PLANT SCIENCE TODAY
ISSN 2348-1900 (online)
Vol 12(sp1): 01–06
https://doi.org/10.14719/pst.6190

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RESEARCH ARTICLE

Effect of aqueous extract of horse purslane (*Trianthema portulacastrum* L.) on germination and seedling growth of selected field crops

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OPEN ACCESS

ARTICLE HISTORY

Received: 20 November 2024
Accepted: 16 January 2025

Available online
Version 1.0 : 21 February 2025

Check for updates

Additional information

Peer review: Publisher thanks Sectional Editor and the other anonymous reviewers for their contribution to the peer review of this work.

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Indexing: Plant Science Today, published by Horizon e-Publishing Group, is covered by Scopus, Web of Science, BIOSIS Previews, Clarivate Analytics, NAAS, UGC Care, etc
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Rathika S, Ramesh T, Kavitha M P, Vanitha K, Natarajan S K, Rajakumar D, Bhuvaneswari J, Satheeshkumar N, Jagadeesan R, Dhanushkodi V, Dinesh G K, Vinoth R. Effect of aqueous extract of horse purslane (*Trianthema portulacastrum* L.) on germination and seedling growth of selected field crops. Plant Science Today. 2025;12(sp1):01-06. https://doi.org/10.14719/pst.6190

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Abstract

An experiment was conducted during 2021 and 2022 in Anbil Dharmalingam Agricultural College and Research Institute, TNAU, Tiruchirappalli, to know the overall allelopathic impact of horse purslane on the germination and seedling growth of rice, ragi, maize, green gram and sunflower. A Completely Randomised Design (CRD) was used to test 6 treatments, including a control and 1%, 2%, 3%, 4% and 5% concentrations of horse purslane whole-plant extract, with 4 replications. Seed germination and subsequent growth and development of selected crops were negatively affected by the extract of horse purslane. The minimum germination was recorded in 5% horse purslane extract, while maximum germination was recorded in control. A consistent decline in germination percentage was observed with increasing extract concentrations. The extract of horse purslane significantly reduced the root length, shoot length, seedling length and seedling vigour index (SVI) of the tested crops. The highest seedling mortality rates were observed at the 5% extract concentration, with values of 83.8%, 78.9%, 47.3%, 51.6% and 81.3% for rice, ragi, maize, sunflower and green gram respectively. The study indicates that horse purslane needs to be controlled effectively in the cropped fields, otherwise, it could reduce the growth and development of field crops. The allelochemicals in horse purslane present significant opportunities for further research on their impact on other weed species, which

could contribute to the development of effective weed management strategies in field crops.

Keywords

allelopathy; horse purslane; seedling length; seedling mortality; SVI

Introduction

Allelopathy refers to biochemical interference by plants that affect the growth, distribution and development of other organisms through the release of chemical compounds called allelochemicals. In both natural and agricultural systems, allelochemicals are released through processes like leaching, root exudates, volatilization and decomposition, influencing plant-plant and plant-microbe interactions (1). These allelopathic chemicals, often derivatives of cinnamic acids, phenolic acids, coumarins, benzoic acids, hydroquinones and benzoquinones are known to supress seed germination and inhibit growth of competing plants.

Horse purslane (*Trianthema portulacastrum* L.) is a noxious weed worldwide which originated in South Africa and is extensively distributed in the subcontinents of Southern Asia, Africa and Tropical America (2, 3). As a highly competitive terrestrial weed, horse purslane's C4 photosynthetic pathway enables it to thrive under high temperatures and light intensities, making it particularly problematic in tropical and subtropical regions. This is a prevalent weed in key field crops in India during the summer (*Zaid*) season, including pulses, maize, sugarcane, cotton and direct-seeded rice (DSR). Its proliferation, particularly in cotton, maize and DSR during the monsoon, can decrease crop yields by 32-60% (4). It also affects crops such as pearl millet, sorghum, maize, wheat, urdbean, mungbean, guar and sunflower causing significant yield losses (5). A study reported the allelopathic inhibition in growth of crop plants due to *Trianthema portulacastrum* (6). The extent of allelopathic inhibition on seedling growth and germination varies among crop species and different plant parts of horse purslane (7-9). Consequently, the research focused on investigating the allelopathic impact of horse purslane on early seedling development, germination and viability of selected field crops *viz.,* rice (*Oryza sativa*), ragi (*Eleusine coracana),* maize (*Zea mays* L.), green gram (*Vigna radiata* L.) and sunflower (*Helianthus annuus* L.).

Materials and Methods

Formulation of horse purslane aqueous extract

Horse purslane plants were first air-dried at ambient temperature and then subsequently oven-dried at 70 °C for about 48 hr. The desiccated material was subsequently cut into 1 cm pieces, pulverised into a fine consistency and mixed with purified water to create solutions with concentrations of 1%, 2%, 3%, 4% and 5%. The percentage concentrations were prepared by soaking 1, 2, 3, 4 and 5 g of plant powdered samples in 100 mL of distilled water for about 24 hr. The water-soluble leachates were individually filtered and purified using Whatman No.1 paper and then centrifuged at 12000 rpm for 5 min. Horse purslane whole-plant extract or phytochemical extract at concentrations of 1%, 2%, 3%, 4%, and 5% were prepared and stored in a cold, dark place for the use of within a week.

Experimental layout and treatment details

The experiment was carried out during 2021 and 2022 in a CRD comprising 4 replications. The experiment included 6 treatments: a control and extract concentrations of 1%, 2%, 3%, 4% and 5% from the whole plant of horse purslane. The crops tested in this experiment were rice, ragi, maize, green gram and sunflower. Prior to sowing, seeds were surfaced-sterilised with 0.1% $HgCl_2$ for 1 min and cleaned 3 times with distilled water to remove any residue. Petri plates were cleaned with 99.9% ethanol and lined with Whatman No. 10 filter paper. About 10 seeds of each crop namely rice, ragi, maize, green gram and sunflower were placed on the filter paper. Horse purslane whole-plant extracts at concentrations of 1%, 2%, 3%, 4% and 5% were added, while controls used distilled water. The petri plates were retained at ambient temperature within standard laboratory conditions.

Treatment Details

T_1 - Control
T_2 - 1% horse purslane whole-plant extract
T_3 - 2% horse purslane whole-plant extract
T_4 - 3% horse purslane whole-plant extract
T_5 - 4% horse purslane whole-plant extract
T_6 - 5% horse purslane whole-plant extract

Observations

Germination percentage

It was documented ten days after sowing (DAS). The percentage of germination was computed by utilising the equation mentioned below (10).

$$Germination\ percentage = \frac{No.of seeds\ germinated}{Total\ seeds} \times 100$$

Emergence index

The emergence index was computed by applying the formula mentioned below

$$EI = \frac{No.of\ emerged\ seeds}{Days\ of\ initial\ count} + ------ + \frac{No.of\ emerged\ seeds}{Days\ of\ final\ count}$$

Growth parameters

$$Seedling\ length\ (cm) = Root\ length\ (cm) + Shoot\ length\ (cm)$$

At 10 DAS, growth characteristics such as shoot and root length were measured using a meter scale and denoted in centimetres.

$$SVI = Germination\ percentage \times Radical\ length\ (cm)$$

Seedling length

It was determined by applying the formula mentioned below

Seedling Vigour Index (SVI)

The SVI was worked out by using the equation (11)

Seedling Mortality

It was determined by applying the formula mentioned below

$$\text{Seedling mortality} = \frac{\text{No. of seedlings emerged} - \text{No. of seedling survived}}{\text{No. of seedling emerged}} \times 100$$

Statistical analysis

The gathered data were organized, arranged and scrutinised statistically according to the suggested methods (12). To assess treatment effects, a one-way ANOVA was performed using AGRES software, with statistical significance evaluated at a critical difference (CD) of $P \leq 0.05$. Non-significant findings were denoted as 'NS'.

Results and Discussion

Role of horse purslane in altering field crop performance via allelopathy

Germination percentage, emergence index, growth metrics such as shoot and root length, seedling length, SVI and mortality percentage were measured under various treatments, which are detailed below.

Germination percentage

Significant inhibition of germination was observed in rice, ragi, maize, green gram and sunflower when treated with horse purslane whole-plant extract, as compared to the control (Fig. 1 and Plate 1). Germination of rice, ragi, maize, green gram and sunflower was significantly reduced by the horse purslane whole-plant extract compared to the control. Seeds treated with 5% horse purslane whole-plant extract showed the lowest germination percentage (10.3%, 22.2%, 40.2%, 16.7% and 37.8% in rice, ragi, maize, green gram and sunflower respectively). The maximum germination percentages (76.7%, 93.3%, 86.7%, 83.3% and 93.3% in rice, ragi, maize, green gram and sunflower respectively) were recorded in the control. The germination percentage decreased significantly with increasing concentrations of horse purslane whole-plant extract, possibly due to inhibitory effects on enzymatic activities such as peroxidase, alpha-amylase and acid-phosphatase (13, 14).

Emergence Index

The emergence index of rice, ragi, maize, green gram and sunflower were remarkably affected by the horse purslane whole-plant extract (Table 1). The extract reduced the emergence index of rice, ragi, maize, green gram and sunflower as compared to the control. At lower concentrations of 1% horse purslane whole-plant extract, the emergence index of field crops was higher (5.01, 34.20, 0.60, 4.24 and 2.01 in rice, ragi, maize, green gram and sunflower respectively) and the lowest emergence index was recorded at higher concentrations of 5% horse purslane whole-plant extract (1.37, 6.26, 0.37, 1.64 and 0.98 in rice, ragi, maize, green gram and sunflower respectively). The

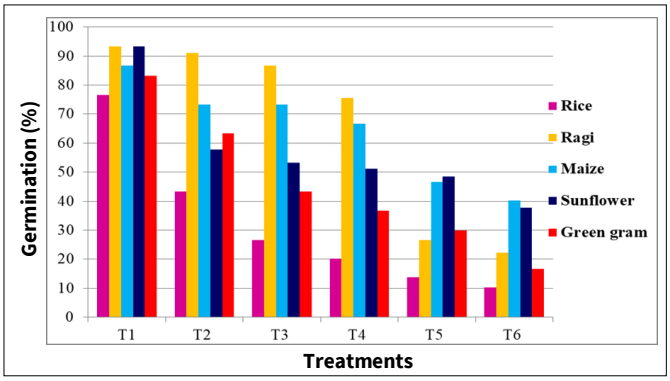

Fig. 1. Allelopathic impact of horse purslane on germination (%) of selected crops.

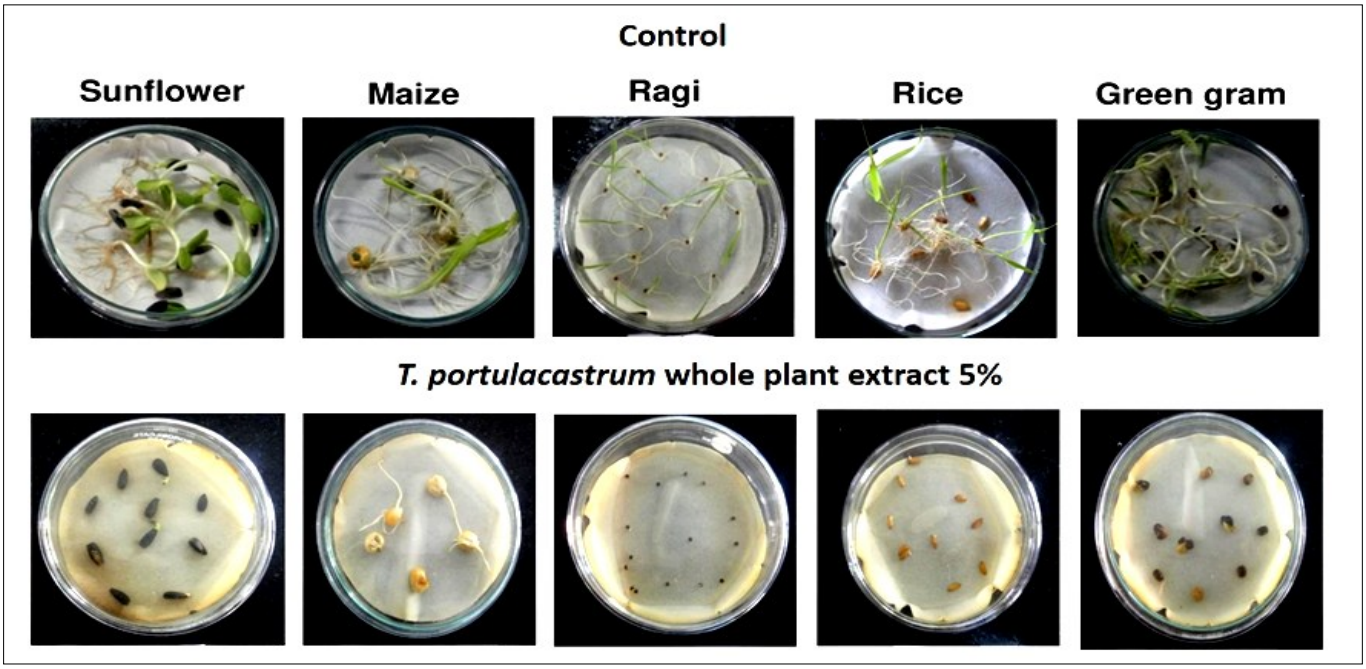

Plate 1. Allelopathic impact of horse purslane on field crops.

whole-plant extract of horse purslane implied a remarkable depletion in the emergence index of rice, ragi, maize, green gram and sunflower was more than the control. This

Table 1. Allelopathic impact of horse purslane on the emergence index of selected crops

Treatments	Emergence Index				
	Rice	Ragi	Maize	Sun-flower	Green gram
T_1 - Control	10.79	38.19	0.87	2.25	5.81
T_2 - 1% horse purslane whole plant extract	5.01	34.20	0.60	2.01	4.24
T_3 - 2% horse purslane whole plant extract	3.36	31.24	0.64	1.89	3.83
T_4 - 3% horse purslane whole plant extract	2.08	22.42	0.55	1.69	2.71
T_5 - 4% horse purslane whole plant extract	2.35	7.47	0.44	1.51	2.62
T_6 - 5% horse purslane whole plant extract	1.37	6.26	0.37	0.98	1.64
SEd	0.11	0.68	0.02	0.06	0.10
CD (P=0.05)	0.23	1.35	0.03	0.11	0.20

might be due to the allelochemicals such as caffeic acid, pyrogallic acid, vanillic acid, ferulic acid, protocatchuic acid, o-coumaric acid and trans-cinnamic acid present in both leaf and stem of horse purslane significantly influence allelopathic interactions and affects the growth of certain field crops (15).

Shoot length

The shoot length of rice, ragi, maize, green gram and sunflower were remarkably affected by the whole-plant extract of horse purslane (Table 2). The maximum length (5.33, 2.80, 4.55, 2.42 and 9.01 cm in rice, ragi, maize, green gram and sunflower respectively) was observed in case of control. Seeds treated with 5% horse purslane whole-plant extract resulted in the shortest shoot length (0.42, 0.17, 0.52, 0 and 0.95 cm in rice, ragi, maize, green gram and sunflower respectively). However, an inverse relationship

Table 2. Allelopathic impact of horse purslane on shoot length of selected crops

Treatments	Shoot length (cm)				
	Rice	Ragi	Maize	Sun-flower	Green gram
T_1 - Control	5.33	2.80	4.55	2.42	9.01
T_2 - 1% horse purslane whole plant extract	4.02	2.71	3.63	2.75	5.43
T_3 - 2% horse purslane whole plant extract	1.75	2.22	2.68	2.17	1.07
T_4 - 3% horse purslane whole plant extract	1.52	2.08	2.13	1.75	0.28
T_5 - 4% horse purslane whole plant extract	0.97	1.77	0.72	1.50	0
T_6 - 5% horse purslane whole plant extract	0.42	0.17	0.52	0.95	0
SEd	0.07	0.05	0.06	0.08	0.12
CD (P=0.05)	0.15	0.11	0.12	0.16	0.24

was observed between shoot length and concentration of horse purslane phytochemical extract. As allelopathic substances have been shown to disrupt the activity of gibberellins and indole acetic acid, cell division has most likely been inhibited, resulting in a reduction in seedling shoot length (16).

Root length

The plant extract remarkably affected the root length of rice, ragi, maize, sunflower and green gram (Table 3). The maximum root length was observed under the control. Seeds treated with 5% horse purslane whole-plant extract recorded the lowest root lengths: 0.08 cm, 0.03 cm, 1.42 cm, 0 cm and 0.46 cm in rice, ragi, maize, green gram and sunflower, respectively. (Improve clarity and consistency in measurement units.) However, root length demonstrat-

Table 3. Allelopathic impact of horse purslane on root length of selected crops

Treatments	Root length (cm)				
	Rice	Ragi	Maize	Sun-flower	Green gram
T_1 - Control	6.75	5.03	4.58	1.58	2.03
T_2 - 1% horse purslane whole plant extract	2.83	4.30	4.35	1.12	1.32
T_3 - 2% horse purslane whole plant extract	1.98	3.33	4.12	1.02	0.51
T_4 - 3% horse purslane whole plant extract	0.22	1.75	2.38	0.72	0.23
T_5 - 4% horse purslane whole plant extract	0.17	0.28	1.75	0.57	0
T_6 - 5% horse purslane whole plant extract	0.08	0.03	1.42	0.46	0
SEd	0.06	0.07	0.09	0.03	0.02
CD (P=0.05)	0.11	0.14	0.17	0.06	0.04

ed a declining pattern with the elevation in the concentration of horse purslane phytochemical extract. Presumably, it occurs because root cell division is impeded by certain phenolic compounds present in horse purslane extract (17). The decrease in root length may be linked to the availability of water-soluble inhibitory compounds. This aligns well with the conclusions of earlier research (18).

Seedling length

The seedling length of rice, ragi, maize, green gram and sunflower were significantly inhibited by horse purslane

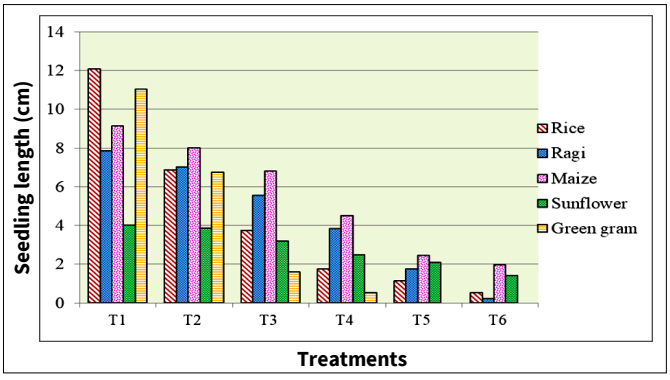

Fig. 2. Allelopathic impact of horse purslane on seedling length of selected crops.

whole plant extract (Fig. 2). The maximum length of seedlings (12.08, 7.83, 9.13, 11.04 and 4.00 cm in rice, ragi, maize, green gram and sunflower respectively) were observed in the control. Seeds treated with 5% horse purslane whole-plant extract exhibited lower seedling lengths (0.50, 0.20, 1.94, 0 and 1.41 cm in rice, ragi, maize, green gram and sunflower respectively at 10 DAS). An inverse relationship was evident, as seedling length diminished with rising concentrations of the whole-plant extract (19, 20).

Seedling Vigour Index (SVI)

The SVI of rice, ragi, maize, green gram and sunflower were remarkably affected after treatment with whole-plant extract of horse purslane (Table 4). The maximum SVI was observed in control (517.7, 499.3, 397.1, 129.9 and 169.1 in rice, ragi, maize, green gram and sunflower respectively). Seeds treated with 5% horse purslane whole-plant extract led to a significant decrease in SVI (0.8, 0.7, 57.1, 0 and 23.4) in rice, ragi, maize, green gram and sunflower respectively). However, there was a notable decrease in SVI with an increase in proportion of horse purslane whole-plant extract. Treatment with horse purslane phytochemical extract resulted in the lowest germination percentage, suggesting the possible impact of allelochemicals. These compounds may have impaired the vitality of the tested crop seeds and obstructed the germination process (21).

Table 4. Allelopathic impact of horse purslane on SVI of selected crops

Treatments	SVI				
	Rice	Ragi	Maize	Sun-flower	Green gram
T_1 - Control	517.7	469.3	397.1	129.9	169.1
T_2 - 1% horse purslane whole plant extract	122.5	391.7	318.9	82.1	83.6
T_3 - 2% horse purslane whole plant extract	52.9	288.7	302.0	70.9	22.1
T_4 - 3% horse purslane whole plant extract	4.4	132.1	158.8	53.1	8.4
T_5 - 4% horse purslane whole plant extract	2.3	7.5	81.7	36.4	0
T_6 - 5% horse purslane whole plant extract	0.8	0.7	57.1	23.4	0
SEd	3.8	7.3	7.1	2.2	1.5
CD (P=0.05)	7.6	14.4	14.2	4.4	3.1

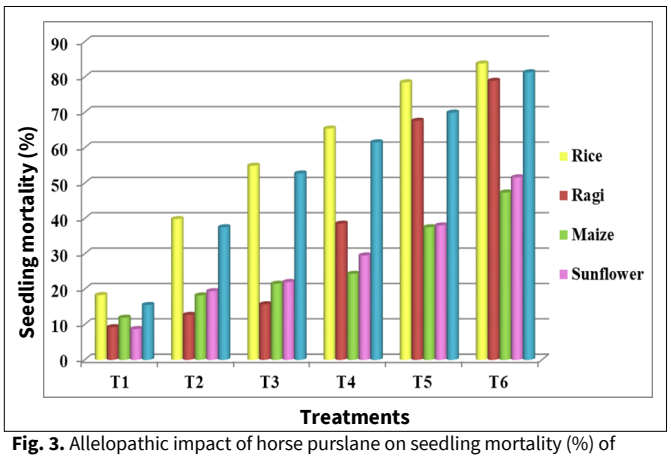

Fig. 3. Allelopathic impact of horse purslane on seedling mortality (%) of selected crops.

These results are consistent with previous research (16).

Seedling mortality

All tested crops exhibited remarkable seedling mortality after treatment with the whole-plant extract of horse purslane (Fig. 3). Seeds treated with 5% horse purslane extract exhibited higher seedling mortality percentage (83.8, 78.9, 47.3, 51.6 and 81.3% in rice, ragi, maize, sunflower and green gram respectively). Lower seedling mortality percentage was noticed in control (18.3, 9.2, 11.9, 15.5 and 8.7 cm in rice, ragi, maize, green gram and sunflower respectively). Seedling mortality increased proportionally with higher concentrations of horse purslane whole-plant extract. The significant inhibitory effects can likely be attributed to the elevated levels of growth-suppressing compounds present in the extract. These results align with the findings reported in earlier studies (22).

Conclusion

The study demonstrated that horse purslane whole-plant extract exerts a significant inhibitory effect on germination and growth of field crops, highlighting its potential for natural weed management. Higher seedling mortality of 83.8, 78.9, 47.3, 51.6 and 81.3% were recorded in rice, ragi, maize, sunflower and green gram respectively under horse purslane whole-plant extract at 5%. The allelopathy potential of horse purslane should be studied on weeds and explore the possibility of developing natural herbicides.

Acknowledgements

We gratefully acknowledge the Tamil Nadu Agricultural University, Coimbatore, India.

Authors' contributions

SR and TR did conceptualization and methodology of the experiment. SR and TR did overall supervision of the experiment and wrote the first draft of the manuscript. MPK, SKN, DR, JB and NS did execution of research on agronomic aspects. TR did project administration and validation. KV, RJ, VD, GKD and RV did edition on manuscript. SR and TR did the final revision of the manuscript. All authors have read and agreed to the published version of manuscript

Compliance with ethical standards

Conflict of interest: Authors do not have any conflict of interests to declare.

Ethical issues: None

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