



Effects of microplastic contamination on growth and physiological responses of *Lablab purpureus* (L.) Sweet seedlings

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Abstract

This study investigates the effects of microplastic contamination on the growth and physiological parameters of *Lablab purpureus* (L.) Sweet seedlings. Seedlings were exposed to different concentrations of microplastics (0%, 0.5%, 1%, and 2%) and assessed after three weeks of germination. A significant decline in growth parameters was observed as microplastic concentration increased. Root length decreased from 17.1 cm in the control to 12.5 cm at 2% concentration, while shoot length declined from 16.2 cm to 12.2 cm in (2%) concentration. Fresh and dry biomass also showed a marked reduction, indicating inhibited plant growth and biomass accumulation. Moisture content remained relatively high across treatments (81.65% to 87.56%), whereas dry matter content decreased in microplastic-treated plants. Chlorophyll content exhibited only minor variation, suggesting a limited effect on photosynthetic pigments. Overall, the results demonstrate that microplastic contamination adversely affects plant growth and biomass accumulation, while having comparatively minimal impact on moisture retention and chlorophyll content. These findings highlight the potential ecological risks of microplastic pollution to plant development and agricultural productivity

Keywords: Biomass, chlorophyll, environmental stress, *Lablab purpureus* (L.) sweet, microplastics, plant growth

Introduction

The extensive usage of plastic materials and their inappropriate disposal have made plastic pollution a serious worldwide environmental concern. Microplastics (MPs), which are commonly described as plastic particles smaller than 5 mm in diameter, are created when massive plastic trash breaks down over time due to physical, chemical, and biological processes. These particles are now widely dispersed throughout terrestrial ecosystems, especially in agricultural soils where they come from fertilizers, irrigation systems, sewage sludge, plastic mulching films, and atmospheric deposition. Concerns regarding microplastics possible effects on soil quality, plant growth, and food security are raised by their ongoing accumulation in soil (Tatum *et al.*, 2025)^[6]. The importance of agricultural soils as microplastic reservoirs is becoming more well acknowledged. Terrestrial environments acquire significant amounts of plastic leftovers from farming activities, in contrast to marine systems that have been thoroughly investigated. Plant development may be impacted by these microplastics ability to change soil structure, water retention capacity, nutrient availability, and microbial activity. According to studies, microplastics may alter the physicochemical characteristics of soil, including pH, electrical conductivity, and moisture content, which could have an impact on the dynamics of plant growth and seed germination (Zhang *et al.*, 2025)^[9].

Important phases of the plant life cycle, such as seed germination and early seedling growth, are extremely vulnerable to environmental stressors. By changing soil aeration, water availability, or by releasing hazardous compounds and chemicals produced from plastic, microplastics in soil can disrupt germination processes. Certain microplastics have been shown in experiments to decrease early plant growth and prevent seed germination. For instance, it has been demonstrated that polyethylene

microplastics considerably inhibit perennial ryegrass seed germination and seedling development, particularly at greater concentrations and smaller particle sizes (He *et al.*, 2023). Microplastics may also affect physiological and biochemical reactions during early plant growth, according to research on crop species including cotton and rice. Polystyrene microplastics have been shown to impact root development and trigger oxidative stress reactions in rice seedlings, underscoring the potential harm that microplastics may do to plants. These results imply that crop yield and ecosystem sustainability may be at risk due to microplastic pollution in agricultural soils (Shorobi *et al.*, 2023)^[5].

The potential of leguminous crops to increase soil fertility through biological nitrogen fixation makes them particularly significant in agriculture. The hyacinth bean, or *Lablab purpureus* (L.) Sweet is a multipurpose legume that is commonly grown in tropical and subtropical areas for soil improvement, food, and fodder. The crop is prized for its high nutritional value, resistance to drought, and capacity to adapt to a variety of environmental circumstances. Although this species is important for agriculture, little is known about how new contaminants like microplastics affect its early development and germination. Evaluating the ecological consequences of plastic contamination in agricultural systems requires an understanding of the relationship between microplastics and plant growth. Thus, the goal of this study is to examine how soil polluted with microplastics affects *Lablab purpureus* (L.) Sweet seed germination and seedling growth. In particular, the study assesses early seedling development responses and germination parameters at different microplastic contamination levels. The results of this study could help us better understand how microplastics may affect agricultural productivity and sustainable soil management (Boots *et al.*, 2019)^[1].

Materials and Methods

The purpose of the current study was to assess how *Lablab purpureus* (L.) Sweet seed germination and seedling growth are affected by soil polluted with microplastics. A completely randomized design (CRD) was used in the experiment, and soil was mixed with varying amounts of microplastics. Many researchers have studied the effects of microplastics on plant development and germination in controlled conditions, employing similar experimental techniques. To prevent environmental variability, the experiment was conducted in a controlled laboratory setting with consistent temperature, humidity, and photoperiod (Li *et al.*, 2025).

Scientific classification

Kingdom: Plantae

Order: Fabales

Family: Fabaceae

Subfamily: Faboideae

Genus: *Lablab*

Species: *Lablab purpureus* (L.) Sweet



Fig 1: Twig of *Lablab purpureus* (L.) Sweet

Plant Material

Healthy, uniform seeds of *Lablab purpureus* (L.) Sweet (hyacinth beans) were collected from the village field. Seeds were stored in sterile containers at room temperature until use. Before the experiment, seeds were sterilised to prevent microbial contamination (Huang *et al.*, 2020) [3]. Seeds were sterilised using the following method: first, they were washed with distilled water.

Surface sterilisation was done using 70% ethanol for 1 minute. Seeds were rinsed 3 - 4 times with sterile distilled water.

Soil Collection and Preparation

Agricultural Soil was collected from the Botanical Garden of the Gujarat University campus. A pesticide free field's top 0 – 15 cm of soil was used to gather agricultural soil was the method used. The soil was processed using the steps:

first, the soil was dried at room temperature. Plant debris and stones were cleared out. To achieve a consistent soil texture, the soil was passed through a 2 mm sieve to remove dirt (Wang *et al.*, 2020) [7].



Fig 2: *Lablab purpureus* (L.) Sweet Brown seeds

Preparation of Microplastic Contaminated Soil

Microplastics at different concentrations were mixed into the soil to simulate contaminated soil conditions. The microplastic powder was prepared from particles of different sizes and plastic materials. Grind into fine microplastic powder. Soil and microplastics were properly combined to give a uniform distribution. Microplastics were added to soil at concentrations ranging from T₀ – Control (0%), T₁ – 0.5% w/w, T₂ – 1% w/w, T₃ – 2% (w/w) to study how plants react in controlled and microplastic contaminated environments as a method used (Zhu *et al.*, 2019) [10].

Experimental Setup

Pots were filled with a mixture of soil and microplastics with different concentrations. Each pot contained 500g of the prepared soil. Two seeds of *Lablab purpureus* (L.) Sweet were sown in each pot. The seeds were inserted into the soil around 1-2 cm deep. Five pots were prepared for each concentration.

Calculation

Germination Percentage of *Lablab purpureus* (L.) Sweet in Microplastic Contaminated Soil

One of the most crucial early phases of a plant's life cycle is seed germination, which is extremely susceptible to environmental stressors. In this study, the percentage of *Lablab purpureus* (L.) Sweet seeds that germinated across various concentrations of soil-mixed polyethene microplastics was assessed. Germination percentage is calculated using the formula:

$$\text{Germination Percentage} = \frac{\text{Number of germinated seeds}}{\text{Total Numbers of seeds}} \times 100$$

Table 1: Germination percentage of *Lablab purpureus* (L.) Sweet in Microplastic Contaminated Soil

Treatment	Concentration	Total number of seeds	Number of Germinated Seeds	Germination %
T0	Control (0%)	10	10	100
T1	0.5 %	10	10	100
T2	1%	10	10	100
T3	2%	10	10	100

Germination of the *Lablab purpureus* (L.) Sweet seeds were found to be 100% among all the treatments. Microplastic concentration did not significantly affect germination when observed, which shows microplastics did not stop the germination process during the experimental conditions.

Measurement of Seedling Growth

After germination, the seedling growth parameters of the healthy and well-developed plants of each concentration were measured. Morphological parameters like Root length (cm), Shoot length (cm), Fresh weight, Dry weight, Moisture content, Chlorophyll content, and Water content.

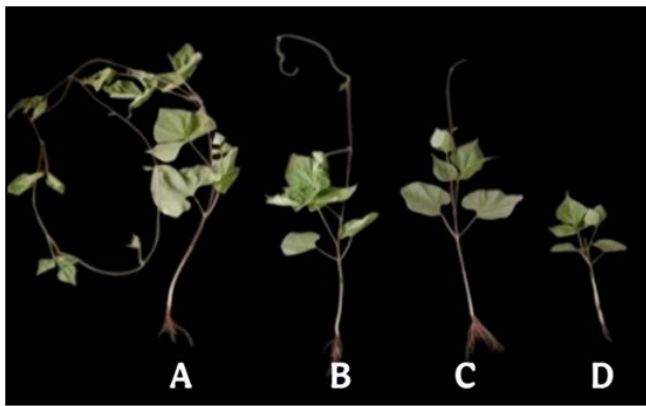


Fig 3: Length of shoot and root of the plants of different concentrations of microplastics in soil. A – T₀ Control (0%), B – T₁ 0.5%, C – T₂ 1%, D – T₃ 2%.

1. Root Length

An essential metric for assessing how environmental stress affects seedling development is root length. Since roots are the first parts of a plant to come into contact with soil pollutants, the presence of microplastics in the soil can have a significant impact on their growth. Microplastics may change the structure of the soil, decrease the amount of water available, and obstruct the intake of nutrients, all of which can prevent roots from growing longer. In this study, the root length of *Lablab purpureus* (L.) Sweet seedlings was assessed in soils with varying microplastic concentrations after 3 weeks of germination. The findings demonstrated a progressive decline in root growth as the concentration of microplastics increased. The treatment with the highest concentration of microplastics produced the shortest roots, whereas the control treatment, which did not include any microplastics, displayed the longest roots.

Table 2: Root length of all the treatments

Treatment	Concentration	Root length (cm)
T0	Control (0%)	17.1 cm
T1	0.5 %	16.5 cm
T2	1%	14.6 cm
T3	2%	12.5 cm

According to these results, root development is adversely affected by rising microplastic contamination levels. Reduced root growth may restrict the plant's capacity to absorb nutrients and water, which would ultimately have an impact on the general health and productivity of the plant.

2. Shoot Length

Shoot length is another crucial measure of seedling health and early plant development. The stem and growing leaves, which are in charge of photosynthesis and plant growth, make up the shoot system. Shoot growth may be indirectly impacted by any environmental condition that affects the roots. The current study examines the shoot length of *Lablab purpureus* (L.) Sweet seedlings at varying concentrations of microplastics. Shoot growth declined as the amount of microplastics in the soil increased, much like root length. Nonetheless, the decrease in shoot length was less pronounced than that in root length, indicating that roots are more vulnerable to microplastic pollution in the soil.

Table 3: Shoot length of all the treatments

Treatment	Concentration	Shoot Length (cm)
T0	Control (0%)	16.2 cm
T1	0.5 %	15.9 cm
T2	1%	13.3 cm
T3	2%	12.2 cm

The results show that microplastic pollution can prevent shoot elongation, perhaps as a result of the roots decreased absorption of nutrients and water. Reduced biomass accumulation and lower plant productivity could result from this drop in shoot growth.

3. Fresh Weight

Fresh weight is the mass of the plant or plant parts immediately after harvesting, including the water present in plant tissues. Since plants contain 60 – 90% water, fresh weight mainly reflects total biomass plus water content. Fresh weight mostly represents total biomass + water content.

The procedure used to remove the seedlings from the soil was done carefully so the roots of the plants would not be damaged. Roots were washed with distilled water to get rid of the soil and dirt. Gently blot with tissue paper. The whole plant was taken to get its fresh weight using a digital balance. The weight was recorded in the unit of grams (g).

Table 4: Fresh weight of all the treatments

Treatment	Concentration	Fresh Weight (g)
T0	Control (0%)	10.9 g
T1	0.5 %	4.1 g
T2	1%	3.4 g
T3	2%	1.4 g

The fresh weight of plants decreased with increasing concentration of the microplastics. The lowest was observed at 2% concentration (1.4 g), and the highest fresh weight was recorded in the Control (10.9 g). The average fresh weight was found to be 4.95 per seedling.

4. Dry Weight

Dry weight is the mass of plant material that has been oven-dried to remove all moisture. It depicts the actual biomass of plants without water.

The procedure used to take the dry weight was as follows: Once the fresh weight was determined, the seedlings were put in paper envelopes. Dry for 48 – 72 hours at 60 – 70°C in a hot air oven. Dry till the weight became consistent. Samples were chilled in a desiccator. Use an analytical balance to weigh.

Table 5: Dry weight of all the treatments

Treatment	Concentration	Dry Weight (g)
T0	Control (0%)	2.0 g
T1	0.5%	0.51 g
T2	1%	0.51 g
T3	2%	0.20 g

The dry weight of plants decreased with increasing concentration of microplastics. The lowest was recorded at 2% concentration (0.20 g), and the highest dry weight was observed in the Control (2.0 g). The average dry weight was found to be 0.805 g per seedlings

5. Water Content

Water content (%) was calculated using the formula:

$$\text{Water content (\%)} = \frac{[(\text{Fresh weight} - \text{Dry weight}) / \text{Fresh weight}] \times 100$$

Table 6: Water Content of all the treatments

Treatment	Concentration	Water Content (%)
T0	Control (0%)	81.65%
T1	0.5 %	87.56%
T2	1%	85.00%
T3	2%	85.71%

The water content of plants decreased with increasing concentration of microplastics. The lower values were recorded at control (81.65%), and the highest water content was observed in the 0.5% (87.56%).

6. Dry Matter Content

Dry matter content (%) was calculated using the formula:

$$\text{Dry matter content (\%)} = (\text{Dry weight} / \text{fresh weight}) \times 100$$

Table 9: Chlorophyll Content of all the treatments

Treatment	Concentrations	Chl-a (mg g ⁻¹)	Chl-b (mg g ⁻¹)	Total chlorophyll (mg g ⁻¹)
T0	0% (control)	0.50	0.38	0.88
T1	0.5%	0.50	0.58	1.07
T2	1%	0.49	0.59	1.08
T3	2%	0.49	0.59	1.09

Results

The current study assessed that there were no effects of microplastics contaminated on germination and early seedling growth of *Lablab purpureus* (L.) Sweet seeds, 100% growth was seen across all the treatments. Whereas the growth parameters show a progressive decrease in both root and shoot length with increasing microplastic concentration in the soil. Length of the root was decreased from 17.1 cm in the control (0%) to 12.5 cm at (2%) concentration. The same result was seen in shoot length; the shoot length was decreased from 16.2 cm in the control

Table 7: Dry Matter of all treatments

Treatment	Concentration	Dry Matter (%)
T0	Control (0%)	18.34%
T1	0.5 %	12.43%
T2	1%	15%
T3	2%	14.28%

The dry matter content of plants varied with increasing concentration of microplastics. The lower values were recorded at the concentration 0.5% (12.43%), and the highest dry matter content was observed in the control (18.34%).

7. Chlorophyll Content

The acetone extraction procedure was used to determine the chlorophyll content, and spectrophotometric analysis was then performed. 0.5 g of fresh leaf samples were homogenized in 10 mL of 80% acetone before being centrifuged. A UV-Vis spectrophotometer was used to determine the supernatant's absorbance at 663 and 645 nm. The Lichtenthaler equations were used to compute total chlorophyll, chlorophyll a, and chlorophyll b. This technique is frequently used to assess changes in photosynthetic pigments under stressful environmental conditions, like microplastic pollution.

The procedure was carried out properly, 0.5 g fresh leaf tissue for each treatment, Control (0%), T0 (0.5%), T1 (1%), T2 (2%) was taken, and grinded in a mortar with 10 ml acetone. The homogenized was then centrifuged at 2160 rpm for 5 to 10 minutes. The supernatant was collected, and the final volume was made up to a known volume with 80% acetone. The absorbance of the extract was measured using a spectrophotometer at 663 nm and 645 nm for chlorophyll a, chlorophyll b, and total chlorophyll, which were calculated using standard equations.

$$\text{Chlorophyll a} = (12.7 \times A_{663} - 2.69 \times A_{654}) \times V / (1000 \times W)$$

$$\text{Chlorophyll b} = (22.9 \times A_{645} - 4.68 \times A_{663}) \times V / (1000 \times W)$$

$$\text{Total chlorophyll} = (20.2 \times A_{645} + 8.02 \times A_{663}) \times V / (1000 \times W)$$

Whereas, A = absorbance at respective wavelengths,

V = total volume of the chlorophyll content (mL)

W = weight of the leaf extract in (gm).

(0%) to 12.2 cm at a (2%) concentration. The result suggests that the decrease in the length of the roots is more adversely affected by microplastics, which block the passive uptake of and nutrient. Due to which the shoot length is declining.

The microplastic concentrations affect *Lablab purpureus* (L.) Sweet Biomass Fresh and Dry Weight. The fresh weight decreases significantly from 10.9 g in the control to 1.4 g at a (2%) concentration. The same result was observed in dry weight, which decreases from 2.0 g in the control to 0.20 g at (2%) concentration. This study suggests a strong detrimental impact of microplastics on overall plant growth

and biomass accumulation. The Water Content and dry matter were also studied and calculated. The moisture content remained relatively high across all the treatments, varying from 81.65% to 87.56%, with only slight differences observed as concentration increased. The study shows that the dry matter content decreased in plants containing microplastics compared to the control. The highest dry matter value recorded was 18.35%, which results in the fact that although water content was stable, the structural biomass was reduced under microplastic stress.

The study also shows that Chlorophyll slight varies among the treatments. Chlorophyll a remained relatively stable across all the concentrations, but Chlorophyll b and total Chlorophyll contents showed a marginal increase with increasing microplastic concentration. Total Chlorophyll content ranged from 0.88 mg g⁻¹ in the control to 1.09 mg g⁻¹ at (2%) Concentration, indicating that photosynthetic pigment levels were not significantly impaired despite reduced growth. The study indicates that microplastic pollution negatively affects plant growth by reducing both root and shoot development, along with biomass accumulation. Nevertheless, moisture content and chlorophyll concentrations remained relatively stable, implying that although structural growth is hampered, basic physiological functions like water retention and the maintenance of photosynthetic pigments are not significantly influenced. This suggests that plants exhibit varying responses to stress induced by microplastics.

Discussion

The present study demonstrates that microplastic contamination exerts a significant negative impact on the growth and biomass accumulation of *Lablab purpureus* (L.) Sweet seedlings. Although germination percentage remained unaffected across all treatments, post-germination growth parameters such as root length, shoot length and biomass showed a clear declining trend with increasing microplastic concentration. This indicates that microplastics primarily influence early seedling development rather than the germination process itself. The reduction in root length observed in this study suggests that microplastics interfere with root elongation, possibly by altering soil structure and reducing porosity. Changes in soil aeration and water availability may hinder root penetration and nutrient uptake. Similar findings have been reported in other studies where microplastics disrupted root architecture and limited nutrient absorption, ultimately affecting plant growth --- Shoot growth was also reduced, although to a lesser extent compared to roots. This may be attributed to the indirect effects of impaired root function, as reduced water and nutrient uptake can limit above-ground growth. The observed decline in fresh and dry biomass further supports the inhibitory effect of microplastics on overall plant productivity. Microplastics may reduce biomass accumulation by creating physical barriers in soil and by releasing toxic additives that affect plant metabolism. Interestingly, moisture content remained relatively stable across treatments, indicating that water retention capacity was not severely affected under the experimental conditions. However, the decrease in dry matter content suggests that structural biomass formation was compromised. This reflects a shift in plant resource allocation under stress conditions. Chlorophyll content showed only minor variation, suggesting that photosynthetic pigment synthesis

was not significantly affected by microplastic exposure. This indicates that while growth processes are inhibited, basic physiological functions such as photosynthesis may remain relatively stable in the early stages of stress exposure. Similar observations have been reported in studies where microplastics had limited effects on chlorophyll content but significantly reduced plant growth parameters.

Overall, the findings suggest that microplastics act as a physical and chemical stressor in soil systems, affecting plant growth primarily through disruption of root development and nutrient uptake rather than direct inhibition of photosynthesis. These results highlight the potential risk of microplastic accumulation in agricultural soils and its implications for crop productivity and ecosystem sustainability.

Conclusion

The present study reveals that microplastic contamination does not significantly affect the germination of *Lablab purpureus* (L.) Sweet seeds but has a pronounced negative impact on seedling growth and biomass accumulation. An increasing concentration of microplastics resulted in reduced root and shoot length, as well as decreased fresh and dry weight, indicating inhibited plant development. While moisture content and chlorophyll levels remained relatively stable, the reduction in dry matter content suggests that structural growth is adversely affected under microplastic stress. These findings indicate that microplastics disrupt the soil plant system, primarily by affecting root development and nutrient uptake.

The study highlights the potential threat of microplastic pollution to agricultural productivity and emphasizes the need for effective management strategies to control microplastic accumulation in soil. Further research is required to understand the long-term effects and underlying mechanisms of microplastic plant interactions.

References

1. Boots B, Russell CW, Green DS. Effects of Microplastics in Soil Ecosystems: Above and below Ground. *Environmental Science and Technology*, 2019;53(19):11496–11506. <https://doi.org/10.1021/acs.est.9b03304>
2. He M, Feng Z, Xu Y, Ding H, Ying C, Cai Y, *et al.* Macro- and microplastic leachates show a slightly toxic effect on seed germination of cotton. *Chemosphere*, 2023, 335. <https://doi.org/10.1016/j.chemosphere.2023.139081>
3. Huang Y, Liu Q, Jia W, Yan C, Wang J. Agricultural plastic mulching as a source of microplastics in the terrestrial environment. *Environmental Pollution*, 2020, 260. <https://doi.org/10.1016/j.envpol.2020.114096>
4. Li H, Liu H, Lin Q, Chen T, Peng R. The Hidden Threat of Microplastics in Desert Environments: Environmental Impact, Challenges, and Response Measures. In *Sustainability* (Switzerland). Multidisciplinary Digital Publishing Institute (MDPI), 2025, 17(5). <https://doi.org/10.3390/su17051897>
5. Shorobi FM, Vyavahare GD, Seok YJ, Park JH. Effect of polypropylene microplastics on seed germination and nutrient uptake of tomato and cherry tomato plants. *Chemosphere*, 2023, 329. <https://doi.org/10.1016/j.chemosphere.2023.138679>

6. Tatum A, Martin V, Kankarla V. Impact of Microplastic-Amended Soil on Seed Germination of Alfalfa (*Medicago sativa*) in a Controlled Environment. *Agronomy*, 2025, 15(1).
<https://doi.org/10.3390/agronomy15010237>
7. Wang F, Zhang X, Zhang S, Zhang S, Sun Y. Interactions of microplastics and cadmium on plant growth and arbuscular mycorrhizal fungal communities in an agricultural soil. *Chemosphere*, 2020, 254. <https://doi.org/10.1016/j.chemosphere.2020.126791>
8. Zhang Q, Zhao M, Meng F, Xiao Y, Dai W, Luan Y. Effect of polystyrene microplastics on rice seed germination and antioxidant enzyme activity. *Toxics*, 2021, 9(8). <https://doi.org/10.3390/toxics9080179>
9. Zhang Y, Wang X, Li J, Yang Y, Gao Y, Wang P. Polyethylene microplastic: impacts on ryegrass seed germination and seedling development. *BMC Plant Biology*, 2025, 25(1). <https://doi.org/10.1186/s12870-025-06891-2>
10. Zhu F, Zhu C, Wang C, Gu C. Occurrence and Ecological Impacts of Microplastics in Soil Systems: A Review. In *Bulletin of Environmental Contamination and Toxicology*. Springer New York LLC.,2019;102(6):741–749.
<https://doi.org/10.1007/s00128-019-02623-z>