterophorous* Whole plant extract	2.75	5.42	6.50	3.16	3.52
T_6 - 25% *P. hysterophorous* Whole plant extract	2.50	4.28	6.25	2.32	3.25
SEd	0.12	0.19	0.24	0.13	0.14
CD (P=0.05)	0.23	0.39	0.48	0.26	0.27

Root length

Different concentrations of *Parthenium hysterophorus* had significant effect on root length of rice, sweet corn, cowpea, gingelly and groundnut (Table 2). The highest root length (5.12, 11.44, 6.05, 5.55 and 7.02 in rice, sweet corn, cowpea, gingelly and groundnut, respectively) was recorded in control. The treatment with 25% *Parthenium hysterophorus* whole plant extract registered minimum root length of different field crops (3.20, 7.85, 3.20, 2.30 and 4.62 in rice, sweet corn, cowpea, gingelly and groundnut, respectively). However, there was decreasing root length with the increasing concentration of *Parthenium hysterophorus* whole plant extract. The strong inhibitory effects of *Parthenium hysterophorus* on root elongation might be due to direct contact of root than the shoot with the extract and subsequently with inhibitory chemicals. This is in agreement with the findingd of Srivastava *et al.* (2010) [16] and Parthasarathi *et al.* (2012) [10].

Table 2: Allelopathic effect of *Parthenium hysterophorous* on root length (cm) of different field crops

Treatments	Rice	Sweet corn	Cowpea	Gingelly	Groundnut
T_1 – Control	5.12	11.44	6.05	5.55	7.02
T_2 - 5% *P. hysterophorous* Whole plant extract	4.48	10.55	5.50	5.02	6.81
T_3 - 10% *P. hysterophorous* Whole plant extract	4.65	9.72	5.32	4.75	6.50
T_4 - 15% *P. hysterophorous* Whole plant extract	4.32	9.41	4.10	4.46	5.22
T_5 - 20% *P. hysterophorous* Whole plant extract	3.01	8.10	3.75	3.52	4.98
T_6 - 25% *P. hysterophorous* Whole plant extract	3.20	7.85	3.20	2.30	4.62
SEd	0.13	0.27	0.14	0.14	0.20
CD (P=0.05)	0.25	0.54	0.27	0.28	0.40

Seedling length

The seedling lengths of rice, sweet corn, cowpea, gingelly and groundnut are significantly influenced by the whole plant extract of *Parthenium hysterophorus* (Table 3). The highest seedling length (10.22, 20.55, 15.07, 10.77 and 12.04 in rice, sweet corn, cowpea, gingelly and groundnut, respectively) was recorded in control. The treatment with 25% *Parthenium hysterophorus* whole plant extract registered minimum seedling length of different field crops (5.70, 12.13, 9.45, 4.62 and 7.87 in rice, sweet corn, cowpea, gingelly and groundnut, respectively). However, there was decreasing seedling length with the increasing concentration of *Parthenium hysterophorus* whole plant extract. These results are in agreement with the findings of Devi *et al.* (2014) [3] who found that aqueous leaf extracts of *Parthenium hysterophorus* had inhibitory effect on plumule and radical length in *Zea mays.*

Table 3: Allelopathic effect of *Parthenium hysterophorous* on seedling length (cm) of different field crops

Treatments	Rice	Sweet corn	Cowpea	Gingelly	Groundnut
T_1 – Control	10.22	20.55	15.07	10.77	12.04
T_2 - 5% *P. hysterophorous* Whole plant extract	9.28	19.05	14.00	9.47	11.31
T_3 - 10% *P. hysterophorous* Whole plant extract	8.86	17.47	13.64	9.09	10.82
T_4 - 15% *P. hysterophorous* Whole plant extract	7.47	15.66	11.32	7.73	9.41
T_5 - 20% *P. hysterophorous* Whole plant extract	5.76	13.52	10.25	6.68	8.50
T_6 - 25% *P. hysterophorous* Whole plant extract	5.70	12.13	9.45	4.62	7.87
SEd	0.25	0.48	0.37	0.27	0.32
CD (P=0.05)	0.51	0.95	0.74	0.55	0.65

Sedling Vigour Index (SVI)

The seedling vigour index (SVI) of rice, sweet corn, cowpea, gingelly and groundnut were significantly influenced by the whole plant extract of *Parthenium hysterophorus* (Fig.2). The highest SVI (461.3, 1144.0, 605.0, 446.8 and 633.2 in rice, sweet corn, cowpea, gingelly and groundnut, respectively) was recorded in control. The treatment with 25% *Parthenium hysterophorus* whole plant extracts registered drastic decrease in SVI (151.0, 331.3, 104.0, 70.4 and 190.3 in rice, sweet corn, cowpea, gingelly and groundnut, respectively). However, there was decreasing SVI with the increasing concentration of *Parthenium hysterophorus* whole plant extract. These results are in agreement with the findings of Safdar *et al.* (2014) [13] who found that aqueous extracts of root, stem, leaf, fruit and whole plant parts of *Parthenium hysterophorus* and its rhizospheric soils showed inhibitory effects on germination, seedling growth and seedling vigour index of maize.

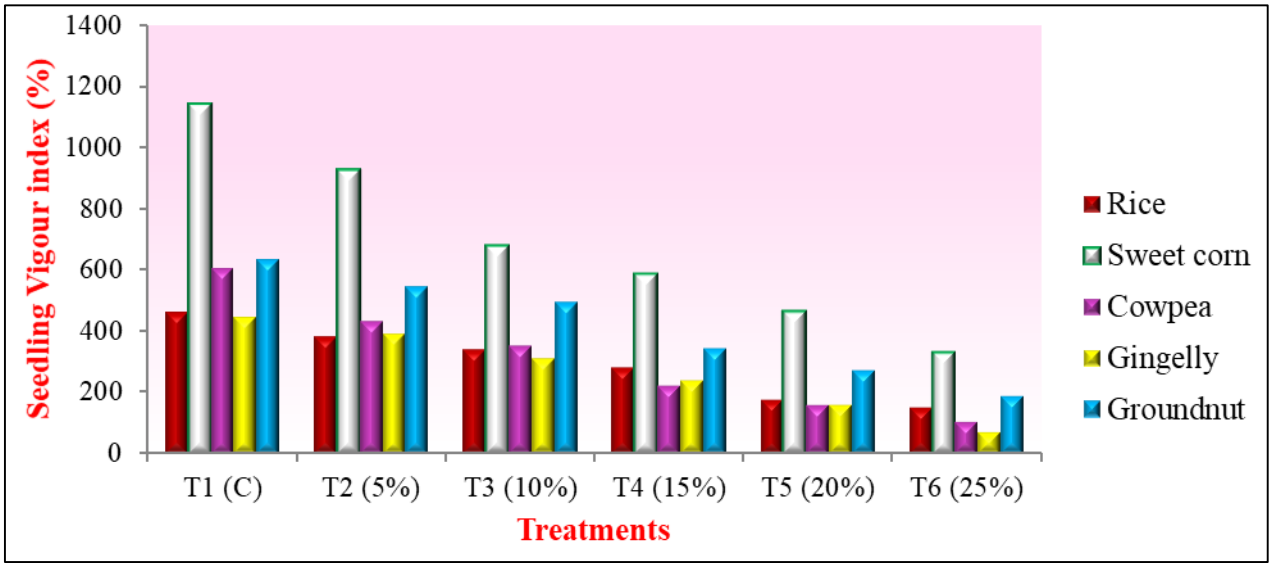

Fig 2: Allelopathic effect of *Parthenium hysterophorous* on SVI of different field crops

Seedling mortality

The seedling mortality of all test crops was significantly influenced by the whole plant extract of *Parthenium hysterophorus* (Fig.3). The treatment of all test crops with 25% *Parthenium hysterophorus* whole plant extract registered higher seedling mortality percentage (72.9, 81.5, 75.6, 76.3 and 78.3 in rice, sweet corn, cowpea, gingelly and groundnut, respectively). The lowest seedling mortality percentage (10.2, 0.0, 0.0, 20.9 and 10.5 in rice, sweet corn, cowpea, gingelly and groundnut, respectively) was recorded in control. However, there was increasing seedling mortality percentage with the increasing concentration of *Parthenium hysterophorus* whole plant extract. This might be due to the greater number of growth inhibitors detected in the *Parthenium* whole plant extract explains the stronger inhibitory activity. These results are in accordance with the findings of Rashid *et al.* (2008) [12].

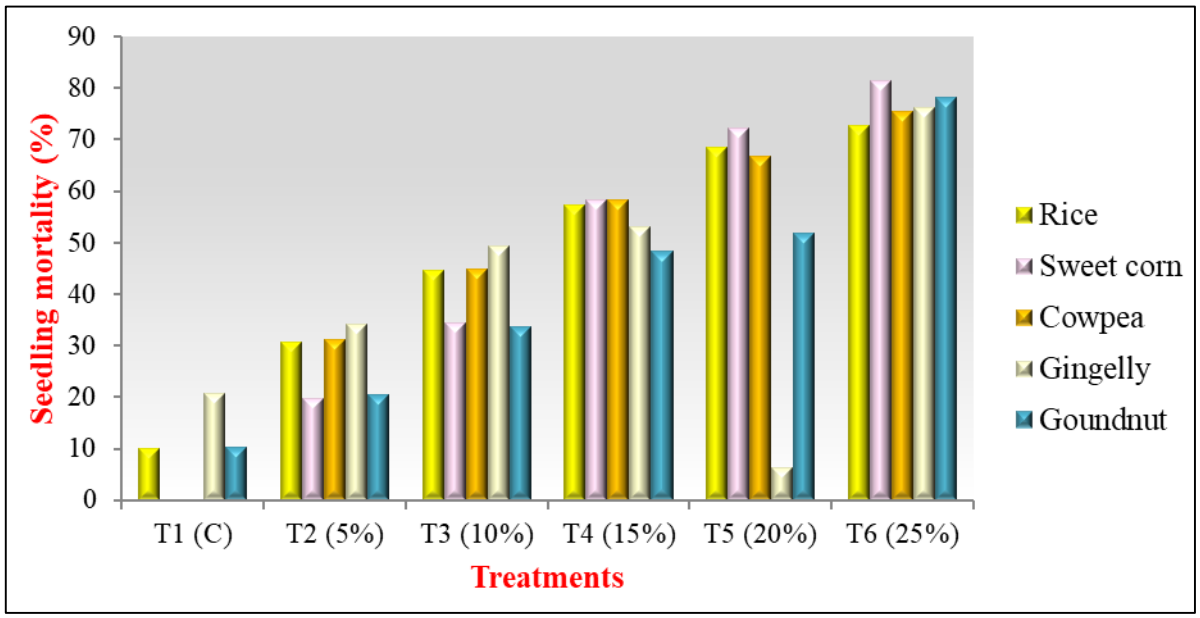

Fig 3: Allelopathic effect of *Parthenium hysterophorous* on seedling mortality (%) of different field crops

Conclusion

Based on the experimental results, it could be concluded that the whole plant extract of *Parthenium hysterophorus* suppressed the germination and seedling growth of field crops viz., rice, sweet corn, cowpea, gingelly and groundnut.

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