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Allelopathic Effect of Aqueous Extracts of *Lantana camara* on Germination of Peanut Seeds

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***Abstract*: *Lantana camara* L., introduced as an ornamental plant in India a century ago, has invaded over 40% forest lands today. It is also actively spreading through Indian states in agricultural farms and interfering with the productivity of several food crops. The detrimental effect of *L. camara* has been recognised on various plants, however, to the best of our knowledge, published studies have not explored its effect on an important cash crop of India i.e., *Arachis hypogea*. Hence, in the present study, the allelopathic effect of aqueous extracts of *L. camara* on germination and chlorophyll, protein profile of peanut seeds was determined. It was observed that 1% *L. camara* aqueous extracts has negligible effect on seed germination, and chlorophyll a and protein content of germinated *A. hypogea* seeds, but significantly affected total chlorophyll and chlorophyll b concentration. At higher concentrations (1% and 3%), the allelopathic effect of *L. camara* aqueous extracts was clearly evident on all three growth parameters of peanuts evaluated in this study. In conclusion, our study reports that *L. camara* may prove to be a much bigger challenge in management of peanut productivity as compared to other invasive weeds, if proper preventive measures are not recognized immediately.**

***Keywords*: Allelopathy, Aqueous extracts, Chlorophyll, *Lantana camara*, Peanuts, Protein, Weeds.**

1. Introduction

Plant allelopathy is a common biological phenomenon whereby one plant produces biochemicals (known as allelochemicals) that influence the growth, survival, development and reproduction of other plants. This interaction may exert either positive or negative pressure on plant ecosystems [1]. For instance, in a recent study, Rial et al. [2] reported the phytotoxic activity of sesquiterpene lactones (in root exudates) of safflower plant against three common and noxious agricultural weeds- *Lolium perenne*, *Lolium rigidum* and *Echinochloa crusgalli*. However, the same allelochemical stimulated the germination of *Phelipanche ramosa* and *Orobanche cumana;* two other varieties of common weeds. In general, the allelopathic interaction of plants has been applied in agricultural fields as crop rotation, cover crops, allelopathic water extracts or mulching for weed control, crop protection or prevention of biological invasion by plant species in a community [1]. Allelochemicals are non-nutritive secondary metabolites of plants classified into 14 categories by Rice [3] based on their chemical similarity. Additionally, plant growth regulators like salicylic acid, gibberellic acid and ethylene are also considered as allelochemicals due to their additive effect on growth and survival of invading plants [1]. Plant decomposition and modification of allelochemicals caused by microorganisms further causes chemical- specific changes in soil and thus acts as a medium for allelopathy [4].

Over the years, the negative allelopathic interaction of *Lantana camara* with many species has resulted in widespread loss of plant diversity in India [5]. The genus *Lantana* consists of 150 species of evergreen potent smelling shrubs known for their therapeutic potential. However, the beneficial characteristics of this plant are largely obscured by the nuisance caused by its invasion in agricultural and forest lands. *L. camara* are resistant to climate changes and can grow extensively at altitudes up to 2000 m in tropical, subtropical and temperate regions forming impenetrable boundaries in the invaded zones [5], [6]. The allelopathic interaction of the fallen leaves also effectively prevents germination and growth of other plant seeds mainly through the inhibitory activity of salicylic acid and methyl coumarin [5], [7]. Attempts to control *L. camara* invasion has been largely in vain since grazing cause ulcers and lesions in livestocks [8], and burning of plants stimulate thicker and stronger regeneration [9]. Though mechanical control is effective, they are extremely labour intensive [10].

Although the negative allelopathic interaction of *L. camara* is commonly reported for many plants, the existing literature lacks relevant information on its effect on *A. hypogea*. Since peanuts are among the world's 15 most consumed food crops, with India being one of the major exporters, study of its interaction with invading species is of agricultural relevance. Moreover, every part of peanut plant has commercial value. The oil is primarily used in cooking and the kernels are consumed as snacks by humans. The plant stalks, shells, haulms, hay as wells as de-oiled groundnut cake are good fodder for livestock [11]. For this reason, studying the interaction of this cash crop with other plants is necessary to prevent anticipated agricultural losses due to invading species. Hence, the current study was carried out with an objective to evaluate, the allelopathic effect of *L. camara* extracts on germination of peanut seeds and, its chlorophyll and protein content.

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2. Materials and Methods

A. Sampling

The (above ground) plant samples of *L. camara* were collected from Airport Colony and PNT Colony, Sahar, Vile Parle East, and Sathaye College campus in Mumbai, India.

B. Treatment of Plant and Preparation of Extracts

The collected plant was transported to the laboratory in clean plastic bags and rinsed with tap water repeatedly. After washing thoroughly, the plant was dried with blotting paper, air dried for one day and then placed in oven (45°C) for 3 days for complete dehydration. The dried plants were crushed and stored in air tight jars for further use. Aqueous extracts of *L. camara* (1%, 3% and 5%) was prepared in 100 ml distilled water with intermittent shaking for 48 h. After incubation, the extract was filtered through Whatman filter paper No. 42 to remove plant debris. The extracts were stored under refrigerated conditions in sterile dark bottle until further use.

C. Study of Allelopathic Effect of L. camara Extracts on Peanut Seeds

Peanut seeds were soaked in *L. camara* aqueous extracts and the Germination Index (GI) was measured for 6 days using the formula:

$$GI = \frac{N1}{T}\ x\ N2 \quad (1)$$

Where N1 is No. of days after sowing seed, N2 is No. of seeds germinated and T is the total no. of seeds planted.

Peanut seeds soaked in distilled water were used as control. On the 7th day, chlorophyll and protein content was estimated using Arnon's formula [12] and Lowry's method [13] respectively. All studies were carried out in duplicates and the significance of observed values was determined using one-way analysis of variance (ANOVA) at 95% confidence level.

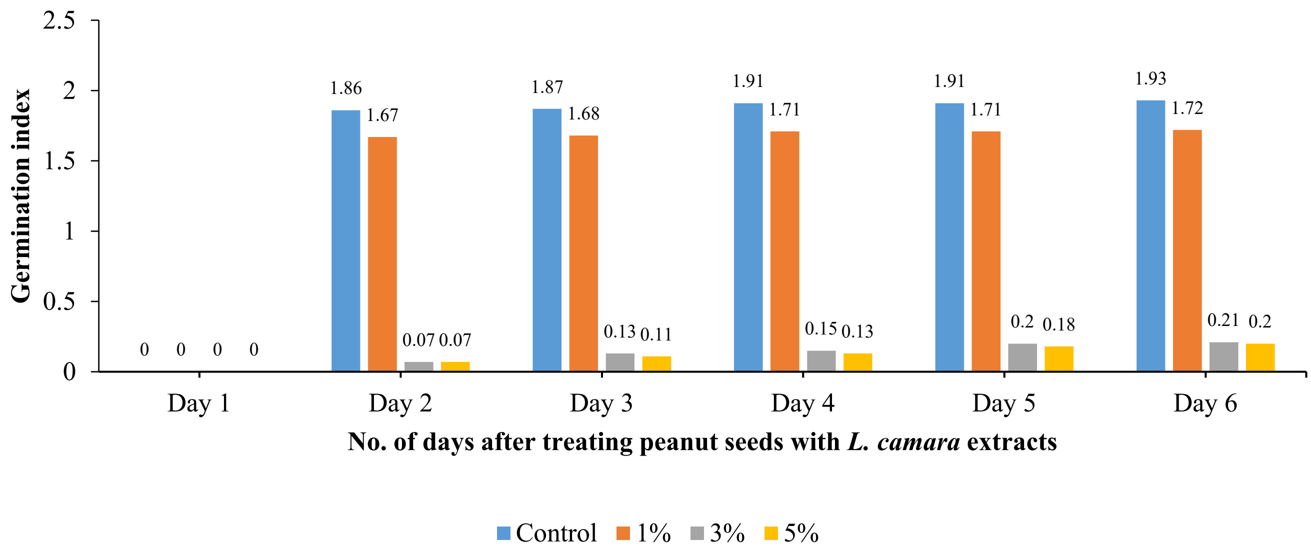
3. Results and Discussion

The allelopathic interaction is a significant factor that influences species distribution of invasive and native plants in a region. According to a recent report, *L. camara* has already invaded over 303,607 km^2 (i.e., 40%) area of Indian forests [10]. In addition, it is fast spreading across agricultural lands in states like Gujarat, Karnataka, Rajasthan, Orissa, Madhya Pradesh and Uttar Pradesh, which are major producers of peanuts [14], [15]. The negative allelopathic interaction of *L. camara* is known against many agricultural crops like green gram [16], black gram [17], wheat, mustard [18], rice [19], radish, tomato, bell pepper and Indian hemp [20]. However, to the best of our knowledge, its effect on peanut plants is not reported in literature. The present study describes the allelopathic effect of *L. camara* aqueous extracts on peanut seed germination and its chlorophyll and protein content. A representation of our study protocol is outlined in Fig. 1 below.

A. Germination Index of Peanuts

The roots of *L. camara* are a rich source of bioactive compounds that are well known for their allelopathic activity [21]. Since *L. camara* invasion of peanut agricultural areas has recently emerged in India, any negative interaction of above ground parts of these plants can be more detrimental since it can further aid in propagation of invasive plant. Hence, we selectively studied the influence of aerial parts of *L. camara* on germination of peanuts. The histogram of peanut GI (Fig. 2) represents day to day changes observed in our study. A concentration dependent allelopathic effect of *L. camara*

Fig. 1. Representative outline of present study showing (A) Semi-dried leaves of *L. camara* (B) Completely dried leaves of *L. camara* (C) Powdered leaves stored in clean plastic bottles (D) Aqueous extracts of *L. camara* (1%, 3% and 5%) stored in black bottles (E) Day 7 observations of control seeds germinated in distilled water extracts and Day 7 observations of peanut seeds germinated in (F) 1% *L. camara* aqueous extracts (G) 3% *L. camara* aqueous extracts (H) 5% *L. camara* aqueous extracts



Null Hypothesis (H_0): There is no significant difference of various concentrations of treatment on germination.
Alternate Hypothesis (H_A): There is a significant difference of various concentrations of treatment on germination.

From the figure,
$\Sigma x = 19.42$ (G)
$\Sigma x^2 = 32.53$ (A)
$\sum \frac{(\Sigma x)^2}{n_c} = 27.13$ (B)
$\frac{G^2}{n_{total}} = 15.71$ (D)

Source of Variation	Sum of Squares	Degrees of Freedom	Mean Square
Between Treatments (T)	11.42	3	3.80
Residual (R)	16.82	20	0.84

$$F = \frac{T\ (mean\ square)}{R(mean\ square)} = 4.52$$

Tabulated F at $p<0.05 = 3.1$

As the calculated value is more than the tabulated value, there is a significant difference of effect of various concentrations of treatment on germination.
H_0 is rejected.

Fig. 2. Germination index of peanut seeds treated with aqueous *L. camara* extracts and statistical analysis

aqueous extracts was evident on germination of peanuts. At 1% concentration, the GI of peanuts was comparable to controls. However, at higher concentrations, *L. camara* significantly inhibited the germination of peanuts. The observed values were also analysed using ANOVA (represented in Fig. 2) which confirmed significant difference of various concentrations of *L. camara* aqueous extracts on germination of peanuts at $p < 0.05$ ($F = 4.52$).

Similar to our study, concentration dependent inhibition of *L. camara* aqueous extracts has also been reported on germination of black gram [17] and green gram [16]. *L. camara* species are reported to inhibit germination by altering the osmotic potential around seeds, which in turn reduces the rate of water absorption, seed elongation and its proliferation [22]. The observations in this study suggest negligible tolerance of peanuts seeds to 3% and 5% *L. camara* extracts. In contrast, peanuts have been reported to tolerate up to 5% leaf extracts of *Parthenium hysterophorus* and the observed tolerance was better than that observed for black and green gram [23]. Our findings thus indicate that the management of peanut cultivation in events of *L. camara* invasion can be much more challenging compared to currently anticipated threat of *P. hysterophorus* weeds.

B. Chlorophyll Content in Germinated Seeds of Peanuts

The Fig. 3 represents the concentration of total chlorophyll, chlorophyll a and chlorophyll b in germinated peanut seeds on Day 7 after treatment with *L. camara* aqueous extracts. At 1% concentration, *L. camara* had no effect on chlorophyll a content in peanut seed, however a sharp decline in total chlorophyll and chlorophyll b content was observed. At higher concentration, *L. camara* significantly affected chlorophyll concentration in germinated seeds.

Reduction in chlorophyll content of germinated *Thespesia populnea* (L.) tree seeds is also reported on treatment with *L. camara* and *P. hysterophorus* aqueous extracts [24]. Also, Lande et al. [25] reported similar observations of no effect on chlorophyll a content in germinated red chillie seeds on treatment with low concentration of *L. camara* extracts, and significant reduction in total chlorophyll and chlorophyll b at higher concentration. Since, chlorophyll a is less polar compared to chlorophyll b [26], this observation may be due to higher stability of chlorophyll a against components present in the aqueous (polar) extracts of *L. camara*. A recently identified allelochemical (methyl palmitate) of *L. camara* is associated with physiological effects exhibited by this plant like

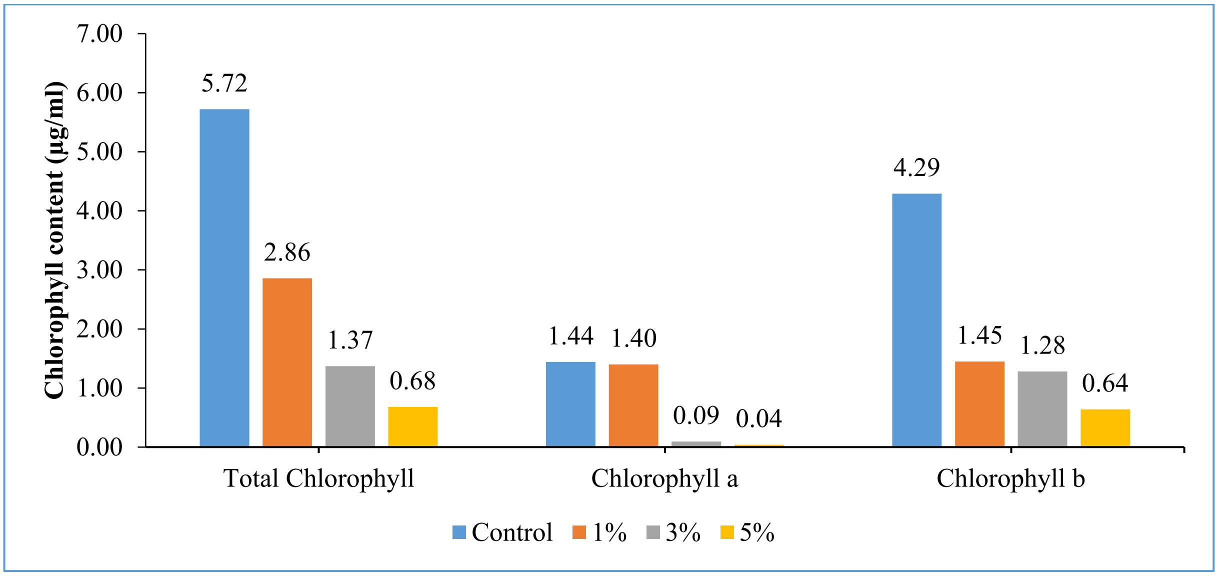


Fig. 3. Estimation of chlorophyll content in peanut seeds treated with aqueous *L. camara* extracts

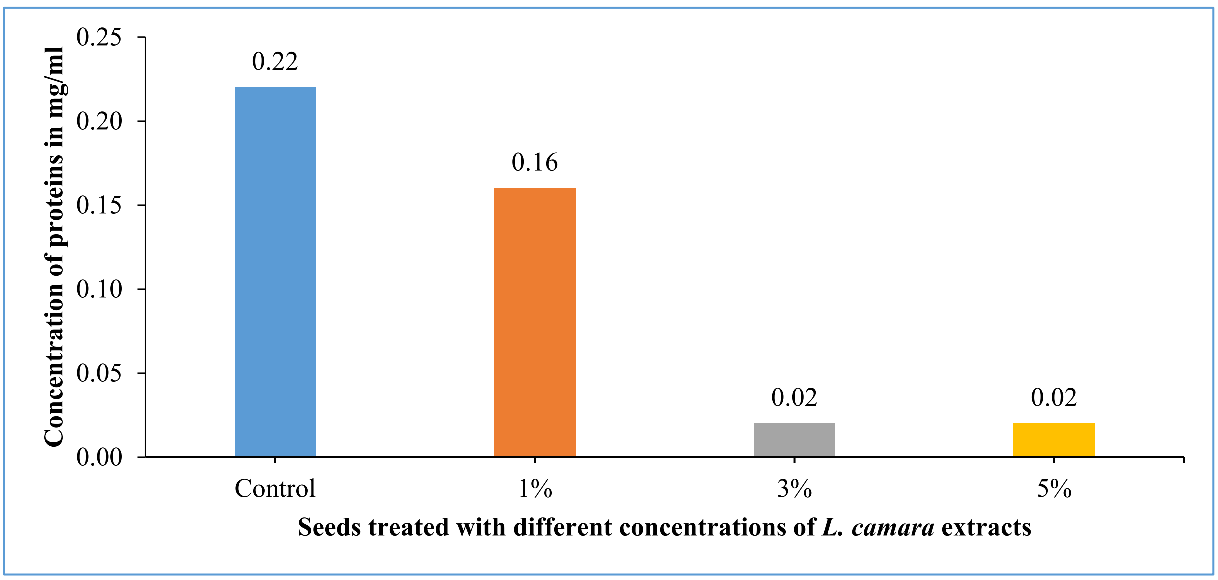


Fig. 4. Estimation of protein content in peanut seeds treated with aqueous *L. camara* extracts

suppression of chlorophyll, antioxidant enzymes and proteins [27]. Additionally other allelochemicals of *L. camara* are also associated with chlorophyll degradation [1]. Hence, the plants that survive germination stage, exhibit varying degree of necrosis, chlorosis and other growth defects during further developmental stages.

C. Protein Content in Germinated Seeds of Peanuts

Like chlorophyll content, the proteins were less affected at lower (1%) concentration of *L. camara* extracts and drastically inhibited at higher (3% and 5%) concentrations (Fig. 4). As indicated earlier, various allelochemicals of *L. camara* inhibit plant growth by exhibiting protease activity during germination and further developmental stages [1], [27]. Previously, protease activity of *L. camara* extracts has been reported in germinated seeds of black gram by Nawab and Yogamoorthi [17].

4. Conclusion

The present study demonstrates negative allelopathic effect of *L. camara* aqueous extracts on peanut seed germination and growth. The reduced levels of chlorophyll and proteins at higher concentration of *L. camara* extracts indicates that it has biomolecule degrading or inhibiting effects of peanuts seeds. Our results, in comparison with published literature briefly suggest that *L. camara* invasion in peanut fields may be much more difficult to manage as compared to *P. hysterophorus*- another potent invasive weed. Thus, with the current extent of invasion of agricultural lands by *L. camara* weed species, it is necessary to pre-plan protective management strategies for saving an important cash crop like peanut from its detrimental effects and prevent agricultural, and resulting economic, losses.

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