*Indian Journal of Weed Science* **52**(4): 400–404, 2020

Print ISSN 0253-8040 Online ISSN 0974-8164

# Allelopathic effect of *Lantana* and *Parthenium* on germination and growth of *Thespesia* tree species

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**Article information**

**DOI:** 10.5958/0974-8164.2020.00079.9

**Type of article:** Research note

**Received** : 1 March 2020
**Revised** : 11 December 2020
**Accepted** : 13 December 2020

**Key words**
Allelopathy

Germination and growth

*Lantana camara*

*Parthenium hysterophorus*

Thespesia populnea

**ABSTRACT**

A pot culture experiment was conducted in the nursery of Department of Silviculture, Forest College and Research Institute, Tamil Nadu Agricultural University, Mettupalayam, Tamil Nadu during summer season (February - April) 2016, to study the allelopathic effect of *Lantana camara* (L.) and *Parthenium hysterophorus* (L.) on germination and growth of *Thespesia populnea* (L.) tree species under greenhouse condition. Aqueous extracts of *L. camara* and *P. hysterophorus* at four concentration levels *viz*. 10, 20, 30 and 40% with absolute control (distilled water) were assigned as experimental treatments under completely randomized design and replicated thrice. Application of whole plant aqueous extract of *P. hysterophorus* and *L. camara* at 40% concentration recorded lower seed germination of 26.7% and 36.7% and germination value of 3.0 and 5.2 respectively than application of aqueous extracts of the weeds at 30, 20 and 10% concentration levels. Application of *P. hysterophorus* weed extract at 40% concentration recorded higher inhibition of shoot growth, root growth, total length and dry matter production of *T. populnea* seedlings than its application at lower concentrations and over *L. camara* weed extract at all concentrations.

Allelopathy is a phenomenon of involving either direct or indirect and either beneficial or adverse effects of a plant (including microorganisms) on another plant through the release of chemicals in the environment. Many weeds, specifically invasive weeds pose an important biological constraint to crop and tree productivity in agricultural and natural forest ecosystems (Devi and Dutta 2012). Invasion of native plant communities by exotic species has been among the most intractable ecological problems of recent years. It is a global scale problem experienced by the natural ecosystems especially forest ecosystems and is considered as the second largest threat to the global biodiversity (Ashok Kumar *et al.* 2012). The invasion of exotic species affects the native flora and reduces the regeneration ability and diversity of native species in forest ecosystems through their allelopathy and competitive interference.

*Lantana camara* and *Parthenium hysterophorus* are the America originated weeds and have spread to the other regions of world including India, threatens ecological biodiversity in forest ecosystems by their huge proliferation in any place at any time thus it exerts negative effects on agriculture, animal husbandry, ecology and environment in natural and managed ecosystems (Ahmed *et al.* 2007). These weeds possess the ability to suppress other plants through the release of allelochemicals from living plants or decomposing plant materials into the environment, which allows these weeds to compete more effectively with crop or tree or pasture species. Though, several researchers have worked on the invasion and allelopathic effects of *L. camara* and *P. hysterophorus* on various agricultural crops throughout the world, but such scientific experiments are scarce in the context of tree crops in India. With this background, the present investigation was undertaken to study the allelopathic effect of *L. camara* and *P. hysterophorus* weeds on germination and growth behaviour of *Thespesia populnea* tree species.

A pot culture experiment was conducted during summer season (February - April 2016), under greenhouse in the Nursery of Department of Silviculture, Forest College and Research Institute, Tamil Nadu Agricultural University, Mettupalayam, located at 11°20' North latitude and 76°56' East longitude with an altitude of about 320 m above mean sea level. Weed species namely *L. camara* and *P. hysterophorus* were selected to study their allelopathic potential on *T. populnea*. The collected weeds were cut into 5-10 cm pieces for preparation of aqueous extract. The extract of 100% concentration was prepared by soaking 1000 g chopped plant material in 1000 ml distilled water (1:1 weight/volume basis) at room temperature (22-26°C) for 72 hours and ground with mixer grinder. The extract was filtered through muslin cloth and the volume of the filtrate was made to 1000 ml with distilled water. The extract was considered as stock solution and a series of solution with different concentration, *viz*. 10, 20, 30 and 40% aqueous extract were prepared by dilution and stored for pot culture experiment.

Pot culture soil media was prepared with soil, sand and farmyard manure in the ratio of 2:1:1 and was filled in pot for sowing of *T. populnea* tree seeds 10 Nos. per poly bag. To obtain uniform germination under normal condition, the seeds were pre-treated with cold water for 24 hours and dried in shade for half an hour and used for sowing. The trial was laid out in completely randomized design (CRD) with the 9 treatments given in **Table 1** and replicated thrice. A 250 ml aqueous extract was applied immediately after sowing in each treatment. Thereafter, equal quantity (100 ml) of aqueous extract was added to the respective treatment on daily basis to keep the pot mixture soil moist enough to get favourable condition for seed germination and seedlings growth. The control treatment was maintained with distilled water. The pot culture experiment was maintained up to 60 days under greenhouse condition.

Data on germinated seeds were counted and recorded on daily basis from 4$^{th}$ to 20$^{th}$ days after sowing in all the treatments. The germination per cent was calculated by using the formula proposed by Jacob *et al*. (2011) and expressed in percentage. Seeds were considered as germinated when the radicle emerged. The observation on germination inhibition percentage was estimated by the formula suggested by Wakjira *et al.* (2009).

$$G_T = \frac{(N_C - N_T)}{N_C} X100$$

Where, $G_T$ - Germination inhibition %, $N_C$ - Number of germinated seeds in control at the end of 10$^{th}$ day and $N_T$ - Number of germinated seeds in treatment at the end of 20$^{th}$ day. Germination value (GV) can be calculated from the following formula (Prasad and Kandya 1992).

$$GV = \frac{DGS}{N} \times \frac{GP}{100}$$

Where, GV - Germination value, DGS - Daily germination speed, obtained by dividing the cumulative germination % by the number of days since sowing, GP - Germination % at the end of the 20$^{th}$ days after sowing and N - Number of daily counts, starting from the date of first germination. With respect to biometric observation, *viz*. seedlings shoot length, root length and total length was measured (cm) following the International Seed Testing Association (ISTA) rules (Anonymous 1999) at 30, 45 and 60 days after sowing. Seedlings sampled for measurement of shoot length, root length and total length were partitioned in to the respective plant parts and oven dried at 70°C for 24 hours to a constant weight and dry matter of each part was weighed separately using sensitive electronic balance and expressed in mg/plant. Seedling vigour index I, based on total seedling length was estimated by the methodology of Bhattacharya *et al.* (1991)

Vigour Index I = Germination (%) x Total seedling length (cm)

Vigour index II, based on seedling dry weight was measured by the methodology proposed by Abdul Baki and Anderson (1973)

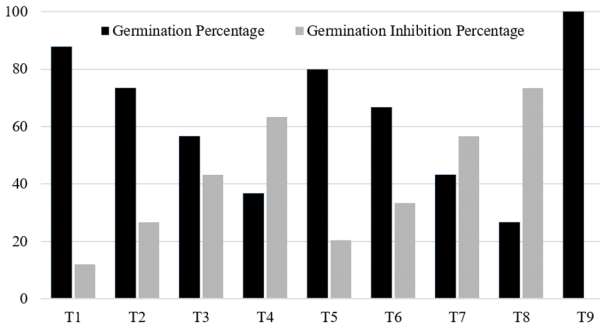
Vigour Index II = Germination (%) x Seedling dry weight (mg/plant)

Significance of the difference in germination percentage, germination inhibition, germination value, germination index, seedling growth, seedling biomass production, and chlorophyll content of seedlings under different treatments were tested and compared using Analysis of Variance (ANOVA) and homogeneity test as suggested by Gomez and Gomez (1984). Wherever the treatments difference was found significant, the critical differences were worked out at 5% probability and values were furnished.

**Total germination, germination inhibition and germination value**

Seed germination is the best indicator of seed viability under biotic or abiotic stressed condition. The result of allelopathic effect of *L. camara* and *P. hysterophorus* weeds at different concentration on total germination and germination inhibition percentage of *T. populnea* is depicted in **Figure 1** and

germination value presented in **Table 1**. Germination percentage, germination value and germination inhibition percentage varied from 26.7 to 100%, 3.0 to 29.3 and 0 to 73.3%, respectively. With the increase of aqueous extract concentration levels, the germination percentage and germination values progressively decreased, whereas germination inhibition percentage linearly increased. Among the two weed species and four concentration levels studied, application of aqueous extract of *L. camara* at 10% concentration recorded the maximum seed germination (87.9%), germination value (25.6) and minimum germination inhibition (12.1%) followed by aqueous extract of *P. hysterophorus* at 10%. This was significantly higher than the application of aqueous extract of *L. camara* and *P. hysterophorus* weeds at 20, 30 and 40% concentration levels. Whereas, the lowest seed germination (26.7%) and germination value (3.0) and the highest germination inhibition of 73.3% was recorded in application of 40% aqueous extract of *P. hysterophorus* followed by 40% aqueous extract of *L. camara*. Similar research findings were reported in an experiment conducted in *Eragrostis tef*




$T_1$- *L. camara* extract 10%; $T_2$- *L. camara* extract 20%; $T_3$- *L. camara* extract 30%; $T_4$- *L. camara* extract 40%; $T_5$- *P. hysterophorus* extract 10%; $T_6$- *P. hysterophorus* extract 20%; $T_7$- *P. hysterophorus* extract 30%; $T_8$- *P. hysterophorus* extract 40%; $T_9$- Control/distilled water

**Figure 1. Effect of *L. camara* and *P. hysterophorus* aqueous extracts on total germination percentage of *T. populnea***

(Tefera 2002), cultivated and wild herbaceous species (Maharajan *et al*. 2007), sunflower (Kumar and Gautam 2008) and wheat (Gella *et al*. 2013). The higher inhibitory effect of *Parthenium* is due to presence of large amount of allelochemicals, which inhibit the process of seed germination and relevant parameters of many plants in nurseries and plantations.

**Shoot length, root length and total length**

The results of allelopathic effect of *L. camara* and *P. hysterophorus* and distilled water on shoot length, root length and total length of *T. populnea* varied from 6.8 to 23.5 cm, 9.6 to 29.6 cm and 12.6 to 36.4 cm, 4.7 to 12.5 cm, 6.6 to 16.8 cm and 9.2 to 21.6 cm, 11.6 to 36.0 cm, 16.2 to 46.4 cm and 21.8 to 58.0 cm at 30, 45 and 60 DAS, respectively (**Table 1**). Irrespective of the stages of observation, the lowest shoot length of 6.8, 9.6 and 12.6 cm, root length of 4.7, 6.6 and 9.2 cm, and total length 11.6, 16.2 and 21.8 cm was recorded in application of 40% aqueous extract of *P. hysterophorus* at 30, 45 and 60 DAS, respectively followed by application of 40% aqueous extract of *L. camara*. This was significantly lower than application of aqueous extract of *L. camara* and *P. hysterophorus* weeds at 30, 20 and 10% concentration levels. The highest inhibiting effect on shoot length, root length and total length with application of 40% aqueous extract of *P. hysterophorus* could be attributed mainly due to the release of different kinds of phytotoxic compounds, *viz*. phenolics, sesquiterpenes and lactones from root and vegetative part of the weed and its accumulation in shoot and root meristem of the plants (Gella *et al.* 2013). These chemicals are capable of suppressing the growth of receptor crops and can have multiple phytotoxic effects *viz*. reduction in plant hormone synthesis, inhibition on nutrient and ion absorption. Earlier works have also reported that aqueous leachates of *P. hysterophorus* reduced the shoot and root elongation of *Oryza sativa* and *Triticum aestivum*

**Table 1. Germination value, shoot length, root length, total length of *T. populnea* as affected by concentration of aqueous extracts of *L. camara* and *P. hysterophorus***

| Treatment | Germination value | Shoot length (cm) | | | Root length (cm) | | | Total length (cm) | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | 30 DAS | 45 DAS | 60 DAS | 30 DAS | 45 DAS | 60 DAS | 30 DAS | 45 DAS | 60 DAS |
| *L. camara* extract 10% | 25.6 | 20.4 | 11.3 | 31.7 | 15.2 | 25.2 | 40.4 | 30.7 | 19.5 | 50.2 |
| *L. camara* extract 20% | 19.0 | 17.6 | 9.9 | 27.5 | 21.8 | 13.3 | 35.2 | 26.6 | 17.2 | 43.8 |
| *L. camara* extract 30% | 11.8 | 14.7 | 8.0 | 22.7 | 18.5 | 10.9 | 29.4 | 22.8 | 14.3 | 37.1 |
| *L. camara* extract 40% | 5.2 | 10.0 | 6.5 | 17.3 | 12.9 | 8.9 | 21.8 | 16.6 | 11.7 | 28.4 |
| *P. hysterophorus* extract 10% | 22.6 | 16.2 | 9.9 | 26.2 | 20.7 | 13.2 | 33.9 | 25.5 | 17.1 | 42.7 |
| *P. hysterophorus* extract 20% | 16.4 | 12.6 | 8.2 | 20.8 | 16.8 | 11.1 | 27.8 | 21.1 | 14.8 | 35.9 |
| *P. hysterophorus* extract 30% | 7.3 | 10.5 | 6.8 | 16.7 | 13.9 | 9.2 | 23.1 | 17.6 | 12.4 | 30.1 |
| *P. hysterophorus* extract 40% | 3.0 | 6.8 | 4.7 | 11.6 | 9.6 | 6.6 | 16.2 | 12.6 | 9.2 | 21.8 |
| Control/distilled water | 31.3 | 23.5 | 12.5 | 36.0 | 29.6 | 16.8 | 46.4 | 36.4 | 21.6 | 58.0 |
| LSD (p=0.05) | 5.4 | 2.5 | 1.4 | 4.0 | 2.7 | 1.7 | 3.0 | 3.5 | 1.4 | 4.5 |

(Singh and Sangeeta 1991), *Zea mays* (Maharajan *et al*. 2007), *Helianthus annuus* (Kumar and Gautam 2008), *Glycine max* (Netsere and Mendesil 2011), *Brassica* species (Singh *et al*. 2005).

**Dry matter and chlorophyll content**

Among the levels of aqueous extract of *L. camara* and *P. hysterophorus* weeds, the maximum reduction in dry matter production and chlorophyll content was found in 40% concentration of *P. hysterophorus,* which registered the dry matter of 4.9, 8.6 and 12.6 mg/plant and chlorophyll content of 13.9, 14.4 and 15.7 µmol chlorophyll/$m^2$ of leaf at 30, 45 and 60 DAS respectively (**Table 2**). At all the stages of observation, dry weight and chlorophyll content of *T. populnea* in control (distilled water) treatment was significantly higher than application of various concentration of aqueous extract of *L. camara* and *P. hysterophorus* weeds, which registered the dry matter of 12.3, 17.9 and 24.2 mg/plant and chlorophyll content of 32.6, 36.8 and 43.4 µmol chlorophyll/m of leaf at 30, 45 and 60 DAS respectively followed by application of aqueous extract of *L. camara* at 10 and 20% concentration level. The survived *T. populnea* seedlings exhibited varying degree of necrosis and chlorosis in their leaves, stunted growth and development and many seedlings lost their ability to develop normally as a result of reduced plume elongation, radicle elongation, shoot necrosis and root necrosis. Changes in leaf chlorophyll content provide an indicator of maximum photosynthetic capacity, leaf developmental stage, productivity and stress. In stressed vegetation, leaf chlorophyll content decrease, thereby changing the proportion of light absorbing pigments and leading to less overall absorption (Zarco-Tejada *et al*. 2000). Allelochemicals may reduce chlorophyll accumulation in three ways, *viz*. the inhibition of chlorophyll synthesis, the stimulation of chlorophyll degradation, and both (Djurdjevic *et al*. 2008).

**Vigour index I and II**

Vigour index of the *T. populnea* seedlings was significantly influenced by the application of aqueous extract of *L. camara* and *P. hysterophorus*. The results of allelopathic effect on vigour index I and II are varied from 308 to 3600, 433 to 4640, and 582 to 5800 and 131 to 1230, 230 to 1790 and 336 to 2420 at 30, 45 and 60 DAS respectively **(Figure 2)**. Based on seed germination percentage and seedling total length, the highest vigour index of 3600, 4640 and 5800 was observed in distilled water at 30, 45 and 60 DAS respectively. Similarly, based on seed germination percentage and dry weight, the highest vigour index of 1230, 1790 and 2420 was also recorded in distilled water at 30, 45 and 60 DAS respectively. This was significantly higher than application of whole plant aqueous extract of *L. camara* and *P. hysterophorus* weeds at all the concentration levels. The maximum inhibitory effect on growth potential of *T. populnea* was observed in application of 40% aqueous extract of *P. hysterophorus*, which recorded vigour index I of 308, 433 and 582 and vigour index II of 131, 230 and 336 at 30, 45 and 60 DAS, respectively followed by 40% aqueous extract of *L. camara*. Reduction in seedling growth, dry matter production and subsequently in vigour index, might be due to the results of the presence of allelochemicals in the aqueous extracts of weeds that were able to inhibit the synthesis of growth hormones which in turn prevented cell division and cell differentiation to promote the shoot and root length and dry matter production (Bhadoria 2011, Kanchan and Jayachandra

**Table 2. Effect of *L. camara* and *P. hysterophorus* weeds aqueous extracts concentration on dry matter and chlorophyll content of *T. populnea***

| Treatment | Dry matter (mg/plant) | | | Chlorophyll content (µmol chlorophyll/$m^2$ of leaf) | | |
|---|---|---|---|---|---|---|
| | 30 DAS | 45 DAS | 30 DAS | 45 DAS | 30 DAS | 45 DAS |
| *L. camara* extract 10% | 11.2 | 16.4 | 22.3 | 30.4 | 33.9 | 39.8 |
| *L. camara* extract 20% | 9.9 | 14.5 | 20.1 | 27.7 | 30.3 | 35.2 |
| *L. camara* extract 30% | 8.4 | 12.6 | 17.8 | 24.2 | 26.0 | 29.3 |
| *L. camara* extract 40% | 6.8 | 10.3 | 15.1 | 19.2 | 19.8 | 21.4 |
| *P. hysterophorus* extract 10% | 10.3 | 15.1 | 20.6 | 29.2 | 32.8 | 38.9 |
| *P. hysterophorus* extract 20% | 8.8 | 13.3 | 18.5 | 25.1 | 28.2 | 33.3 |
| *P. hysterophorus* extract 30% | 7.1 | 11.2 | 15.7 | 20.2 | 22.3 | 25.8 |
| *P. hysterophorus* extract 40% | 4.9 | 8.6 | 12.6 | 13.9 | 14.4 | 15.7 |
| Control/distilled water | 12.3 | 17.9 | 24.2 | 32.6 | 36.8 | 43.4 |
| LSD (p=0.05) | 1.5 | 2.0 | 3.4 | 1.6 | 1.9 | 2.0 |

**Table 3. Allelopathic inhibitory potential of *L. camara* and *P. hysterophorus* weeds aqueous extracts on *T. populnea* vigour index I and II**

| Treatment | Vigour index I | | | Vigour index II | | |
|---|---|---|---|---|---|---|
| | 30 DAS | 45 DAS | 30 DAS | 45 DAS | 30 DAS | 45 DAS |
| *L. camara* extract 10% | 2786 | 3551 | 4413 | 978 | 1418 | 1939 |
| *L. camara* extract 20% | 2016 | 2580 | 3211 | 728 | 1063 | 1473 |
| *L. camara* extract 30% | 1287 | 1667 | 2104 | 474 | 717 | 1003 |
| *L. camara* extract 40% | 635 | 800 | 1042 | 251 | 375 | 547 |
| *P. hysterophorus* extract 10% | 2096 | 2712 | 3416 | 821 | 1205 | 1660 |
| *P. hysterophorus* extract 20% | 1387 | 1854 | 2395 | 588 | 888 | 1245 |
| *P. hysterophorus* extract 30% | 723 | 1000 | 1303 | 309 | 490 | 693 |
| *P. hysterophorus* extract 40% | 308 | 433 | 582 | 131 | 228 | 338 |
| Control/distilled water | 3600 | 4640 | 5800 | 1150 | 1670 | 2260 |
| LSD (p=0.05) | 382 | 476 | 557 | 181 | 243 | 377 |

1980). Different allelochemicals have different sites of action in plant. Thus, the sensitivity to allelochemicals and the extent of growth inhibition varied with species and organs (Maharajan *et al*. 2007).

It was concluded that application of aqueous extract of *P. hysterophorus* at 40% concentration had strong allelopathic inhibitory effect on germination, seedling growth and dry matter production of *T. populnea* than *L. camara*. Allelopathic potential of *P. hysterophorus* may be an important mechanism involved in invasive success of this weed in natural ecosystems.

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