Volume: 5 Issue: 1 Pages: 118-121

Effect of *Calotropis gigantea* Extracts on Early Growth Performance and Soil Quality in Cluster Bean (*Cyamopsis tetragonoloba*)

[*1] SM Sangle and [2]Jyoti Phulambrikar

[*1] Department of Botany, PG Department and Research Centre, Government Institute of Science, Chhatrapati Sambhajinagar, Maharashtra, India.

Article Info.
E-ISSN: 2583-6528
Impact Factor (QJIF): 8.4
Peer Reviewed Journal
Available online:
www.alladvancejournal.com

Received: 18/Dec/2025
Accepted: 24/Jan/2026

***Corresponding Author**
SM Sangle
Department of Botany, PG Department and Research Centre, Government Institute of Science, Chhatrapati Sambhajinagar, Maharashtra, India.

Abstract
The present research article provides an integrated and critical evaluation of the allelopathic influence of *Calotropis gigantea* on germination, early seedling growth and soil health parameters of cluster bean (*Cyamopsis tetragonoloba* (L.) Taub.), an economically and ecologically significant legume crop. Aqueous extracts prepared from different plant parts of *C. gigantea* (leaf, stem and flower) were incorporated into soil under controlled conditions and their effects were compared with untreated control soil. Germination percentage, seedling height at different growth stages, and a comprehensive set of soil physico-chemical parameters were assessed. Results revealed differential, plant-part-specific effects: flower and leaf extracts showed moderate stimulatory effects on germination and early growth, whereas stem extract exerted strong inhibitory effects. Soil analysis indicated marked alterations in pH, electrical conductivity, organic carbon, macro- and micronutrient availability, bulk density, carbon stock and soil health index. A critical interpretation suggests that the allelochemicals present in *C. gigantea* mediate complex plant–soil feedbacks that can either suppress or transiently enhance crop performance depending on residue type and concentration. The study highlights both the ecological significance of *C. gigantea* in agroecosystems and the need for cautious evaluation before its biomass is considered for agronomic use.

Keywords: Allelopathy, *Calotropis gigantea*, Cluster bean, Soil health, Plant–soil interaction

Introduction

Cluster Bean: Agricultural and Economic Importance

Cluster bean (*Cyamopsis tetragonoloba* (L.) Taub.), commonly known as guar, is an annual leguminous crop predominantly cultivated in the arid and semi-arid regions of India, Pakistan and parts of Africa. India contributes nearly 80% of the global production, making guar a strategically important crop for national and international markets. The seeds are valued for guar gum, a galactomannan polysaccharide extensively used in food processing, pharmaceuticals, cosmetics, paper, textile, mining and oil drilling industries. In addition to its industrial relevance, guar improves soil fertility through biological nitrogen fixation, enhances soil structure and serves as fodder and green manure, thereby supporting sustainable agricultural systems.

Ecological Profile of *Calotropis Gigantea*

Calotropis gigantea (giant milkweed) is a perennial shrub or small tree belonging to the family Asclepiadaceae. It is widely distributed in tropical and subtropical regions, particularly in wastelands, roadsides, fallow fields and degraded soils. The plant is well adapted to harsh environmental conditions, including drought, salinity and nutrient-poor soils. Its ability to dominate disturbed habitats has been attributed to its robust physiology and production of a wide range of secondary metabolites such as cardenolides, alkaloids, flavonoids, phenolics and terpenoids.

Allelopathy and Plant–Soil Interactions

Allelopathy refers to the biochemical interaction among plants, wherein one plant releases compounds into the environment that influence the growth, development and survival of other plants. These allelochemicals may enter the soil through root exudation, leaching from leaves, volatilization or decomposition of plant residues. The effects of allelopathy are often mediated through soil processes, including changes in nutrient availability, microbial activity and physicochemical properties. Understanding allelopathic interactions is crucial for agroecological management, weed control and sustainable crop production.

Rationale and Significance of the Study

Despite extensive ethnobotanical and pharmacological research on *C. gigantea*, its influence on agricultural crops through soil-mediated allelopathic effects remains inadequately explored. In regions where *C. gigantea* coexists with crop plants or where its biomass is inadvertently incorporated into soil, understanding its impact becomes agronomically relevant. The present study was undertaken to critically assess how aqueous extracts of different plant parts of *C. gigantea* affect germination, early growth of cluster bean and key indicators of soil health.

The Specific Objectives of the Study were as Follows

1. To evaluate the effect of *C. gigantea* extracts on germination percentage of cluster bean.
2. To assess the influence of these extracts on early seedling growth.
3. To analyze changes in soil physico-chemical properties and nutrient status following extract incorporation.
4. To critically interpret the ecological and agronomic implications of the observed effects.

Allelopathy: Concept and Mechanisms

The concept of allelopathy was first proposed by Molisch (1937) and has since evolved into a key area of plant ecology and agronomy. Allelochemicals such as phenolic acids, flavonoids, alkaloids and terpenoids can interfere with physiological processes including cell division, membrane permeability, enzyme activity and nutrient uptake. The magnitude and direction of allelopathic effects depend on plant species, plant part, concentration of allelochemicals, soil type and environmental conditions.

Allelopathic Potential of *Calotropis* Species

Several studies have documented the inhibitory effects of *Calotropis* species on germination and growth of agricultural crops. Aqueous leaf extracts of *C. procera* and *C. gigantea* have been reported to suppress germination and seedling growth in cereals and legumes, attributed to high phenolic and cardenolide content. However, some studies indicate that low concentrations of extracts may stimulate growth, supporting the concept of hormesis.

Impact of Plant Residues on Soil Properties

Plant residues can significantly modify soil pH, organic carbon, nutrient cycling and microbial activity. While leguminous residues often enhance nitrogen availability, residues rich in phenolics may immobilize nutrients or inhibit microbial processes. The incorporation of allelopathic plant biomass into soil can thus have complex and sometimes contradictory effects on soil fertility and crop performance.

Research Gaps

Although isolated studies exist on the allelopathic effects of *Calotropis* species, comprehensive investigations integrating crop response and soil health parameters are limited. The present study addresses this gap by combining germination, growth and soil analyses within a single experimental framework.

Materials and Methods

Experimental Site and Materials

The experiment was conducted under controlled conditions using soil collected from the local region of Chhatrapati Sambhajinagar, Maharashtra. Seeds of cluster bean (*Cyamopsis tetragonoloba*) were used as the test crop. Fresh leaves, stems and flowers of *Calotropis gigantea* were collected from nearby wastelands.

Preparation of Aqueous Extracts

Fresh plant materials were washed, weighed (100 g each) and ground using mortar and pestle. The paste was diluted in 1 L of distilled water to prepare aqueous extracts. The extracts were incorporated into soil placed in plastic trays and allowed to equilibrate for 24 hours.

Experimental Design

Four treatments were maintained: control (distilled water), leaf extract, stem extract and flower extract. Each tray contained equal quantity of soil and was subdivided into partitions for uniform sowing. A total of 100 seeds per tray were sown and irrigated with distilled water.

Germination and Growth Observations

Germination percentage was recorded on the 5th day after sowing. Seedling height was measured on the 5th and 10th days using a standard scale.

Soil Analysis

Soil samples were analyzed for pH, electrical conductivity (EC), organic carbon, organic matter, available nitrogen, phosphorus, potassium, sulphur, micronutrients (Fe, Zn, Cu, B), bulk density, carbon stock and soil health index using standard analytical procedures.

Results

Germination Percentage

Flower extract treatment recorded the highest germination percentage (52%), followed by leaf extract (46%) and control (45%). Stem extract significantly reduced germination to 30%, indicating strong inhibitory effects.

Seedling Growth

On both the 5th and 10th days, seedlings grown in leaf and flower extract-treated soils exhibited greater mean height compared to control, whereas stem extract treatment consistently showed reduced growth.

Soil Physico-Chemical Properties

Soil pH increased under leaf extract treatment, while EC showed minor variations among treatments. Organic carbon and organic matter content declined in extract-treated soils compared to control. Stem extract treatment resulted in near-zero availability of several nutrients, indicating severe alteration of soil nutrient dynamics.

Discussion

Plant-Part-Specific Allelopathic Effects

The contrasting responses observed among treatments highlight the differential distribution of allelochemicals in various plant parts of *C. gigantea*. Leaves and flowers may contain compounds that at low concentrations stimulate growth, whereas stems appear rich in inhibitory metabolites.

Soil Health Implications

The drastic reduction in nutrient availability under stem extract treatment raises concerns regarding the incorporation of *C. gigantea* biomass into agricultural soils without proper evaluation. Changes in soil health index suggest that allelopathic effects extend beyond plant growth to influence overall soil quality.

Ecological and Agronomic Significance

The ability of *C. gigantea* to alter soil properties may contribute to its dominance in disturbed ecosystems. From an agronomic perspective, understanding these interactions is essential for weed management and sustainable land use.

Table 1: Effect of plant extracts on soil contains

S. No.	Parameters	Control	Leaf extract	Stem extract	Flower extract
1.	PH	7.61	8.38	7.86	7.42
2.	EC	0.18dS/m	0.09dS/m	0.11dS/m	0.20dS/m
3.	Organic Carbon	0.84w%	0.66w%	0.79w%	0.76w%
4.	Organic Matter	1.45w%	1.14w%	1.36w%	1.31w%
5.	Available Nitrogen	322kg/ha	186kg/ha	0.00kg/ha	195kg/ha
6.	Available Phosphorus	32.23kg/ha	38.38kg/ha	0.00kg/ha	7.83kg/ha
7.	Available Potassium	26.00kg/ha	26.25kg/ha	105.00kg/ha	27.17kg/ha
8.	Available Sulphur	29.16mg/kg	3.30mg/kg	0.00mg/kg	3.12mg/kg
9.	Available Copper	0.93 mg/kg	0.99 mg/kg	0.00 mg/kg	0.90 mg/kg
10.	Available Iron	4.18 mg/kg	4.19 mg/kg	0.00 mg/kg	4.14 mg/kg
11.	Available Zinc	1.15mg/kg	1.15mg/kg	0.00mg/kg	1.20mg/kg
12.	Available Boron	0.95mg/kg	0.92mg/kg	0.00mg/kg	0.97mg/kg
13.	Carbon Stock	100.8T/Ha	99.0T/Ha	94.8T/Ha	171T/Ha
14.	Soil Health Index	0.55	0.55	0.18	0.45
15.	Bulk Density	0.8 g/cc	01g/cc	0.8 g/cc	1.5 g/cc

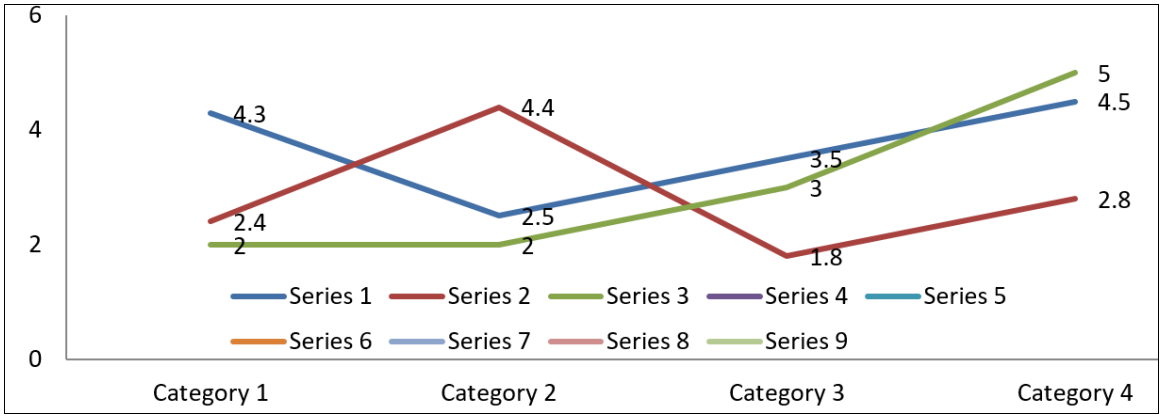

Fig 1: Analysis of Soil Parameters by Using Line Graph

a b

Fig 2: (a) (b) Growth of cluster bean in soil containing various extracts

Conclusion

The present investigation demonstrates that *Calotropis gigantea* exerts significant allelopathic effects on cluster bean growth and soil health, with responses strongly dependent on the plant part used. While leaf and flower extracts may exhibit mild stimulatory effects at low concentrations, stem extracts are highly inhibitory and detrimental to soil nutrient status. These findings underscore the complexity of plant–soil interactions and the need for cautious utilization of allelopathic plant resources in agriculture.

References

1. Ahloowalia BS, Maluszynski M. Induced mutations-A new paradigm in plant breeding. Euphytica. 2001; 118:167-173.

2. Dhugga KS. *et al*. Guar seed beta-mannan synthase is a member of the cellulose synthase super gene family. Science. 2004; 303:363-366.
3. Kays SE, Morris JB, Kim Y. Total dietary fiber variation in guar. *Journal of Food Quality*. 2006; 29:383-391.
4. Molisch H. Der Einfluss einer Pflanze auf die andere. Jena, 1937.
5. Rice EL. Allelopathy. Academic Press, 1984.
6. Prabaharan M. Guar gum as drug delivery system. *Int. J. Biol. Macromol.* 2011; 49:117-124.
7. Kharkwal MC. Plant mutagenesis in crop improvement. CABI, 2012.
8. Francois LE. *et al*. Salinity effects on guar. *Agron. J.*,. 1990; 82:587-592.
9. Morris JB. Legumes: nutraceutical uses. Marcel Dekker, 2004.
10. Arora RN. *et al*. Mutagenesis in guar. *Plant Mutation Reports*. 2008; 2:1-6.
11. Roychowdhury R, Tah J. Mutagenesis for crop improvement. Springer, 2013.
12. Kharkwal MC. *et al*. Mutation breeding in legumes. ISGPB, 2008.
13. Lingakumar K, Kalandaivelu G. Growth responses in guar. *Photosynthetica.* 1998; 35:335-343.
14. Singh VP, Aggarwal S. High yielding mutants in guar. *Indian J. Agric. Sci.*,. 1986; 56:695-700.
15. Wani MR. *et al*. Mutation breeding in pulses. Springer, 2014.
16. Das B, Arora SK. Guar seed chemistry. Forage Res, 1978.
17. Goldstein AM, Alter EN. Guar gum. Industrial Gums, 1959.
18. Nerkar YS. Induced variation in legumes. *Indian J. Genet,* 1972.
19. Shu QY. *et al*. Plant mutation breeding. CABI, 2012.
20. Vig BK. Cytomorphology of guar. Sci. & Cult, 1965.
21. Pandey RN, Pawar SE. Induced mutations in legumes, 1998.
22. Stafford RE. Genetic traits in guar. Crop Sci, 1988.
23. Yadav SL. Evaluation of M3 progenies in guar. *Indian J. Genet,* 2004.
24. Kumar A. *et al*. Antidiabetic properties of cluster bean, 2013.
25. Rice EL. Biological control of weeds and plant diseases. CRC Press, 1995.