ISSN 2449-8866

Current Life Sciences

Research Article

Allelopathic potential of caffeine as growth and germination inhibitor to popular tea weed, *Borreria hispida* L.

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Received: 04 August 2016; **Revised submission:** 03 October 2016; **Accepted:** 20 October 2016

DOI: http://dx.doi.org/10.5281/zenodo.163671

ABSTRACT

Allelopathic compounds are considered as growth and germination indicators. The present investigation elucidates the impact of caffeine as an allelopathic substance reducing the growth and biomass production and inhibiting the germination of popular tea weed, *Borreria hispida* L. seeds. Seed treatment of tea weed, *Borreria hispida* L. with different concentrations of caffeine indicated delay in germination start for a longer period of time. The growth and germination of *Borreria hispida* L. seeds were affected maximum at caffeine concentrations of high dose. The seedlings of the *Borreria hispida* L. had also an abnormal growth and twisted form after exposed to caffeine. The study also revealed negative impacts of caffeine at its maximum dose (1000 ppm) on *Borerria hispida* L. showing a reduction of plant height by 11.1 cm against control. The study, thus, provides evidence of allelopathic syndrome in tea eco-system. This is the first report evaluating the caffeine allelopathy influencing the growth and germination to popular tea weed, *Borreria hispida* L.

Keywords: Allelopathic compounds; *Borreria hispida* L.; Germination indicators; Plant biomass; Tea ecosystem.

1. INTRODUCTION

The allelopathic compounds are secondary metabolites, including a variety of compounds that are released from plants into the environment by means of ecological processes like volatilization, leaching, decomposition of plant residues in soil and root exudation. Plants synthesize a large number of allelopathic compounds with diverse chemical structures [1]. Muller [2] defined allelopathy as the process where a plant releases toxic compounds into its surroundings. Whittaker and Feeny [3] stated the significance of allelochemicals in speciation. Allelopathy is also believed to play major roles in the adaptation of plants to the environment [4].

Caffeine (1,3,7-trimethylxanthine) is an allelochemical, naturally found in approximately 100 plant species [5]. It is psychostimulant and known for increasing the alertness through surmounting fatigue [6]. Caffeine is connected with allelopathic effects, including the inter and intraspecific effects [7]. According to Dash and Gummadi [8], caffeine

has negative impacts on soil microbiota and thereby earn ecological imbalance. Reports are there indicating the influence of caffeine in delaying the act of germination [9].

However, information on impact of caffeine in tea ecosystem is scarce. Hence, a study has been initiated to elucidate the role of caffeine as growth and germination inhibitors to popular tea weed, *Borreria hispida* L. The studies on allelopathy in tea ecosystem have significance in the exploration of potent caffeine degrading microbes and to understand their mechanism of action to detoxify the allelochemical and thereby to induce plant growth and seed germination.

2. MATERIALS AND METHODS

2.1. Effect of caffeine on plant growth parameters

To observe the effect of caffeine on diverse plant growth parameters, seeds of *Borreria hispida* L. were first collected from Tocklai Experimental Tea Garden, TTRI, TRA. Healthy seeds of *Borreria hispida* were pre-soaked in distilled water for 12 hours and then subjected to ten different concentrations (100 ppm, 200 ppm, 300 ppm, 400 ppm, 500 ppm, 600 ppm, 700 ppm, 800 ppm, 900 ppm and 1000 ppm) of caffeine solution prepared in phosphate buffer of pH 7 for 48 hours. One set of seed was kept untreated to act as control. Treated seeds were sown in earth filled pots which were kept in the nursery under partial shade. To keep the soil moist, pots were watered as and when required. Diverse plant growth parameters such as plant height, fresh weight, dry weight, seedling growth were measured after 60 days of plant growth. The experimental data were statistically analyzed using the analysis of variance [10].

2.2. Caffeine as growth and germination inhibitors to *Borreria hispida* L. seeds

Effect of caffeine on *Borreria hispida* L. seeds were made in accordance with the standard methodology of Khursheed et al. [11] with little modifications. For this, healthy seeds of the common tea weed were pre-soaked on moistened whatman filter paper in sterile petridishes for 12 hours. Sterile distilled water (SDW) was used during the moistening of seeds. The seeds are then subjected to ten different concentrations of caffeine solution, as mentioned above for 48 hours using required number of sterile petridishes and filter papers to transfer them. Control seeds were soaked in water for the same period. After completion of the treatment period of 48 hours, seeds were thoroughly washed in SDW to reduce the residual effects of mutagen sticking to the seed coat. Treated seeds were sown in earth filled pots which were kept in the nursery under partial shade. To keep the soil moist, pots were watered as and when required. Three replications of 30-seeds each were sown for each treatment in pots to raise the M1 generation. For measuring the seedling height, 10 selected seedlings were removed from the pots with an intense care out of entire population.

3. RESULTS AND DISCUSSION

In the present investigation, caffeine reduced plant height as compared to the control (Fig. 1). Maximum reduction of plant height was recorded when the seeds of the test plant are treated with high doses of caffeine (1000 ppm). The study revealed the negative impact of caffeine at its maximum dose on *Borerria hispida* L. showing a reduction of plant height by 11.1 cm against control (Fig. 2). Similarly, plant biomass of the weed was also found to be reduced by 1.17 g against the control (Fig. 3). The controlled plant was found to be giving more promising results as compared to the test plants for all the tested concentrations. Montes et al. [12] established different doses of caffeine on the development and performance of pepper crops under greenhouse. The investigation suggests a highly variable influence of caffeine on the germination and development of different vegetable structures during the entire cultivation cycle over production period. Seed germination was also influenced due to caffeine treatments. After 48 hours of treatment application (Caffeine 1000 ppm concentration) the seedling growth was found to be delayed (Fig. 4a-4b) and leads to development of plants with comparatively low in biomass yield (both fresh weight and dry weight) and plant height as compared with the untreated control. Application of higher doses of caffeine may control the

germination of seedlings by limiting water uptake to embryos and thereby probably affects the cell wall extensibility or membrane rigidity by biophysical interaction with phospholipid. The results are in accordance with Leshem et al. [13] who too observed the interaction of allelochemical, ABA with membrane phospholipid content. The effect of some allelochemicals on seed germination of *Coronilla varia* L. seeds have been investigated by Isfahan and Shariati [7] and thereby established the influence of certain allelochemicals like caffeine, abscisic acid (ABA), in delaying the germination for a longer period.

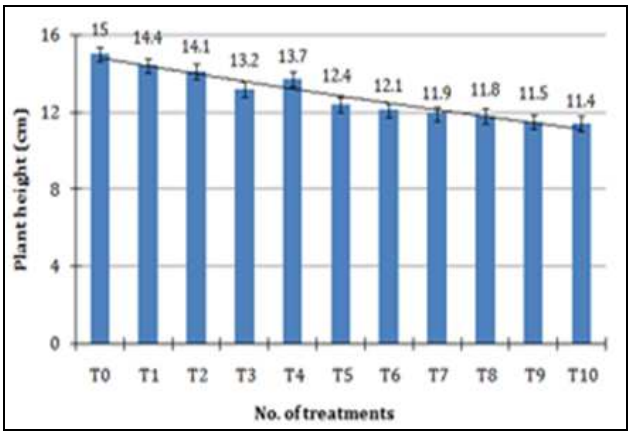

Figure 1. Effect of caffeine of different concentrations on plant height. Concentrations: T0: Control, T1; caffeine 100 ppm; T2; caffeine 200 ppm; T3; caffeine 300 ppm; T4; caffeine 400 ppm; T5; caffeine 500 ppm; T6; caffeine 600 ppm; T7; caffeine 700 ppm, T8; caffeine 800 ppm, T9; caffeine 900 ppm, T10; caffeine 1000 ppm.

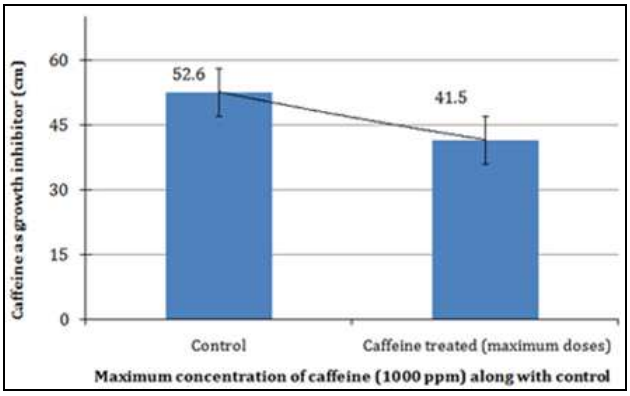

Figure 2. Effect of caffeine as growth inhibitor as compared with untreated control.

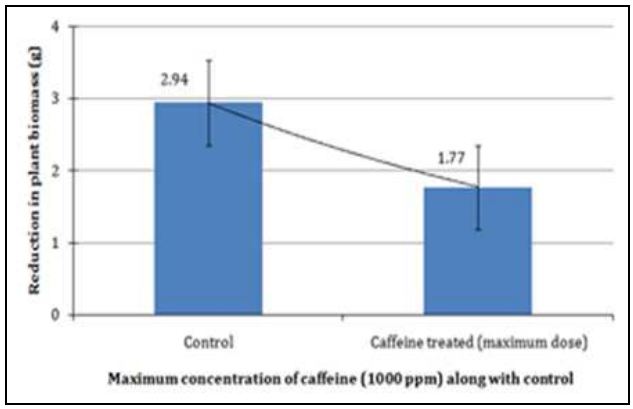

Figure 3. Effect of caffeine as plant biomass inhibitor as compared with untreated control.

Figure 4. Photo plates showing the inhibitory effect of caffeine (at its highest concentration 1000 ppm) as growth and germination inhibitor as compared with untreated control.

4. CONCLUSION

The study provides the evidence of existence of allelopathic syndrome in tea ecosystem. During the present investigation, we have observed the effect of caffeine as growth and germination inhibitors to popular tea weed, *Borreria hispida* L. Caffeine concentrations at a higher dose up to 1000 ppm are more inhibitory reducing the height and biomass production of the test plant. The results also indicated negative impacts of caffeine responsible for slow growth of the *Borreria hispida* L. seedlings as compared to untreated control.

AUTHOR'S CONTRIBUTION

AJT contributed in laboratory works, collection and identification of plants and related pot experiments. PNB assisted in the manuscript preparation and overall statistical design and associated analysis works. Literature review related to this manuscript

has been carried out by SPS. The final manuscript has been read and scrutinized by AJT, PNB and PD.

TRANSPARENCY DECLARATION

The authors declare no conflicts of interest.

ACKNOWLEDGEMENTS

The authors are thankful to the Director, Tocklai Tea Research Institute (TTRI), Tea Research Association (TRA), Jorhat, Assam, India for providing the necessary facilities to undertake the study. The authors also acknowledge the copious encouragements of Dr. B. K. Barthakur, Ex-Head, Mycology and Microbiology Deptt., TTRI, TRA, and Mrs. I. Phukan and Dr. S. Debnath for their suggestions during the experimental set up.

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