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Allelopathic influence of *Senna uniflora* on morphological traits of *Vigna mungo* (Black gram)

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Abstract
The present study entitled *"*Allelopathic Influence of *Senna uniflora* on Morphological Traits of *Vigna mungo"* was conducted at JSA College of Agriculture and Technology, Cuddalore, to evaluate the allelopathic effects of plant part extracts of *Senna uniflora* on black gram (*Vigna mungo*). The experiment was laid out in a Randomized Block Design (RBD) with three replications and four treatments: leaf extract (T_1), stem extract (T_2), root extract (T_3), and control (T_4), with each extract prepared using 50 g of plant material in 50 ml of distilled water.The results revealed that the leaf extract (T_1) significantly inhibited seed germination and seedling growth of black gram compared to the control. Shoot length, root length, fresh weight, dry weight, seedling vigour indices (SVI-I & SVI-II), and response index were all adversely affected. In contrast, stem and root extracts (T_2 and T_3) showed negligible effects on seed germination and seedling growth. The study concludes that allelochemicals are likely concentrated in the leaves of *Senna uniflora*, causing phytotoxic effects on black gram.

Keywords: *Senna uniflora*, black gram (*Vigna mungo*), allelopathy, germination inhibition

1. Introduction
The term allelopathy was first coined by Australian plant physiologist Hans Molisch in 1937. It is derived from the Greek words *"allelon"* (mutual) and *"pathy"* (harm). Allelopathy refers to the direct or indirect, beneficial or harmful effects of one plant on another through the release of allelochemicals, which are phytotoxic substances that can inhibit germination and growth. According to Musa (2017) [3], allelopathy involves both stimulatory and inhibitory effects via secondary compounds released by plants into their surroundings.

Pulses are a vital source of protein in India. However, the per capita availability (42g/day) is below the required level (60g/day for men, 55g/day for women). India ranks first globally in both area (35%) and production (25%) of pulses, with 24 million hectares producing 16.5 million tonnes (FAO, 2016; Dr. J. Vasanthakumar, 2016) [1, 9]. Despite this, productivity remains low at 650 kg/ha, compared to the world average of 909 kg/ha.

In Tamil Nadu, black gram (46%) occupy around 71% of the pulse area. However, yields are lower than the national average due to constraints such as lack of high-yielding varieties, poor seed quality, and low seed replacement rate (SRR) (Dr. J. Vasanthakumar, 2016) [9].

Black gram (*Vigna mungo*), also known as urad dal, is a key pulse crop in India, grown nationwide. It belongs to the Leguminosae family and is resilient to adverse climatic conditions, enhancing soil fertility by fixing atmospheric nitrogen. It contains about 26% protein, nearly three times that of cereals, along with essential minerals and vitamins. It contributes to soil enrichment by fixing around 22.10 kg N/ha, equivalent to 59,000 tonnes of urea annually. India is the largest producer and consumer of black gram, which makes up 10% of the country's total pulse production (Narayan & Kumar, 2015) [4].

Senna uniflora (Mill.) - A Botanical Overview
Senna uniflora (Mill.) H.S. Irwin & Barneby is an annual, woody, erect herb, commonly known as one-leaf senna or single-flowered senna. The genus name *Senna* is derived from the Arabic word for a thorny bush, while *uniflora* means "single-flowered" in Latin.

Distribution

- **Global:** Found in tropical South America, Brazil, West Indies, Mexico, and India.
- **India:** Reported in Thrissur district, Kerala**.** (Dr. N. Sasidharan, KFRI, Peechi)

Habitat

- Grows in plains, wastelands, and bushy hillsides.
- Occurs in both moist and dry open areas.
- Commonly seen at elevations of 200-1,000 meters.
- Often found as a weed in cultivated lands. (Dr. N. Sasidharan; Standley & Steyermark)

Morphological Description

Habit

- Annual, erect woody herb, about 1 meter tall.
- Young stems are striated and reddish hairy (*rufous pilose*), becoming glabrous (smooth) with age.
- Stipules: 6-8 mm, lanceolate, hairy on both sides, and persistent.

Leaves

- Pinnately compound, alternate, 7-10 cm long.
- Leaflets in 3-5 pairs; shapes range from ovate-lanceolate to oblanceolate or obovate.
- Upper surface: sparsely hairy near apex.
- Lower surface: densely hairy, especially along veins.
- Petiole: 1.8-2 cm long with stalked yellow glands between leaflet pairs (except terminal).

Inflorescence and Flowers

- **Inflorescence:** Axillary racemes with short, hairy peduncles and pedicels.
- **Flowers:**
- Yellow, 6-7 mm long, bracteate.
- **Sepals:** 5, unequal, boat-shaped, pubescent.
- **Petals:** 5, unequal, obovate or oblong, prominently veined.
- **Stamens:** 10 (including 2 large anthers); all dehisce through terminal pores.
- **Staminodes:** 3, sterile.
- **Pistil:** Hairy ovary with 7-9 ovules, pubescent style, and trumpet-shaped stigma.

Fruits and Seeds

- **Pods:** Straight, quadrangular, 25-30 mm long, hairy, wrinkled, and constricted between seeds.
- **Seeds:** 6-9 per pod, dark brown, rhomboid to subquadrangular, glabrous.

Flowering & Fruiting Period

- From August to December.

Agroforestry and Ecological Relevance

- In India, *Senna uniflora* is cultivated to suppress the invasive weed Parthenium hysterophorus.
- Despite being in the Fabaceae family, the species does not fix atmospheric nitrogen, as it lacks a symbiotic relationship with nitrogen-fixing bacteria.
- Within its native range, the plant is also considered a weed.

2. Pharmacological and Environmental Significance of *Senna uniflora*

Several studies have explored the pharmacological and ecological properties of *Senna uniflora* (Mill.) H.S. Irwin & Barneby:

Phytochemical and Antioxidant Properties

L.P. Kothapalli (2017) [2] reported the presence of important phytochemicals in the leaf extract of *Senna uniflora*. The extract demonstrated significant antioxidant activity, and its gel formulation also showed promising potential as a natural source of antioxidants.

Antimicrobial and Phytochemical Studies

T. Jothirathinam and V.D. Victor (2016) conducted a study on the phytochemical constituents and antimicrobial activity of *Senna uniflora*. Their findings suggest the plant's potential in traditional medicine due to its bioactive compounds, offering health applications at an affordable cost. Additionally, the benzene and alcohol extracts of the plant were analyzed for their ability to remove copper from aqueous solutions, highlighting its application in environmental remediation.

Allelopathic and Autotoxic Effects

J.A. Kumari and P. Prasad (2018) investigated the allelopathic and autotoxic effects of *Senna uniflora*, contributing valuable insights into its ecological interactions and potential impact on plant growth dynamics.

3. Materials and methods

The experiment was carried out at JSA College of Agriculture and Technology (TNAU Affiliated), Thittagudi, Tamilnadu, India during 2021-2022 to study and evaluate the allelopathic chemical screening of aqueous extract of leaf, stem and root of *Senna uniflora.*

3.1. Experiment Details

Collection and Preparation of Plant Extracts:

Fresh leaf, stem, and root parts of *Senna uniflora* were collected from the field of JSA College of Agriculture and Technology. The study was conducted in the Agronomy Laboratory. The plant materials were cleaned thoroughly to remove soil and debris.

Each plant part was processed as follows:

- **Leaf extract**: 50 g of leaves were crushed and soaked in 50 ml of distilled water.
- **Stem extract**: 50 g of stems were crushed and soaked in 50 ml of distilled water.
- **Root extract**: 50 g of roots were crushed and soaked in 50 ml of distilled water.

All samples were soaked for 24 hours, after which the aqueous extracts were filtered and used for allelopathic bioassay.

Allelopathic Bioassay Using Green Gram and Black Gram Seeds the allelopathic effect of *Senna uniflora* extracts was tested on the seeds of green gram and black gram. The roll towel method was employed for the germination test.

- Seeds were placed on germination sheets soaked with the prepared aqueous extracts:
- **T_1**: Leaf extract
- **T_2**: Stem extract

- **T_3**: Root extract
- **T_4**: Distilled water (Control)
- Extracts were reapplied every 24 hours to keep the sheets moist and avoid drying.
- After 7 days, the number of germinated seedlings was recorded for each treatment.

Measurement of Seedling Growth Parameters

- Fresh weight of the seedlings was recorded immediately after 7 days.
- For dry weight, the germinated seedlings were placed in a hot air oven at 100°C until completely dried, and the weight was then measured.

3.2. Treatment details

Table 1: Leaf, stem, root, water, extracts

Treatment	Extracts of plant parts	Distilled water
(T_1) Leaf extract	50g leaf sample	50ml
(T_2) Stem extract	50g stem sample	50ml
(T_3) Root extract	50g root sample	50ml
(T_4) Distilled water	-	50ml

3.3. Observation recorded

3.3.1. Germination percentage (%)

The seeds were considered as germinated when it's radicle was about 2mm long, and the germination percentage was determined by counting the number of germinated seeds on the 7th day after sowing (DAS).After final count, Germination percentage (GP%) was calculated by using the following formula (Raun *et al.*, 2002) expressed as percent.

Germination percentage (%) = number of germinated seeds/number of seeds kept for germination ×100

3.3.2. Shoot length (cm)

After 7 DAS, seedlings from each extracts were carefully removed and the Seedling shoot length was measured from the collar region to the top of the longest leaf and expressed as cm.

3.3.3. Root length (cm)

The root length of the seedlings was measured from the base of the stem to the tip of the longest root and expressed as cm.

3.3.4. Fresh weight (mg)

After measuring the root length and shoot length of the seedlings, the fresh weight should be measured by using the weighing balance and expressed as mg.

3.3.5. Dry weight (mg)

After that the seedlings was placed on hot air oven to drying up, then the dry weight of the seedlings were measured by using weighing balance and expressed as mg.

3.3.6. Seedling vigour index I - [standard germination% × seedling length (cm)]

3.3.7. Seedling vigour index II - [standard germination% × seedling dry weight (mg)]

The vigour index of the seedlings was calculated using the following formula proposed by Abdul- Baki and Anderson (1973) and expressed as percent were evaluated.

3.3.8. Response Index (RI) were determined as follows (Richardson and Williamson, 1988)

- If T > C, RI = 1 - (C/T)
- If T = C, then RI = 0
- If T < C, then RI = (T/C) 1

Whereas, T is treatment and C is control. A negative RI reflects in output of seedling (germination (%), shoot length (cm), root length (cm), fresh weight (mg), and dry weight (mg)) of black gram & green gram seedlings in treatment relative to output in control.

The experiment was carried out at JSA College of Agriculture and Technology (TNAU Affliated), Tittagudi, Tamil Nadu, India during 2021-2022 to study the morphological traits and allelopathic chemical screening of *Senna uniflora*. The results obtained from the experiment are discussed in this chapter.

4. Results

4.1. Germination Percentage (%)

The germination experiment was conducted using Black gram seeds. All seeds germinated successfully except those treated with the leaf extract (T_1). The highest germination rate (100%) was observed in seeds treated with stem extract (T_2) and root extract (T_3), as well as in the control (T_4). The lowest germination rate (80%) was recorded in the leaf extract treatment (T_1). The overall germination percentage across all treatments was calculated as 93.33%.

4.2. Shoot Length (cm)

Shoot length varied among the different treatments:

- Leaf extract (T_1): 8.15 cm
- Stem extract (T_2): 10.10 cm
- Root extract (T_3): 12.76 cm
- Control (T_4): 10.24 cm

The maximum shoot length was recorded in the root extract (T_3), while the minimum was in the leaf extract (T_1) treatment.

4.3. Root Length (cm)

Root length also showed variation with treatments:

- Leaf extract (T1): 5.74 cm
- Stem extract (T2): 6.61 cm
- Root extract (T3): 11.99 cm
- Control (T4): 6.10 cm

The longest root was observed in seedlings treated with root extract (T_3), and the shortest in those treated with leaf extract (T_1).

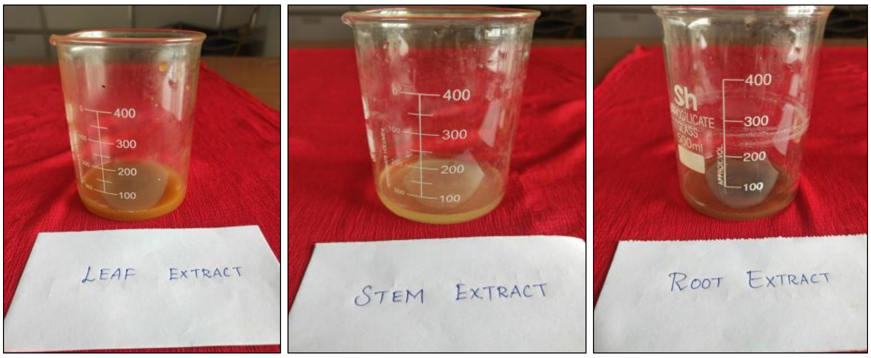
Table 1: Inhibitory effect of *Senna uniflora* parts on black gram

Treatment	Germination (%)	Shoot length (cm)	Root length (cm)	Fresh weight (mg)	Dry weight (mg)	Seedling vigour index-I	Seedling vigour index-II
Black gram	93.33±6.66	10.33±1.33	8.11±1.95	0.25±0.02	0.02±0.002		2.14659
Distilled water	100±0	9.97±0.27	7.55±1.45	0.28±0.015	0.026±0.002	1752	2.6

Table 2: Response index values for allelopathic effect of *Senna uniflora* parts on black gram

Treatment	Germination (%)	Shoot length (cm)	Root length (cm)	Fresh weight (mg)	Dry weight (mg)
Black gram	93.33±6.66	10.33±1.33	8.11±1.95	0.25±0.02	0.02±0.002
Distilled water	100±0	9.97±0.27	7.55±1.45	0.28±0.015	0.026±0.002

Extract Preparation of *Senna uniflora*



Extracts of *Senna uniflora* parts & its germination on black gram

5. Discussions

5.1. Allelopathic Effect of *Senna uniflora* on Germination Percentage

Different plant extracts of *Senna uniflora* were tested for their allelopathic effect on the germination of black gram seeds. Among the treatments, the highest germination percentage was observed in the control (T_4), while the lowest was recorded in the leaf extract treatment (T_1). The stem (T_2) and root (T_3) extracts did not show significant allelopathic effects on germination when compared to the control.

The reduced germination observed in the leaf extract treatment may be attributed to a higher concentration of allelochemicals, which likely interfered with the normal germination process. The inhibitory effect on seed germination suggests that the leaves of *Senna uniflora* contain more potent allelochemicals than the stem and root parts.

5.2. Allelopathic Effect of *Senna uniflora* on Seedling Length: The seedling length of black gram varied across treatments with different plant extracts. Among them, root extract (T_3) promoted better seedling growth than the control (T_4). In contrast, the leaf extract (T_1) exhibited the most pronounced inhibitory effect, reducing both shoot and root lengths.

Notably, the inhibition was more severe in root length than in shoot length, indicating that the allelochemicals present in the leaf extract of *Senna uniflora* may have a stronger suppressive effect on the root development of black gram seedlings.

5.3. Allelopathic Effect of *Senna uniflora* on Seedling Vigour: Seedling vigour was found to decrease with increased concentrations of allelochemicals. In this study, the lowest seedling vigour was recorded in the leaf extract treatment, while the highest was observed in the control group.

This suggests that the allelochemicals present in the leaf extract significantly reduced seedling vigour. The order of seedling vigour among treatments indicates that black gram seedlings were most vigorous in the control (T_4), followed by root (T_3), stem (T_2), and least in the leaf extract (T_1).

6. Conclusions

The study clearly demonstrates that different parts of *Senna uniflora* exhibit varying degrees of allelopathic effects on black gram (*Vigna mungo*). Among all treatments, the leaf extract (T_1) showed the strongest inhibitory effect, significantly reducing germination percentage, seedling length (especially root length), and seedling vigour. This suggests that the leaves of *Senna uniflora* contain a higher concentration of allelochemicals compared to the stem and root.

In contrast, the root extract (T_3) not only showed no inhibitory effect but even slightly enhanced seedling growth when compared to the control (T_4), indicating its relatively non-toxic or possibly growth-promoting nature under the conditions tested.

Overall, the findings highlight the potential allelopathic impact of *Senna uniflora* leaf extract on crop species in black gram. These results emphasize the need for careful management of *Senna uniflora* in agricultural fields, especially during the early germination and seedling stages of susceptible crops.

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