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Effects of *Pontederia crassipes* (Water Hyacinth) Aqueous Leaf Extract on the Germination and Growth of *Corchorus olitorius* L.

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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Abstract

Water hyacinth (*Pontederia crassipes*) is an invasive aquatic plant whose biomass has potential agricultural applications, although the effects of its aqueous leaf extract on crop development may vary with concentration. This study examined the responses of *Corchorus olitorius* L. to different concentrations of *Pontederia crassipes* leaf extract (PCLE) during seed germination and vegetative growth. Leaves collected from Ojo Lagoon, Lagos, Nigeria, were dried, processed and mixed with distilled water to prepare 25%, 50%, 75% and 100% treatments, alongside a distilled-water control. Germination was monitored in Petri dishes, while plant height, number of leaves, leaf length, leaf breadth and leaf area were recorded over seven weeks of growth. Analysis of variance was specified for comparison of treatments. Germination was highest at 25% PCLE (83%), followed by control (81%), 75% (79%), 50% (78%) and 100% (76%). At Week 7, the 75% treatment produced the greatest mean plant height (16.47 cm), compared with 12.88 cm in the control. However, the control had the greatest final leaf length (7.73 cm), leaf breadth (4.45 cm), leaf area (25.83 cm²) and number of leaves (12.50). Responses therefore differed among developmental measures, and no single extract concentration was optimal across all assessed parameters. The findings indicate that further evaluation of PCLE as a crop input should consider concentration-specific benefits and possible inhibitory effects.

Keywords: Biofertilizer; invasive species; phytotoxicity; plant growth; seed germination; sustainable agriculture.

1. Introduction

Pontederia crassipes belongs to the family Pontederiaceae. It is a perennial aquatic plant (hydrophyte) that usually grows on the surface of rivers, lakes, canals and ponds. It may be rooted in the muddy bottoms of shallow waters and is native to tropical and subtropical South America (Dechassa, 2020). Water hyacinth also increases decomposing vegetation and hinders air exchange in water, thereby creating unfavourable conditions for fish and other aquatic organisms (Ratnani *et al.,* 2024). Therefore, the International Union for Conservation of Nature has identified it as one of the 100 most invasive species and among the worst weed species worldwide (Ruiz Téllez *et al.*, 2008). The speed of its spread makes its management and elimination especially difficult. A recent synthesis also describes recovering water-hyacinth biomass as a complementary management pathway, while emphasising the need to assess the suitability and safety of its proposed uses (Kashyap *et al.*, 2026).

Despite these negative effects, there is growing interest in utilising materials derived from invasive species such as *P. crassipes* for productive purposes, particularly in sustainable agriculture. Water hyacinth is a source of organic matter that may improve the physical, chemical, and biological properties of the soil (Begum *et al.*, 2022). Moreover, *P. crassipes* exhibits allelopathic properties and releases secondary metabolites, such as phenolics, alkaloids, flavonoids, and terpenoids, into the surrounding environment, potentially affecting the germination and growth of other plant species (Chai *et al.*, 2013; Gul *et al.*, 2017). Allelochemicals may either have growth-promoting or growth-inhibitory effects depending on the concentration of the allelochemicals and the sensitivity of the recipient plant. Water-hyacinth compost has been characterised as a potential organic soil amendment (Nashrullah *et al.*, 2025), and field evidence indicates that compost application can improve soil conditions and support crop production (Gezahegn *et al.*, 2024). These studies concern composted biomass and do not directly establish the effects of aqueous leaf extract.

Given the increasing need for sustainable vegetable production in tropical regions, *Corchorus olitorius* was chosen as the test crop based on its nutritional and economic value. *C. olitorius* is a typical green leafy vegetable commonly known as ewedu among Yoruba communities in south-western Nigeria and is eaten with the staple food amala. In West African countries, particularly Ghana, Nigeria and Sierra Leone, leafy vegetables supplement staple diets based on starchy foods such as rice, cassava, maize and yams (İlhan *et al.*, 2007). It is regarded as a healthy vegetable because of its content of vitamins, minerals, and phenolic compounds. Corchorus is a genus of jute comprising more than 170 species, described as annual fibrous plants (Maity *et al.*, 2012). Jute leaves contain various chemical constituents and have a role in the national and international market (Islam, 2013). The seeds are usually brown to black in colour and have a rough surface. These seeds are important for propagation and are also used *for* culinary and industrial purposes. *C. olitorius* generally grows in well-drained soils with high organic matter content but can also grow in various soil types such as sandy and loamy soils. The plant tolerates growing conditions in both lowland and elevated areas, provided that adequate moisture is available.

Previous studies have demonstrated that *P. crassipes* organic extracts have the potential to improve seed germination, root growth, and general plant growth owing to the presence of phytohormones and growth-stimulating substances (Gul *et al.*, 2017). *P. crassipes* leaf extract (PCLE) also contains nutrients, such as nitrogen, phosphorus and potassium, that are essential for plant growth. As an organic manure, it can reduce reliance on chemical fertilisers and support sustainable farming practices (Chai *et al.*, 2013). Its nutrient composition and potential to improve soil conditions may support plant growth and productivity. PCLE has also been associated with antimicrobial effects that may inhibit the development of fungal and bacterial pathogens (Ratnani *et al.*, 2024). The extract may also have potential as a biopesticide alternative to chemical pesticides. In general, *P. crassipes* leaf extract (PCLE) has the potential to be a sustainable biofertilizer or organic supplement in the agricultural sector and may reduce the use of synthetic fertilisers while improving soil conditions (Mondal *et al.*, 2024). In a separate study, the application of water-hyacinth bioslurry was associated with differences in soil properties and teff yield across treatment rates (Mulu *et al.*, 2026). Because bioslurry differs from the aqueous leaf extract examined in the present experiment, the reported responses cannot be assumed to be equivalent.

Although water-hyacinth-derived materials have been investigated for agricultural applications, the studies discussed above do not establish how varying concentrations of aqueous *P. crassipes* leaf extract affect both seed germination and subsequent vegetative growth of *C. olitorius*. Examining these responses across the same treatment concentrations may help identify whether favourable and inhibitory responses differ between the two stages.

Therefore, this study was conducted to evaluate the effects of *P. crassipes* leaf extract on the germination and growth of *C. olitorius.*

2. Materials and Methods

The study was conducted in the laboratory and botanical garden greenhouse of the Department of Botany, Lagos State University, Ojo campus.

2.1 Treatment Preparation

Pontederia crassipes leaf samples were collected from Ojo Lagoon, Lagos, Nigeria and rinsed with tap water to remove contaminants. The samples were washed, cut into smaller pieces and oven-dried at 40°C for one week until completely dry. The dried samples of *P. crassipes* were blended and mixed with distilled water to prepare the treatments (Revathi & Nithya, 2023). Treatment preparation is presented in Table 1.

Table 1. *Pontederia crassipes* leaf extract (PCLE) treatment preparation

Treatment	PCLE (%)	Amount in grams	Preparation
T1	0%	0g	Distilled water (control)
T2	25%	25g	25g PCLE + 100mL of DW
T3	50%	50g	50g PCLE + 100mL of DW
T4	75%	75g	75g PCLE + 100mL of DW
T5	100%	100g	100g PCLE + 100mL of DW

DW=Distilled water

2.2 Germination Study

The workbench was meticulously cleaned using ethanol and cotton wool to provide an aseptic working environment. The Petri dishes were cleaned with ethanol-soaked cotton wool to remove contaminants, after which filter paper was placed in each dish. The dormancy of the *C. olitorius* seeds was broken by soaking the seeds in hot water for 5 minutes, followed by cold water (Maina *et al.,* 2011). A total of 20 Petri dishes were used, each containing 25 seeds, with five replicates per treatment. A sterilized syringe was used to measure 5 mL of each treatment (25% PCLE, 50% PCLE, 75% PCLE, 100% PCLE and control) daily and applied to the respective replicates. Data was collected daily to assess the germination rate of *C. olitorius* seeds in response to different treatments.

2.3 Growth Study

This was conducted in the screen house of the Department of Botany, Lagos State University, Ojo, Lagos. The dormancy of the *C. olitorius* seeds was broken by soaking in hot water followed by cold water. The seeds were initially planted in two buckets containing soil at the botanical garden nursery before transplanting. After a few weeks, *C. olitorius* seedlings were transplanted into 20 replicate buckets containing soil before the application of treatments. A 10 mL volume of each treatment (control [distilled water], 25% PCLE, 50% PCLE, 75% PCLE and 100% PCLE) was measured and applied to the plants weekly for seven weeks to study the growth and yield of *C. olitorius* in response to the treatments.

2.4 Statistical Analysis

This study used quantitative experimental research design. Statistical Package for the Social Sciences (SPSS) was used to analyse the data. Analysis of variance (ANOVA) was conducted to compare treatment groups, using a significance threshold of $p < 0.05$.

3. Results and Discussion

The germination percentages of *Corchorus olitorius* seeds under control (distilled water) and 25%, 50%, 75% and 100% *Pontederia crassipes* leaf extract (PCLE) treatments are presented in Table 2 and Fig. 1. The germination percentages were 81% in control, 83% with 25% PCLE, 78% with 50% PCLE, 79% with 75% PCLE and 76% with 100% PCLE. The 25% PCLE treatment had the highest observed germination percentage.

Table 2. Germination percentage of *Corchorus olitorius* seeds using different treatments

Treatment	T1	T2	T3	T4	T5
Germination Percentage %	81	83	78	79	76

T1= Control (Distilled Water); T2= 25% PCLE; T3= 50% PCLE; T4= 75% PCLE; T5= 100% PCLE. PCLE= Pontederia crassipes Leaf Extract

Table 3 presents the plant heights (cm) of *C. olitorius* over seven weeks under 25%, 50%, 75% and 100% *Pontederia crassipes* leaf extract and the control (distilled water), showing differences in growth patterns across treatments. The control group had mean plant heights of 4.43 cm in Week 1 and 12.88 cm in Week 7. The 25% PCLE group increased from 4.70 cm to 14.80 cm, while the 50% PCLE group increased from 4.45 cm to 16.03 cm. The 75% PCLE group increased from 5.68 cm to 16.47 cm. The 100% PCLE group increased from 4.98 cm to 13.85 cm.



Fig. 1. Images showing differences in germination rate of control (distilled water, CT2), 25% PCLE (WH25), 50% PCLE (WH50), 75% PCLE (WH75), and 100% (WH100) on *Corchorus olitorius* treated seeds

Table 3. Plant height (cm) of *Corchorus olitorius* across different weeks using different treatments

	Weeks						
Treatments	**1**	**2**	**3**	**4**	**5**	**6**	**7**
Control	4.43 ± 0.50^{a}	5.28 ± 0.26^{ab}	6.35 ± 0.39^{b}	7.65± 0.47^{c}	9.25± 0.64^{d}	10.83 ± 1.03^{e}	12.88± 1.30^{f}
25% PCLE	4.70±0.28^{a}	5.60±0.59^{ab}	7.45±0.79^{bc}	9.50±1.36^{cd}	11.88±1.70^{d}	15.58±1.17^{e}	14.80±3.29^{e}
50% PCLE	4.45±0.17^{a}	5.20±0.08^{a}	6.60±0.43^{ab}	8.33±0.62^{b}	11.08±1.39^{c}	14.75±1.84^{d}	16.03±3.06^{d}
75% PCLE	5.68±1.12^{a}	6.58±1.32^{a}	7.70±1.42^{ab}	9.55±0.37^{bc}	11.50±0.84^{cd}	13.08±1.28^{d}	16.47±3.50^{e}
100% PCLE	4.98±1.63^{a}	5.95±1.52^{a}	7.00±2.03^{ab}	8.33±2.26^{ab}	9.85±3.48^{abc}	12.18±4.54^{abc}	13.85±5.57^{bc}

Control = Distilled Water; PCLE= Pontederia crassipes Leaf Extract

The numbers of leaves of *C. olitorius* recorded over seven weeks under 25%, 50%, 75% and 100% *Pontederia crassipes* leaf extract and the control (distilled water) are presented in Table 4. The control group increased from a mean of 4.50 leaves in Week 1 to 12.50 leaves in Week 7. The 25% PCLE treatment increased from 4.00 leaves in Week 1 to 13.00 in Week 6, before declining to 5.75 in Week 7. The 50% PCLE group increased from 4.75 to 10.25 leaves. The 75% PCLE group started with 5.00 leaves and reached 9.67 leaves in Week 7, while the 100% PCLE group increased from 4.75 to 11.50 leaves over the same period.

Table 4. Number of leaves of *Corchorus olitorius* across different weeks using different treatments

	Weeks						
Treatments	**1**	**2**	**3**	**4**	**5**	**6**	**7**
Control	4.50±1.30^{a}	5.50±1.73^{a}	7.00±1.41^{ab}	8.50±2.08^{ab}	9.75±2.50^{b}	11.50±3.32^{c}	12.50±4.20^{c}
25% PCLE	4.00±0.82^{a}	5.50±0.58^{ab}	7.00±0.82^{bc}	9.25±1.26^{cd}	11.50±2.08^{de}	13.00±1.83^{e}	5.75±2.87^{ab}
50% PCLE	4.75±0.50^{a}	5.50±0.58^{ab}	6.75±0.96^{ab}	8.75±1.71^{bc}	8.75±0.96^{bc}	10.75±2.63^{cd}	10.25±3.86^{cd}
75% PCLE	5.00±0.82^{a}	5.75±1.26^{ab}	6.25±1.50^{abc}	7.25±2.06^{abc}	7.50±2.38^{abc}	10.00±2.31^{c}	9.67±4.73^{bc}
100% PCLE	4.75±1.50^{a}	6.00±1.83^{a}	7.50±2.52^{ab}	8.25±2.87^{ab}	9.50±2.89^{ab}	11.25±3.77^{ab}	11.50±3.11^{ab}

Control = Distilled Water; PCLE= Pontederia crassipes Leaf Extract

Leaf length in *C. olitorius* over seven weeks under the four PCLE concentrations and the control is presented in Table 5. The control group showed an increase in leaf length from 3.60 cm in Week 1 to 7.73 cm in Week 7. In the 25% PCLE group, leaf length was 4.10 cm in Week 1, peaked at 6.23 cm in Week 6 and declined to 5.43 cm in Week 7. Leaf length in the 50% PCLE group increased from 3.68 cm to 6.20 cm. The 75% PCLE group increased from 4.03 cm to 6.33 cm, while the 100% PCLE group increased from 3.63 cm to 6.08 cm. The control group recorded the greatest leaf length in Week 7, followed by 75% PCLE treatment.

Table 5. Leaf length (cm) of *Corchorus olitorius* across different weeks using different treatments

	Weeks						
Treatments	**1**	**2**	**3**	**4**	**5**	**6**	**7**
Control	3.60±0.12^{a}	4.08±0.24^{ab}	4.45±0.21^{b}	4.83±0.35^{c}	5.28±0.38^{c}	7.03±0.99^{d}	7.73±0.61^{d}
25% PCLE	4.10±0.58^{a}	4.83±0.75^{ab}	5.08±0.60^{ab}	5.43±0.82^{ab}	5.45±1.28^{ab}	6.23±1.38^{b}	5.43±1.27^{ab}
50% PCLE	3.68±0.50^{a}	4.40±0.75^{ab}	4.70±0.67^{ab}	4.88±0.60^{ab}	5.25±0.79^{ab}	6.35±1.53^{bc}	6.20±2.56^{bc}
75% PCLE	4.03±1.03^{a}	4.63±1.00^{ab}	4.85±1.04^{ab}	4.80±1.19^{ab}	5.13±1.50^{ab}	5.43±1.33^{ab}	6.33±0.58^{b}
100% PCLE	3.63±0.45^{a}	4.08±0.48^{a}	4.30±0.68^{a}	4.35±0.66^{a}	4.48±1.42^{a}	5.13±2.05^{a}	6.08±2.88^{a}

Control = Distilled Water; PCLE= Pontederia crassipes Leaf Extract

Table 6 presents leaf breadth in *C. olitorius* over seven weeks under the four PCLE concentrations and control, showing different growth patterns. In the control group, mean leaf breadth increased from 1.55 cm in Week 1 to 4.45 cm in Week 7. In the 25% PCLE group, leaf breadth increased from 1.80 cm in Week 1 to 3.93 cm in Week 6 before declining to 3.08 cm in Week 7. The 50% PCLE group increased from 1.65 cm to 3.93 cm in Week 7. The 75% PCLE group increased from 1.75 cm to 3.80 cm, while the 100% PCLE group increased from 1.58 cm to 3.33 cm.

Table 6. Leaf breadth (cm) of *Corchorus olitorius* across different weeks using different treatments

	Weeks						
Treatments	**1**	**2**	**3**	**4**	**5**	**6**	**7**
Control	1.55±0.06^{a}	1.90±0.08^{ab}	2.35±0.24^{bc}	2.75±0.47^{c}	3.38±0.48^{d}	4.05±0.33^{e}	4.45±0.06^{e}
25% PCLE	1.80±0.34^{a}	2.08±0.36^{ab}	2.40±5.0^{ab}	2.90±0.73^{abc}	3.53±1.07^{c}	3.93±0.88^{c}	3.08±0.72^{bc}
50% PCLE	1.65±0.30^{a}	2.03±0.26^{ab}	2.33±0.33^{ab}	2.80±0.36^{c}	3.38±0.39^{cd}	3.85±0.78^{de}	3.93±1.20^{de}
75% PCLE	1.75±0.44^{a}	2.15±0.37^{ab}	2.60±0.41^{abc}	3.00±0.67^{c}	3.40±0.99^{c}	3.40±0.95^{c}	3.80±0.40^{c}
100% PCLE	1.58±0.15^{a}	1.98±0.38^{ab}	2.23±0.59^{ab}	2.45±0.72^{ab}	2.78±1.07^{ab}	3.18±1.59^{ab}	3.33±1.75^{ab}

Control = Distilled Water; PCLE= Pontederia crassipes Leaf Extract

Table 7 shows the leaf area of *C. olitorius* using different treatments. The control group initially had a leaf area of 4.18 cm^2 and reached 25.83 cm^2 by week 7. The 25% PCLE started at 5.65 cm^2 and reached 12.98 cm^2 by week 7. The 50% PCLE initially had a leaf area of 4.65 $cm^2$and increased to 19.78 cm^2 by week 7. In contrast, the 75% PCLE began with 5.53 cm^2 and reached 18.23 cm^2 while the 100% PCLE started with 4.33 cm^2 and reached 17.98 cm^2 by week 7. The control had the greatest leaf area in Week 7.

Table 7. Leaf area (cm^2) of *Corchorus olitorius* across different weeks using different treatments

	Weeks						
Treatments	**1**	**2**	**3**	**4**	**5**	**6**	**7**
Control	4.18±0.21^{a}	5.85±0.48^{ab}	7.83±0.48^{bc}	9.90±1.33^{c}	13.40±2.28^{d}	21.45±3.95^{e}	25.83±2.25^{f}
25% PCLE	5.65±1.94^{a}	7.65±2.48^{ab}	9.25±2.81^{ab}	12.10±4.34^{abc}	15.20±8.03^{bc}	19.00±8.31^{c}	12.98±5.64^{abc}
50% PCLE	4.65±1.39^{a}	6.80±1.85^{a}	8.30±2.03^{a}	10.28±1.96^{ab}	13.38±3.03^{ab}	19.00±8.80^{b}	19.78±14.37^{b}
75% PCLE	5.53±2.76^{a}	7.65±2.89^{ab}	9.70±3.24^{ab}	11.40±4.53^{abc}	13.85±6.94^{bc}	14.55±6.43^{bc}	18.23±3.44^{c}
100% PCLE	4.33±0.78^{a}	6.15±1.70^{a}	7.40±3.15^{a}	8.30±3.75^{a}	10.13±7.28^{a}	14.03±13.08^{a}	17.98±18.01^{a}

Control = Distilled Water; PCLE= Pontederia crassipes Leaf Extract

Table 2 shows that the germination of *Corchorus olitorius* seeds was influenced by the varying levels of *Pontederia crassipes* leaf extract (PCLE). The 25% PCLE treatment had a marginally higher germination percentage than the control; bioactive compounds in the extract may have contributed to this response. Germination percentages were lower at all concentrations above 25%, suggesting a possible inhibitory response at higher extract concentrations. This pattern may be compared with the work of Ratnani *et al.* (2024), which revealed that bioactive compounds found in water hyacinth extracts can promote the germination of seeds in low dosages but inhibit it in the case of excessive concentration. Similarly, Laemoh and Waewthongrak (2022) reported concentration-dependent allelopathic effects of water-hyacinth aqueous extract on another plant species. Thus, 25% PCLE produced the highest observed seed germination, whereas all higher tested concentrations had lower germination percentages.

Pontederia crassipes leaf extract (PCLE) at different concentrations was associated with differences in plant height over seven weeks. The highest height of plants was recorded in the 75% PCLE treatment, followed by the 50% PCLE treatment; both were greater than the control, while the 100% PCLE group had a lower final height than either of these treatments. The results may also be considered alongside those of Mondal *et al.* (2024), who found that PCLE may be used to stimulate plant growth because of its nutrient content, which may include nitrogen, potassium, and trace elements, and growth-promoting phytohormones such as auxins and cytokinins, which may have contributed to the height observed in the 75% PCLE group. Concentration-dependent effects of water-hyacinth aqueous extracts have also been reported by Laemoh *and Waewthongrak* (2022) in another plant species. High extract concentrations may, however, be associated with growth inhibition through phytotoxic effects or imbalanced nutrient availability. It is also possible that the combined effects of the nutrients of the 75% PCLE treatment have contributed to the observed height. Conversely, the shorter plants in the control group may reflect the absence of additional nutrients and growth-promoting compounds supplied by the extract. The observed difference in plant height between the control and 75% PCLE groups suggests that PCLE warrants further evaluation as an organic agricultural amendment.

The 25% PCLE group had the highest observed mean number of leaves in Week 6, although this value declined by Week 7. The variation in leaf numbers among the PCLE treatments may be associated with the effects of the bioactive components in the extract which include nitrogen and potassium that are critical in the development of leaves. This is consistent with the study conducted by Abdel-Razek *et al.* (2022) which indicated that leaf development in *C. olitorius* depends on the availability of nutrients. Elevated concentrations of bioactive compounds or allelopathic chemicals in the extracts may reduce leaf numbers through phytotoxic stress, potentially contributing to the lower Week 7 value in the 75% PCLE group than in the control.

Among the extract-treated groups, the greatest Week 7 leaf length was recorded at 75% PCLE, followed by 50% PCLE; these responses may reflect effects of nutrients and bioactive compounds on leaf growth. The control group had the greatest Week 7 leaf length, possibly because it was not exposed to allelopathic or inhibitory compounds present in PCLE. Water hyacinth contains bioactive constituents that may suppress aspects of plant growth, including leaf elongation. Oh *et al.* (2007) discuss the regulation of plant development by internal growth responses. In the control, it is possible that the plants accessed the necessary nutrients without exposure to possible growth-inhibitory substances in PCLE. On the other hand, leaf length in the 50% PCLE treatment was relatively high among the extract treatments, which indicates that the concentration might have offered the most desirable balance of nutrients and bioactive compounds without causing any severe stress. Moderate nutrient availability may promote leaf growth, although Sierra-Carmona *et al.* (2022) discussed potential agricultural applications of water hyacinth. The 50% treatment may therefore have provided a balance between growth-promoting and growth-inhibitory compounds. The relatively low effectiveness of

the 75% and 100% PCLE treatments to stimulate the leaf length as compared to the control group may be associated with effects of bioactive constituents on plant stress. These responses suggest that extract concentration should be considered carefully when assessing possible effects on leaf elongation.

The leaf breadth results showed that the control group had greater Week 7 leaf breadth than the PCLE-treated groups. Among the PCLE treatments, the 50% group had the greatest Week 7 leaf breadth. The 25%, 75% and 100% PCLE treatments had smaller Week 7 leaf breadths than the 50% PCLE treatment. The greater leaf breadth in control plants may reflect the absence of potentially inhibitory allelopathic compounds in the extract treatments. These responses may be discussed in relation to the plant-growth inhibitory mechanisms reviewed by Peng *et al.* (2023). The relatively greater leaf breadth under 50% PCLE suggests a possible concentration-dependent response to bioactive constituents. The smaller leaf breadths under 25%, 75% and 100% PCLE suggest that the response was not linear across the concentrations examined. The 25% treatment might not have been sufficient to provide bioactive compounds to the extent of increasing the breadth of the leaf greatly, whereas the 75% and 100% treatment may have contained levels of bioactive constituents associated with phytotoxic responses.

Leaf area differed among treatments, with the control recording the greatest value in Week 7. The response was not consistently proportional to PCLE concentration, although all extract-treated groups had smaller leaf areas than the control in Week 7. The greater leaf area in the control group may reflect the absence of exposure to potentially inhibitory allelopathic chemicals, which could influence leaf development (Maity *et al.*, 2012). The relatively greater Week 7 leaf area under 50% PCLE, compared with some other extract treatments, may reflect a balance between potentially beneficial and inhibitory effects (Dersseh *et al.,* 2019). Possible explanations include differences in nutrient uptake and photosynthetic activity. Bioactive compounds and phytohormones in PCLE may have influenced the leaf-area response under the 50% treatment. This concentration may have provided a balance between growth-promoting and growth-inhibiting constituents.

4. Conclusion

This study examined the effects of aqueous *Pontederia crassipes* leaf extract on the germination and vegetative growth of *Corchorus olitorius* under the experimental conditions described. The results showed that the response depended on both extract concentration and the plant characteristic measured. The 25% treatment produced the highest recorded germination percentage (83%), slightly exceeding the distilled-water control (81%), whereas the 100% treatment produced the lowest value (76%). In the seven-week growth assessment, the 75% treatment resulted in the greatest final mean plant height (16.47 cm), compared with 12.88 cm in control. However, the control produced the greatest final number of leaves, leaf length, leaf breadth and leaf area. These findings do not establish that the extract consistently improves overall plant development or yield. Rather, they suggest that apparent benefits for selected traits may occur alongside less favourable responses in others. The potential use of this aquatic weed as an agricultural input therefore requires further investigation, including clearer treatment replication, verification of statistical outcomes and assessment of the extract's composition and longer-term effects under different growing conditions.

5. Limitations

The study assessed germination and vegetative characteristics under laboratory and screen-house conditions over seven weeks; field performance and longer-term outcomes were not evaluated. The chemical composition of the prepared extracts was not reported, limiting interpretation of potential nutrient-related and allelopathic mechanisms.

Declaration of AI Use

This manuscript was prepared through the intellectual contributions of the author(s) to the study design, data analysis, interpretation of results, and scholarly content. Grammarly and ChatGPT were used solely to assist with grammatical refinement and reference formatting during manuscript revision. The author(s) accept full responsibility for the accuracy, integrity, and final content of the manuscript.

Competing Interests

Authors have declared that they have no known competing financial interests or non-financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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