J. Indian bot. Soc. (2022) Vol. 102 (2):140-147
https://doi: 10.5958/2455-7218.2022.00022.5

e-ISSN:2455-7218, ISSN:0019 - 4468
www.indianbotsoc.org

RESEARCH ARTICLE

# Allelopathy as a potential mechanism of *Cassia tora* L. dominance in the Sariska Tiger Reserve, India

**V. P. Gupta[1] and Santosh Sharma[2]**



**Abstract** Allelopathic potential and dominance of the *Cassia tora* weed was evaluated in the forests of Sariska Tiger Reserve in Rajasthan. It is a tropical dry deciduous thorn forest located between $76^0$ 17' E to $76^0$ 34' E and $27^0$ 5' N to $27^0$ 33' N in the north - eastern part of the Rajasthan. *Cassia tora,* has invaded the core area and grows almost in pure stands in this forest. It adversely affects the growth and abundance of several associated herbaceous plant species in field situation. Bioassay experiments have established that leaf leachate and extract of this weed not only delayed and inhibited seed germination, but also caused reduction in radicle and plumule growth of four common herbaceous species viz.,*Setaria verticillata, Corchorus aestuans, Pupalia lappacea and Chrysopogon fulvus.* The extent of inhibition was often correlated with leaf leachate/extract concentration. Study suggested that *Cassia tora* suppresses the growth of associated herbaceous species through the release of allelochemic substances from its decomposing leaves in nature.

**Keywords**: **A**llelopathy, Dominance, Exotic weed, Extract, Leachate

## Introduction

*Cassia tora* L. (Caesalpiniaceae) an annual herb, a native of Tropical America (Duthie, 1929) is one of the common weed growing all over the area along roadsides and in the wastelands of Rajasthan. Preliminary field observations and interaction with concerned forest officials indicated that recently it emerged as a serious weed problem in the core area of the Sariska Tiger Reserve. It grows almost in pure stands at the base of hill slopes posing a serious threat to the indigenous herbaceous vegetation. Observations also indicated that the density and growth of local herbaceous species is suppressed by *Cassia tora,* which may be through competition for resources or by secreting allelochemic substances, which may inhibit the germination and growth of herbs. Any plant species or a group of plant species, which react upon environment so as to control the growth of other species, may be functionally regarded as dominant. Dominance has a significant time dimension (Becking 1969) within which reaction and response occur. The reactions may result from interference in form of resource competition and/or allelopathy. Plants Inter action play a crucial role in natural ecosystems. Upon invasion, weeds compete with other plant species, causing adverse effects on natural vegetation. The invasive nature of weeds may be due to their allelopathic property. Sharma *et al.* (2009) investigated the effect of the extract of several weeds on seed germination of different varieties of wheat. Several reports suggested allelopathy as one of the factors determining the pattern and process of vegetation, and dominance of a given species in a community. (Rai and Tripathi 1982, Nakano, *et al* 2002, Ambika *et al.* 2003, Yu *et al.* 2003, Knox *et al.* 2011). It was suspected that the dominance and vigorous growth of *Cassia tora* may be due to production of certain allelochemics. Hence, in the present study an attempt has been made to evaluate the allelopathic effect of *Cassia tora* on some of the important herbaceous species of the Sariska Tiger Reserve.

✉ V.P. Gupta
gupta_ved7@rediffmail.com

1 Department of Botany, Government post graduate college, Alwar, Rajasthan, India-301001
2 Department of Botany, Govt. P.G. college, Jhalawar, Rajasthan India

Received : 01 November 2021 Accepted : 08 April 2022 Published online : 30 June 2022

## Materials and methods

To understand the allelopathic effects of *Cassia tora* on herbaceous species, both field based and laboratory based approach was adopted. Field observations on the presence, density and basal area of plant species in close vicinity of *Cassia tora* were recorded on the Sariska Tiger Project through quadrat method.10quadrats were laid on the site infested with *Cassia tora* plants and the second set of 10 quadrates on the weed free site. Both the sites were characterized by identical topography and soil type. Within each quadrat, the density and IVI of species encountered were enumerated. For laboratory tests, initially seeds of 10 herbaceous species were collected from the Sariska Tiger Reserve area and subjected to germination tests in the laboratory conditions by applying necessary mechanical and chemical scarification methods. Later, out of these herbaceous species, four species viz. *Setaria verticillata, Chrysopogon fulvus, Pupalia lappacea* and *Corchorus aestuans* are equally palatable and showed good germination in laboratory condition at 32°C thus were selected as the test species to study allelopathic effects of *Cassia tora.* For the purpose, mature and dried leaves of the *Cassia tora* were collected from the Sariska Tiger Reserve area. The aqueous leaf leachates of 1%, 3%, 5% and 10% concentrations were prepared following Rai and Tripathi (1982) by soaking 1, 3, 5 and 10g of mature and dried leaves in 50ml distilled water for 48 hrs. Then the leachates were filtered and the volume was raised to 100ml by adding distilled water. Similarly, the aqueous leaf extract of 1%, 3%, 5% and 10% concentration were prepared by grinding 1,3,5 and 10g of mature and dried leaves with a pestle and mortar. The crushed material was filtered through a muslin cloth and raised to 100ml by adding distilled water.

For bioassay test, fully ripened seeds of all the four test species were soaked in the leachates and leaf extracts of different concentrations for 24 hrs. In each case, sixty treated seeds were kept for seed germination in separate Petri Dish on filter papers (Whatman No. 125mm) underlined by cotton moistened with leaf leachates or leaf extracts of respective concentrations. In each case three replicates were maintained. A corresponding control where the seeds were soaked in distilled water for the same period was also maintained for each of the four species. The seeds were kept for germination in dark at 32°C in a BOD incubator.

Allelopathic effects of leaf leachates and extracts of *Cassia tora* were evaluated on the seed germination and growth of the radicle and plumule elongation of four test plant species. For germination test, the observations of all the treated and control seeds were taken daily over a fifteen days period after soaking. However, in each set of experiment growth of radicle and plumule of ten seeds was measured after five days period.

## Results

Density ($m^{-2}$) Basal area ($mm.m^{-2}$) and IVI of most of herbaceous species were low in plots where *Cassia tora* was intact (Table1). Several herbaceous species such as *Acalypha lanceolata, Boerhavia diffusa, Chloris dolichostachya, Chrysopogon fulvous, Cyperus bulbosus, Corchorus aestuans, Dichanthium annulatum, Digitaria adscendens, Euphoribia hirta, Oplismenus burmannii, Panicum antidoale Paspalidiu flavidum, Phyllanthus simplex, Pupalia lappacea, Setaria verticillata, Sida cordifolia, Sida veronicifolia* and *Sorghum halepense* were totally absent in plots where *Cassia tora* was allowed to grow. However, *Achyranthes aspera, Brachiaria ramosa, Elytraria acaulis, Heteropogon contortus* and *Sida acuta* exhibited low density in plots where *Cassia tora* was intact. The impact of *Cassia tora* seems to be more on the monocotyledonous grass species as compared to the dicotyledonous herbs.

### Effect on seed germination

The leaf leachates of *Cassia tora* inhibited seed germination of all the four tested species. In case of *Pupalia lappacea,* it was reduced from 63% in controlled to 1.3% in 10 percent concentration of leachates (Fig.1). Similar effect of leaf leachates was observed on the seed germination of other three species examined. In *Setaria verticillata* effect was more severe from the 1% concentration onwards and seed germination was reduced from 72% in controlled to complete inhibition in the 10% concentration of leachates. The effect of leaf extract was almost similar to that of the leaf leachates in case of *Pupalia lappacea*. However, the leaves extract more severely reduced germination of *Corchorus aestuans*, *Setaria verticillata* and

**Table 1.** The effect of *Cassia tora* on Density ($m^{-2}$) Basal area ($mm.m^{-2}$) and IVI of some important herbaceous species in the different study sites of the Sariska Tiger Project. (±S.E.).

| Vegetation in *Cassia tora* removed area (Control) | | | | | Vegetation with *Cassia tora* | | |
|---|---|---|---|---|---|---|---|
| **S.N.** | **Species Name** | **Density** | **Basal area** | **IVI** | **Density** | **Basal area** | **IVI** |
| 1 | *Achyranthes aspera* Linn. | 0.8±0.25 | 2.38±0.54 | 4.0 | 1.3±0.35 | 2.12±0.62 | 16.52 |
| 2 | *Acalypha lanceolata* wild. | 0.9±0.27 | 4.99±0.78 | 3.98 | - | - | - |
| 3 | *Boerhavia diffusa*Linn. | 1±0.33 | 3.53±0.71 | 4.01 | - | - | - |
| 4 | *Brachiaria ramosa*Linn. | 7±2.02 | 59.20±2.51 | 10.4 | 4±0.98 | 11.31±1.63 | 11.43 |
| 5 | *Cassia tora*Linn. | -* | - | - | 109.5±7.74 | 66658.6±20.6 | 200.77 |
| 6 | *Chloris dolichostachya*Lagasca | 23.6±11.62 | 1750.45±23.2 | 57.46 | - | - | - |
| 7 | *Corcorus aestuans* Linn. | 1.6±0.34 | 6.78±1.06 | 9.11 | - | - | - |
| 8 | *Cyperus bulbosus*Vahi | 5±1.49 | 81.75±3.06 | 9.31 | - | - | - |
| 9 | *Chrysopogon fulvous* (Spreng)Chiov. | 4.8±1.80 | 12.72±3.86 | 4.23 | - | - | - |
| 10 | *Dichanthim annulatum*(Forsk.)Stapf. | 4.8±2.11 | 82.87±4.52 | 7.61 | - | - | - |
| 11 | *Digitaria adscendens*(HBK.) Henr. | 11.6±2.82 | 479.74±6.02 | 22.43 | - | - | - |
| 12 | *Elytraria acaulis* (Linn.) Linn. | - | - | - | 1.5±3.4 | 33.61±1.49 | 15.44 |
| 13 | *Euphoribia hirta*Linn. | 3.752±1.60 | 11.05±1.61 | 5.81 | - | - | - |
| 14 | *Euphoribia parviflora* Linn. | 1.7±0.63 | 8.05±1.27 | 4.66 | - | - | - |
| 15 | *Euphoribia prostrasa*Ait. | 1.4±0.70 | 5.69±1.35 | 3.86 | - | - | - |
| 16 | *Hemarthria compress* (Linn.f.)*R.Br* | 1.8±0.96 | 48.42±4.2 | 4.03 | - | - | - |
| 17 | *Heteropogon contortus*Linn. | 8.4±3.27 | 162.02±5.6 | 12.55 | 4.1±1.22 | 23.00±1.6 | 17.42 |
| 18 | *Leucas urticaefiolia*(Vahi.) i. donn | 0.9±0.40 | 6.43±1.28 | 3.47 | - | - | - |
| 19 | *Mollugo nudicaulis* Lam*k.* | 0.2±0.13 | 0.03±0.01 | 1.2 | - | - | - |
| 20 | *Oplismenus burmannii*Beauv. | 5±2.46 | 15.91±2.22 | 6.9 | - | - | - |
| 21 | *Oxalis corniculata*Linn. | 1.1±1.10 | 2.84±1.92 | 1.46 | - | - | - |
| 22 | *Panicum antidoate*Retz. | 2.8±1.3 | 62.24±4.15 | 5.62 | - | - | - |
| 23 | *Paspalidiu flavidum (*Refz.)A.camus | 8.4±3.87 | 539.35±12.1 | 20.6 | - | - | - |
| 24 | *Paspalum distichum* Linn. | 2±1.36 | 14.94±2.98 | 2.95 | - | - | - |
| 25 | *Peristrophe bicalyculata*(Retz) Nees | 0.7±0.26 | 3.67±0.8 | 13.26 | - | - | - |
| 26 | *Phyllanthus niruri* Hk. F non Linn. | 0.6±0.4 | 1.04±0.77 | 2.6 | 1.2±0.33 | 4.23±0.63 | 13.41 |
| 27 | *Phyllanthus simplex* Retz. | 0.9±0.43 | 2.75±0.9 | 2.87 | - | - | - |
| 28 | *Physalis minima* Linn. | 0.5±0.22 | 0.97±0.5 | 2.51 | - | - | - |
| 29 | *Pupalia lappacea*Linn. Juss | 1.7±0.26 | 4.52±0.66 | 5.23 | - | - | - |
| 30 | *Rivea hypocrateritomis* choisy | 0.3±0.21 | 0.32±0.45 | 1.29 | - | - | - |
| 31 | *Setaria glauca* (Linn.) P. Beauv | 1.8±0.96 | 2.69±0.99 | 3.05 | - | - | - |
| 32 | *Setaria verticillata*Linn. | 13.2±3.93 | 1099.03±11.2 | 35.96 | - | - | - |
| 33 | *Sida acuta* Burm.f. | 0.5±0.22 | 1.06±0.52 | 2.52 | 3.2±1 | 5.52±0.83 | 14.91 |
| 34 | *Sida cordifolia* Linn. | 3.8±2.70 | 50.41±5.74 | 8.26 | - | - | - |
| 35 | *Sida ovata* forsk. | 0.2±0.2 | 0.09±0.34 | 0.68 | - | - | - |
| 36 | *Sida veronicifolia*Lamk. | 1.6±0.56 | 15.00±1.39 | 5.26 | - | - | - |
| 37 | *Solanum indicum* Linn. | 0.5±0.26 | 0.31±0.34 | 1.97 | - | - | - |
| 38 | *Sorghum halepense*Linn. | 3±1.37 | 434.65±10.8 | 13.25 | - | - | - |
| 39 | *Tridex procumbens* Linn. | 0.5±0.22 | 1.06±0.52 | 2.52 | - | - | - |

* - means value nil.

**Table 2:** Plumule (P) and radicle (R) elongation of four species in aqueous leaf leachates and extracts of *Cassia tora.*

| Test Species | Concentration (%) | Leaf leachates | | Leaf extracts | |
|---|---|---|---|---|---|
| | | P (cm) | R (cm) | P (cm) | R(cm) |
| *Pupalia lappacea* | Control | 2.26±0.12 | 5.26±0.18 | 2.46±0.29 | 2.14±0.16 |
| | 1% | 1.87±0.07 | 2.71±0.24 | 1.92±0.11 | 1.58±0.14 |
| | 3% | 1.78±0.1 | 2.47±0.13 | 1.36±0.16 | 1.52±0.09 |
| | 5% | 1.45±0.11 | 1.27±0.1 | 1.04±0.08 | 1.54±0.1 |
| | 10% | 0.36±0.05 | 0.02±0.01 | 0.3±0.01 | 0.35±0.06 |
| *Corchorus aestuans* | Control | 1.94±0.12 | 1.00±0.03 | 2.78±0.12 | 1.44±0.1 |
| | 1% | 1.73±0.05 | 0.93±0.02 | 2.19±0.11 | 0.32±0.05 |
| | 3% | 1.54±0.04 | 0.85±0.03 | 1.85±0.06 | 0.22±0.03 |
| | 5% | 0.15±0.01 | *- | 1.57±0.06 | 0.2±0.01 |
| | 10% | - | - | - | - |
| *Setaria verticillata* | Control | 5.22±0.16 | 3.03±0.11 | 4.88±0.13 | 2.29±0.11 |
| | 1% | 3.94±0.11 | 2.06±0.1 | 4.12±0.15 | 1.08±0.06 |
| | 3% | 1.62±0.08 | 1.12±0.05 | 1.05±0.08 | 0.52±0.02 |
| | 5% | 0.57±0.01 | 0.29±0.01 | 0.42±0.03 | 0.17±0.01 |
| | 10% | - | - | - | - |
| *Chrysopog on fulvus* | Control | 3.73±0.15 | 1.46±0.07 | 4.43±0.2 | 1.48±0.01 |
| | 1% | 2.94±0.09 | 1.11±0.08 | 3.28±0.09 | 1.22±0.06 |
| | 3% | 2.43±0.04 | 0.92±0.02 | 2.97±0.09 | 0.93±0.03 |
| | 5% | 1.17±0.03 | 0.42±0.01 | 1.92±0.05 | 0.77±0.03 |
| | 10% | 0.5±0.01 | 0.09±0.01 | - | - |

* - means value nil.
Difference between control and treatments of each parameter are significant at 0.05 level

*Chrysopogon fulvus* (Fig.2).

The leaf leachate delayed the germination of seeds in all the tested species. However, the effect was more severe in *Setaria verticillata*, In *Chrysopogon fulvus* and *Corchorus aestuans* it was delayed by a week while it was delayed by 12 days in *Pupalia lappacea* and by 13 days in *Setaria verticillata*. The leaf extract delayed effect on seed germination was almost similar to that of the leaf leachates (Fig. 4,6).

**Effect on radicle and plumule elongation**

The elongation of radicle and plumule was reduced in presence of leaf leachates of *Cassia tora*. In case of *Pupalia lappacea* even at 1 percent concentration of leachates, the length of radicle was 2.71 cm in comparison to 5.25 cm in control. Further, the radicle elongation was reduced to 0.02cm at 10 percent concentration of leaf leachates (Table 4). The effect of leaf leachates was observed to be more on the radicle growth of *Corchorus aestuans* as it was completely inhibited at 5 percent concentration of leachates. The plumule elongation of both the species also

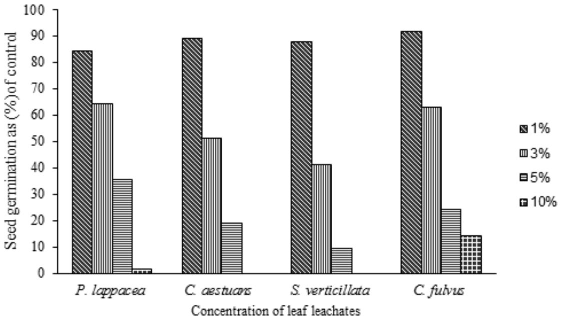


**Figure 1:** Effect of different concentrations of aqueous leaf leachate of *Cassia tora* on seed germination of above four species

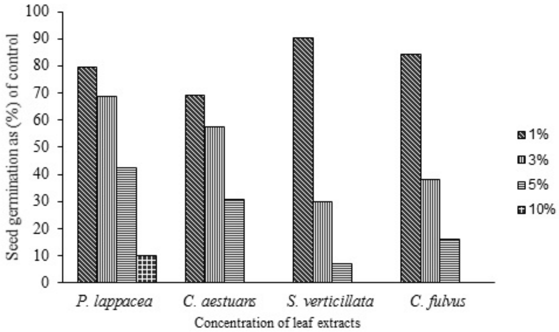


**Figure 2.** Effect of different concentrations of aqueous leaf extract of *Cassia tora*on seed germination of above four species

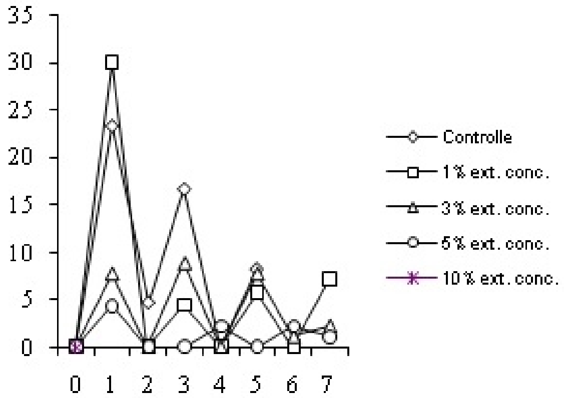


**Figure 3.** Effect of different concentrations of aqueous leaf leachate of *Cassia tora* on seed germination of *Corchorus aestuans*

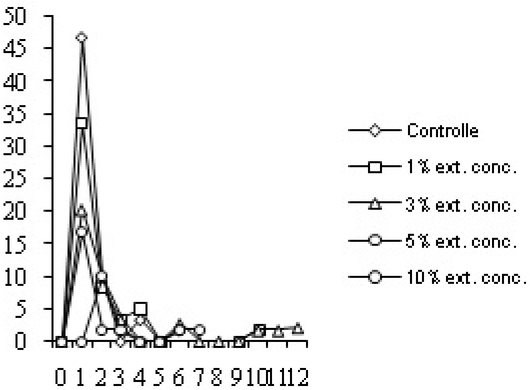


**Figure 4.** Effect of different concentrations of aqueous leaf extract of *Cassia tora*on seed germination of *Pupalia lappacea*

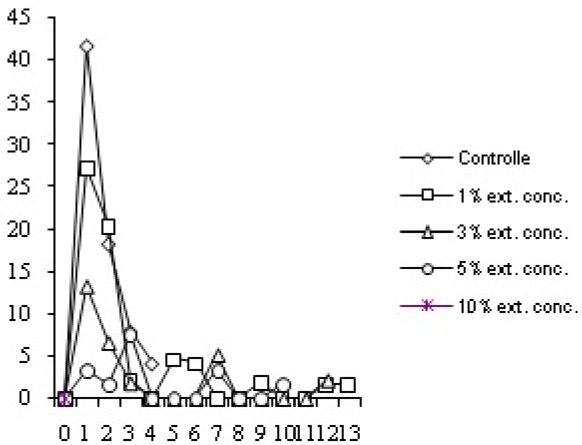


**Figure 5**. Effect of different concentrations of aqueous leaf leachate of *cassia tora* on the speed of seed germination of *Setaria verticillata*

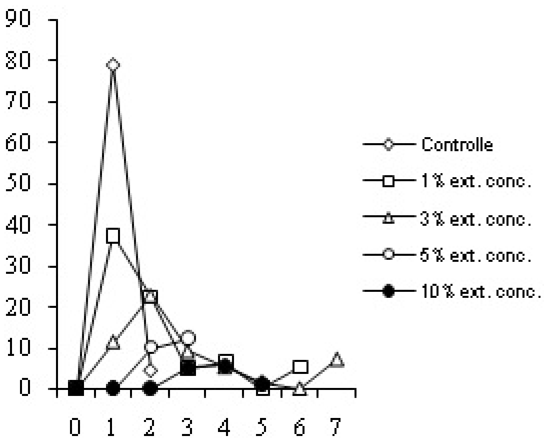


**Figure 6**. Effect of different concentrations of aqueous leaf extract of *cassia tora* on the speed of seed germination of *Chrysopogon fulvus*

exhibited reduction in growth with increase in concentration of leaf leachates of *Cassia tora*. However, inhibition was more in *Corchorus aestuans.* In case of *Setaria verticillata,* even 1% concentration of leachates reduced radicle growth form 3.03 cm in control to 2.06 cm in 1% concentration and further reduced to 0.29 cm in 5% concentration of leachates (Table 2). Similar effect of leaf leachates was observed on the radicle growth of *Chrysopogon fulvus*. The plumule elongation of both the grass species tested also exhibited reduction in growth with increase in concentration of leachates.

The inhibitory effect of leaf extract on plumule elongation of tested species was similar to that of the effect of leaf leachates (Table 4). However, in case of *Corchorus aestuans* and *Setaria verticillata* the radicle growth was more severely reduced by the leaf extract.

## Discussion

The result suggests that the leaf leachates and leaf extract of *Cassia tora* have inhibitory effect on seed germination and seedling growth of all the four species examined. The inhibitory effect increased with increase concentration of leachates/extracts. The inhibitory effect was observed even at one percent concentration, which was further enhanced with the increasing in concentration upto10 percent of the leaf leachates / extracts. This is conformed with Dhawan and Dhawan (1995) and Dhawan *etal* (2000) who observed inhibition of seed germination of *Parthenium hysterophorus* by aqueous extracts of *Cassia tora*. The results are in conformation with Rai and Tripathi (1982) who observed strong inhibitory effects of aqueous plant extract of the exotic weed *Eupatorium adenophorum* and *E. riparium* respectively on seed germination of associated species Gauchan *etal* (2004) observed that leaf extracts of *Cassia occidentalis* inhibited germination and seedling growth of *Citrullus colocynthis* and *Alhagi pseudalhagi*..

The aqueous leaf leachates and leaf extract of *Cassia tora* exhibited strong inhibitory effect on the elongation of radicle and plumule in all the four species examined. However, the inhibitory effect was more in case of *Setaria verticillata* as compared to other species. The inhibition of germination was less as compared to that seedling growth in all the test species. This finds support from Kawisi *etal* (1995) who reported that aqueous extracts of tubers of *Cyperus rotundus* suppressed the shoot and root growth more than the seed germination in vegetable crops. Dey (2007) also observed that *Holoptelea integrifolia*, *Prosopis juliflora*, *Capparis sepiaria* and *Lantana camara* leaf leachates have more inhibitory effect on radicle and plumule growth in *Indigofera trita*. *Cassia tora* suppresses the growth of associated herbaceous species through the release of allelochemic substances from the seeds and decomposing leaves in nature. Patil *et al*(2004), Thapar and Singh (2006) reported large number of chemicals present in different organs of the *Cassia tora* plant. Souto *etal* (2001) who reported that *Acacia melanoxylon* has strong inhibitory effect on seed germination and growth of understory plants and further suggested that allelopathic phenomenon could be, at least partially, responsible for the low species diversity in understory of the exotic tree stands. Meiners *etal* (2002) also emphasized that the abundance of exotic species may cause a reduction in community diversity.

Several workers have also reported that allelochemics determine the pattern and processes of vegetation, and dominance of a given species in a community (Friedman *etal* 1977, Stowe 1979).del Moral and Cates (1971) observed that *Acer circinatum, Arbutus menziesii* and *Rhododendron albiflorum* cause changes in composition of ground-cover vegetation beneath the canopy of these species through allelochemic influences. The results obtained in the present study indicate low density and reduced growth of herbaceous species in *Cassia tora* infested site in natural condition. As indicated, both the germination is reduced and delayed due to soaking of four test species. The late emerging individuals may be put to disadvantageous position as far as the appropriation of resources is concerned and their growth may be suppressed. As a consequence, the intensity of competition offered by such plant species might be reduced. Obviously, the species whose germination and seedling growth are not adversely affected by soaking might tend to benefit from such a situation. On the basis of observations reported in the present paper, it could be argued that allelopathy helps *Cassia tora* in gaining dominance over the other neighbouring species in close vicinity through the secreting of allelochemic substances from the seeds and decomposing leaves in nature. The growth of *Cassia tora*, an exotic species, in almost pure stands in the core area of the Sariska Tiger Project would drastically reduce the growth of the local herbaceous species particularly grasses which are important source of food for the herbivores which in turn affect the fauna of the forest.

## Acknowledgements

The authors are grateful to the Chief Wild Life Warden, Rajasthan, Jaipur and the Field Director, the Sariska Tiger Reserve Forest for granting permission for doing fieldwork. The financial assistance from the University Grant Commission, New Delhi is gratefully acknowledged.

## References

Ambika S R, Poornima S, Palaniraj R, Sati S C and Narwal S S 2003 Allelopathic plant *Lantana camara* L. *Allelopathy Journal* **12** 147-161.

Becking R W 1969 Vegetation response to change in environment and change in species tolerance with time. *Vegetaitio*.**16**135-158.

Del Moral R and Cates R G 1971 Allelopathic potential of the dominant vegetation of western Washington. *Ecology* **52** 1030-1037.

Dey V N 2007 *Studies on the population dynamics of Indigofera trita* L. Ph.D. thesis University of Rajasthan, Jaipur.

Dhawan S R, Dhawan P and Gupta S K. 2000. Allelopathic potential of leguminous plant species towards *Parthenium hystenphorus* L. *Flora and Fauna Jhansi* **4** 1998.

Dhawan S R and Dhawan P 1995 Bio-control of congress grass: studies on seed germination. *World Weeds* **2** 3-9.

Duthie J F 1929 *Flora of the upper Gangetic plains and of the Adjacent Siwalik and Sub-Himalayn tracts*. Reprint, 1960. Botanical Survey of India, Calcutta.

Friedman J, Orshan G and Zigerefir Y 1977 Suppression of annuals by *Artemisia herba-alba* in the Negev desert of Israel. *Journal of Ecology*. **65** 413-426.

Gauchan D P, Dhingra A and Dhingra S 2004. Allelopathic effect of *Cassia occidentalis, Parthenium hysterophorus, Peganum harmala* and *Xanthium strumarium* on seed germination and seedling growth of some medicinal plants of great Indian Desert. *Indian Journal of Environmental Science* **8**113-115.

Kawisi M, Chivinge O A and Mashingaidze A B 1995. Allelopathic effect of purple nutsedge (*Cyperus rotundus* L.) tuber extracts on germination and seedling growth of some horticultural crops grown in Zimbabwe. *Zimbabwe Journal of Agricultural Research* **33** 117-131.

Knox J, Jaggi D and Paul M S 2011 Population dynamics of *Parthenium hysterophorus* (Asteraceae) and its biological suppression through *Cassia occidentalis* (Caesalpiniaceae). *Turkish Journal of Botany* **35** 111-119.

Meiners S J, Pickett S T A and Cadenasso M L 2002. Exotic plant invasions over 40 years of old field successions: Community patterns and associations. *Ecography*. **25** 215-223.

Nakano H, Fujii Y, Yamada K, Kosemura S, Yamamura S, Hasegawa K and Suzuki T 2002 Isolation and identification of plant growth inhibitors as candidate(s) for allelopathic substance(s), from aqueous leachate from mesquite (*Prosopis juliflora* (Sw.) DC.) leaves. *Plant Growth Regulation* **37**113-117.

Patil U K, Saraf S and Dixit V K 2004 Hypolipidemic activity of seeds of *Cassia tora* Linn. *Journal of Ethnopharmacology* **90** 249-252.

Rai J P N and Tripathi R S 1982 Allelopathy as a factor contributing to dominance of *Eupatorium riparium* Regel. *Indian Journal of Ecology* **9** 14-20.

Rai J P N and Tripathi R S 1984 Allelopathic effect of *Eupatorium riparium* on population regulation of two species of *Galinsoga* and soil microbes. *Plant and Soil* **80** 105-117.

Sharma K, Rao P B and Pandey N 2009.

Allelopathic effect of seven weed extracts on seed germination in different varieties of wheat (*Triticum aestivum* L.). *Journal of India Botanical Society* **88** 35-40.

Souto X C, Bolano J C, Gonzalez L and Reigosa M J 2001 Allelopathic effect of tree species on some soil microbial populations and herbaceous plants. *Biological Plantarum* **44** 269-275.

Takahashi Y, Saitoh S, Otani I, Uozumi S, Hagino K and Igarashi R 1995 Studies on allelopathic interactions among some grassland species.6.Screeningof allelopathic activities from native grassland species by using the lettuce seed bioassay with the plant shoot extracts. *Grassland science* **41** 232-239.

Thapar R and Singh N B 2006 Phytotoxic effects of *Cassia tora* on growth and metabolism of *Parthenium hysterophorus* L. *Allelopathy Journal* **17** 235-246

Yu J Q, Ye S Y, Zhang M F and Hu W H 2003 Effects of root exudates and aqueous root extracts of cucumber (*Cucumis sativus*) and allelochemicals on photosynthesis and antioxidant enzymes in cucumber. *Biochemical Systematics and Ecology* **31** 129-139