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ALLELOPATHIC EFFECT OF SELECTED EUPHORBIACEAE SPECIES ON GERMINATION AND GROWTH OF ECONOMICALLY IMPORTANT CROPS

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Abstract

The study was conducted to investigate the allelopathic effects of aqueous leaf extracts from *Euphorbia helioscopia* L., *Euphorbia milii* Des Moulins, *Euphorbia prostrata* Aiton, and *Putranjiva roxburghii* Wall. on the seed germination and early seedling development of *Triticum aestivum* (wheat), *Spinacia oleracea* (spinach), *Pisum sativum* (pea) and *Oryza sativa* (rice). The filter paper method was used to assess the effects of three concentrations (1%, 3%, and 5%) of each plant extract on the selected test species. The aqueous extract of *Euphorbia milii* significantly inhibited seed germination in spinach (65%), rice (11%) and wheat (7%). *Euphorbia helioscopia* exhibited a promotive effect on germination of spinach and rice, while suppressing seedling growth across all test species. All donor species, except *Euphorbia prostrata*, distinctly inhibited seedling development in rice. Moreover, *Putranjiva roxburghii* and *Euphorbia milii* demonstrated species-specific and concentration-dependent effects on both germination and seedling development. Current findings showed the inhibitory potential of *Euphorbia helioscopia.* These results suggest that the incorporation of such plant extracts into agricultural soils could exert either stimulatory or inhibitory influences, dependent upon the associated crop species. Therefore, a complete investigation regarding the effects of allelopathic species is needed before introducing them in agricultural practices.

Keywords: Allelopathy, *Euphorbia*, inhibitory potential, *Putranjiva*

INTRODUCTION

Allelopathy involves chemical interactions among plants, affecting the growth of neighboring species (About *et al.,* 2022). It includes both intraspecific (autotoxic) and interspecific (antitoxic) effects. These interactions are mediated by allelochemicals or biochemicals released into the environment as secondary metabolites or by-products (Deepti *et al*., 2023). The Euphorbiaceae family consists of approximately 300 genera and around 2,150 species. It has a cosmopolitan distribution, with the majority of its species found in tropical and temperate regions (Al-Anbari *et al*., 2017). In Pakistan, almost 24 genera and 90 species were reported (Alyas *et al*., 2021). This family is usually consisted of trees, shrubs, herbs and rarely woody climbers. The members of this family are rich in secondary metabolites. A number of phytochemicals 6-Octadecenoic acid, Ricinoleic acid, (9E,11E)-Octadecadienoic acid have been reported in the cells and tissues of these plants (Ullah *et al.,* 2023). Members of *Euphorbia* genus were comprised of milky sap which was rich in diterpenoids and phenolic compounds (Chaudhary *et al*., 2023). *Euphorbia* species secrete a milky sap or latex that contains a complex mixture of bioactive compounds, but primarily diterpenoids. This latex has been extensively explored due to its diverse biological activities and potential uses in both traditional and modern medicine (Benjamaa *et al*., 2022; Salehi *et al*., 2019).

A medicinally important macrocyclic diterpenoid ester has also been reported in *Euphorbia helioscopia* (Singh *et al*., 2023). Members of this family are economically and medicinally very important. *Euphorbia helioscopia* L. has been used to treat malaria, bacillary dysentery, osteomyelitis, and tumor in Chinese folk medicine (Nirmala *et al*., 2023). Leaves and fruits of *Putranjiva roxburghii* Wall have traditionally been used for the treatment of fever, muscle twisting, hemorrhoids arthralgia and rheumatism (He *et al*., 2023). It was also used as antinociceptive, antipyretic and anti-inflammatory (Singh *et al*., 2023). *Euohorbia prostrata* Aiton also contain medicinally important phytochemicals including anthraquinone glycosides, flavanoids, phenols, phlobotannins, polysaccharides, saponins, tannins and terpenoids (Yadav *et al*., 2024).

Phytochemicals responsible for various activities are found in different plant parts, including leaves, stems, fruits, roots, rhizomes, buds, and seeds. Leaves are considered the primary producers of phytochemical compounds and therefore exhibit strong allelopathic interactions with their surroundings (Bufano *et al.,* 2021; Mustafa *et al*., 2023). Mostly, these interactions are harmful to surrounding plants, but they can also provide advantages to certain selected species (Ain *et al*., 2023). In allelopathy research, inhibitory substances were often argued to explain the growth pattern, while other substances remained neglected (Naila *et al*., 2021). In addition to their role in various plant functions, phenols are also regarded as highly toxic to other plants (Pratyusha *et al*., 2022; Zhang *et al*., 2023). The impact of these phytotoxic substances should be evaluated on surrounding crops before introducing such plants into cultivation, as associated weeds may negatively affect economically important crops (Motmainna *et al*., 2021).

The strong allelopathic impact of *Euphorbia helioscopia* on *Triticum aestivum*, *Rumex dentatus*, *Helianthus annuus*, *Zea mays*, and *Avena fatua* was studied by Anwar *et al*. (2017). They identified *E. helioscopia* as a capable applicant for weed management, due to highlighting its potential to influence conventional agricultural strategies through natural biochemical interactions (Anwar *et al*., 2019). A previous study on *Euphorbia prostrata* revealed that its methanolic extract significantly inhibited wheat seed germination, with the highest suppression observed at a concentration of 1000 µg/ml. Furthermore, the extract notably reduced germination, root elongation, and shoot growth, indicating a dose-dependent allelopathic effect (Khan *et al*., 2012). Other weed extracts, including *Euphorbia heterophylla*, have also been reported to exhibit similar allelopathic activity, indicating the presence of intricate phytochemical interactions that can suppress crop germination and growth (Popoola *et al*., 2020).

Previous studies have shown that extracts from *Euphorbia* species, including *E. hirta* and *E. dracunculoides*, inhibit seed germination in various crop species. Specifically, methanolic extracts of *E. hirta* have been found to significantly reduce seed germination rates in certain genera of the Cucurbitaceae family, particularly at higher concentrations (Akter and Begum, 2024). *E. dracunculoides* inhibited radish and canola seed germination, suggesting potential allelopathic effects in Euphorbia species. This raises the possibility that

E. milii may have similar properties, requiring further investigation into its role in crop-weed interactions (Zeb *et al*., 2024). Aqueous leaf extracts of *Putranjiva roxburghii* were used in different concentrations (0-100%). Chickpea (*Cicer arietinum*) seed germination and early growth were inhibited to the greatest extent by the highest concentration (100%) (Oraon and Mondal, 2020). However, *P. roxburghii* has shown both growth-inhibitory allelopathic potential and positive growth-inducing properties (Beni *et al*., 2021), emphasizing the necessity of further research to clarify its dual role in sustainable agriculture.

In recent years, many researchers had checked the effects of different plants on the germination and growth of different crops (Bashar *et al*., 2023; Nadeem *et al*., 2023; Alemayehu *et al*., 2024). Naeem *et al*. (2023) examined the effect of *Gossypium hirsutum* extracts on wheat (*Triticum aestivum* L.) germination and growth and due to improvement in biochemical activities. Naeem *et al*. (2023) investigated the effects of *Gossypium hirsutum* extracts on the germination and growth of wheat (*Triticum aestivum* L.) and reported enhanced biochemical activity. Krumsri *et al*. (2020) investigated the inhibitory effects of *S. zeylanica* on rice shoot and root length as well as seed germination were measured using various sections of the plant. Krumsri *et al*. (2020) examined the inhibitory effects of *S. zeylanica* on rice by assessing seed germination, shoot length, and root length.

Despite the known allelopathic potential of *Euphorbia* species, their effects on key crops like wheat, rice, pea, and spinach remain underexplored. This study aims to evaluate the allelopathic impact of selected Euphorbiaceae species on seed germination and seedling growth of two monocots (wheat, rice) and two dicots (pea, spinach), contributing to sustainable and eco-friendly weed management strategies.

MATERIALS AND METHODS

The experiments were conducted to investigate the allelopathic potential of *Euphorbia helioscopia* L. *Euphorbia milii* Des Moulins. *Euohorbia prostrata* Aiton and *Putranjiva roxburghii* Wall. on seed germination and seedling growth of *Triticum aestivum* L. (Wheat), *Pisum sativum* L. (Pea) *Spinacia oleracea* L. (Spinach), and *Oryza sativa* L. (Rice).

COLLECTION AND DRYING OF PLANT MATERIAL

Mature and healthy plants leave of *Euphorbia helioscopia*, *Euphorbia milii, Euohorbia prostrata* and *Putranjiva roxburghii* were collected after 20-25 days. Then washed thoroughly with water and air dried for 20-25 days. The dried plant sample was ground into fine powder and stored in dry condition until used. The seeds of four different crops wheat (Akbar 19), pea (Sarsabz), spinach (Leo) and rice (Pusa Basmati 1692) were used to investigate the allelopathic potential of donor plants against them. Seeds were obtained from Punjab Seed Corporation, Lahore, Pakistan.

PREPARATION OF AQUEOUS EXTRACTS

The fine powder of each donor species was divided into three parts i.e., 1g, 3g, and 5g to prepare three different concentrations (1%, 3% and 5% respectively). To prepare the aqueous extracts of different concentrations, maceration technique was used (Tanveer *et al*., 2015). Weighed materials were soaked in 100ml of distilled water for each concentration and kept for overnight in the beakers. After 24 hours, the extracts were filtered with cheese cloth firstly to remove plant debris and finally filtered with the help of Whatman filter paper. The filtrate was obtained in the flasks and stored in refrigerator for further use.

PREPARATION OF MEDIUM FOR GERMINATION

Filter paper is the best medium for germination of seeds as it provides porosity for airflow and absorbance of plant extract. Moreover, the filter paper method is also effective and easy to handle. Aqueous extracts of 1%, 3% and 5% concentrations were applied on test plants by soaking double layer of filter papers. For sterilization of medium from dust particles or fungal attack, petri dishes were cleaned with ethanol dipped cotton. Ten sterilized seeds of each test species were placed in sterilized petri dishes having two folds of filter paper (Jain *et al*., 2020). Aqueous extracts of plants were applied on seeds. Distilled water was used for control set, instead of extracts. The experiment with each treatment was replicated three times.

GERMINATION AND GROWTH RECORDS

The experiments were set at a room temperature ranging from 25-30°C. The experiment was extended over a period of seven days. The results were determined by counting the number of germinated seeds and measuring the length of root and shoot by following (Gad *et al*., 2021). The hypocotyls and radicles of seeds were measured with centimeter (cm) scale followed by (Cui *et al*., 2020).

FORMULAE USED

$$\% \, Germination = \frac{Total\ number\ of\ germinated\ seeds}{Total\ number\ of\ seeds} \times 100$$

$$\% \, Inhibition\ or\ Stimulation = 1 - \frac{Root\ or\ Shoot\ length\ with\ treatment}{Root\ or\ Shoot\ length\ with\ control} \times 100$$

STATISTICAL ANALYSIS

Data was analyzed by Costat and Microsoft Excel. Single-factor ANOVA and Duncan's Multiple Range Test were performed to investigate the significance of results. Level of significance was 0.05. Percentage germination and growths of radicle and hypocotyl were represented by line graph.

RESULTS AND DISCUSSION

Allelopathy has the potential to exert a considerable influence on plant germination and growth and, subsequently on species population dynamics and community assembly. Plant growth is based on seed germination, which has an immediate impact on a plant's ability to survive and thrive (Khasabulli *et al*., 2018; Gorai, *et al*., 2014; Wang *et al*., 2019). Many natural substances are considered allelochemicals, including coumarins, which in high concentrations can be toxic to neighboring plants, thus impeding competition (Kostina-Bednarz *et al.,* 2023). *Euphorbia jolkinii* aqueous extracts inhibited photosynthesis and promoted stress related metabolites in *Arundinella hookeri*, resulting in less biomass (Xiao *et al*., 2025). *Euphorbia heterophylla* also inhibited germination and growth of *Cenchrus echinatus* by up to 93.95% and 84.6% for root and shoot growth, respectively (Elshamy *et al*., 2019). Among the biological methods of detection most frequently employed in allelopathy research is the seed germination test (Zhao *et al*., 2022). In the present study, four medicinal species of family Euphorbiaceae were analyzed to study their allelopathic impacts on different food crops including wheat, spinach, pea and rice. *Euphorbia helioscopia* significantly reduced the seed germination of wheat at all concentrations. Similarly, reduction in the emergence and length of radicle and hypocotyl, weight of test crops and vigor index have indicated that soil treated with *Euphorbia helioscopia* extract contained leached phytotoxins from the leaf residues, that had reduced the growth of the test species (Abedi *et al*., 2022). Present results were also correlated with the findings of Valiño *et al.* (2023).

EFFECT ON SEED GERMINATION OF TEST PLANTS

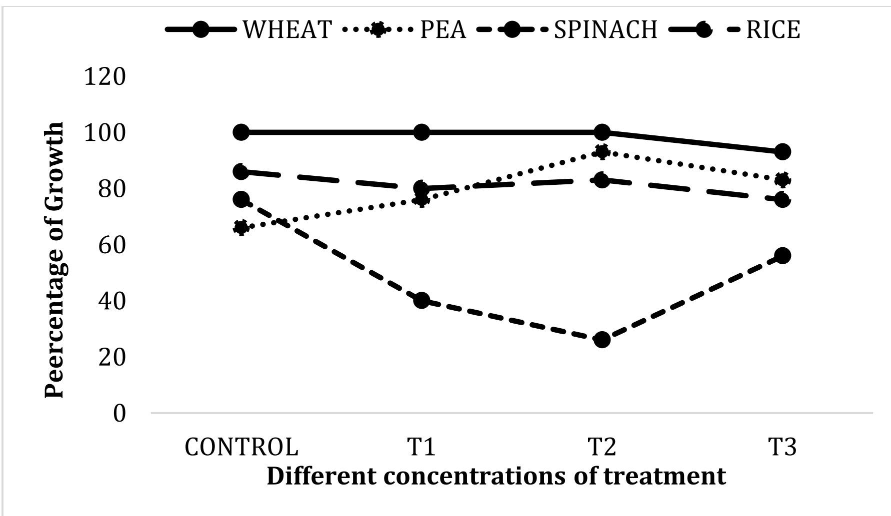
Aqueous extracts of fresh plants were used to check the seed germination of crop plants like wheat, pea, spinach, and rice. Donor plants displayed both stimulatory and inhibitory effects on seed germination of test plants (Janusauskaite *et al*., 2023). The aqueous extract of *Euphorbia milii* exhibited up to 40% stimulation in seed germination of pea at 3% concentration (Figure 1a). Similar results were reported by Janusauskaite *et al*. (2023) that boreal sunflower aqueous extracts can boost pea growth and promote pea seed germination, but they may also reduce the photosynthetic rate and adversely affect physiological characteristics. In the current study, *Euphorbia milii* inhibited seed germination of spinach and rice at all of its concentrations. 47% retardation was observed in seed germination of spinach at 1% concentration while up to 65% retardation was observed at 3% concentrations. Seed germination in rice was increased up to 11% at 5% concentration while 3% decrease in seed germination was recorded at 3% concentration (Figure 1a).

Euphorbia helioscopia exhibited up to 36% stimulation in germination of test plants at 1% concentration (Figure 1b). According to Madany *et al*. (2015), the aqueous extract of *Euphorbia helioscopia* had a significant negative impact on early seedling growth and the germination of wheat and peas. In present results, it was observed that at high concentrations, the rate of stimulation was also increased. Similarly, 28% stimulation was recorded at 5% concentration of extract. The results of Tanveer *et al*. (2010) supported these findings that *Euphorbia helioscopia*, being an allelopathic plant, has a strong inhibitory effect on the seed germination and seedlings growth of wheat, chickpeas; the leaf extract has the highest inhibitory effect. In another study, it was reported that the growth of vegetable crops' seedlings and seed germination are inhibited by *Euphorbia hirta* leaf extract (Bindumole *et al*., 2018). The methanolic extract of *Euphorbia hirta* has a higher inhibitory impact than the aqueous extract, considerably impeding seed germination and seedling growth (Akter *et al*., 2024).

Different concentrations of *Putranjiva roxburghii* showed suppression in seed germination. 38% retardation was observed at 3% concentration of *P. roxburghii* in seed germination of pea (Figure 2a). Consequently, it was examined that aqueous leaf extracts inhibit chickpea seed germination and early growth phases from *Putranjiva roxburghii*; the strongest inhibitory impact is observed in 100% extract (Oraonand and Mondal, 2020). Because *Putranjiva roxburghii* plants include lignins, starch, alkaloids, tannins, and calcium oxalate crystals, they exhibit pharmacognostic characteristics with possible medicinal benefits (Minj *et al*., 2018). In present findings, using a 3% concentration extract of *Putranjiva roxburghii*, 22% stimulation in seed germination of spinach was also observed. On the other hand, only 4% stimulation was recorded, at 3%

concentration, in the seed germination of rice. Extracts from *Putranjiva roxburghii* were found to be the most inhibitory on crop seed germination, especially at higher concentrations (Kadıoğlu *et al*., 2005).

Donor plants showed both stimulatory and inhibitory effects by the aqueous extract of *Euphorbia prostrata* at different concentrations. 38% simulation in seed germination of spinach was observed at 3% concentration, while 23% suppression in the same test plant was recorded at 5% concentration (Figure 2b). In our study, 13% retardation was observed by 1% concentration of *E. prostrata* in seed germination of wheat. At 3% concentration, 18% stimulation was observed in the seed germination of rice. Similarly, 8% stimulation was recorded at 1% concentration in the seed germination of rice. The results were corroborated with the findings of Khan *et al*. (2012) that the methanolic extract of *Euphorbia prostrata* exhibited a maximal inhibitory impact at 1000 µg/ml on seedling growth and wheat germination.



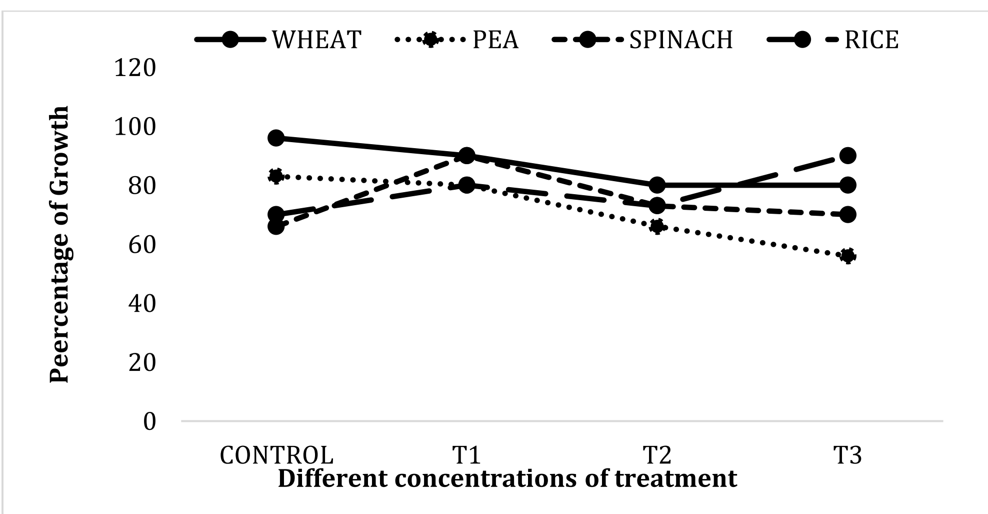


Figure 1: Effect of a) *Euphorbia milii* b) *Euphorbia helioscopia* on germination of test plants

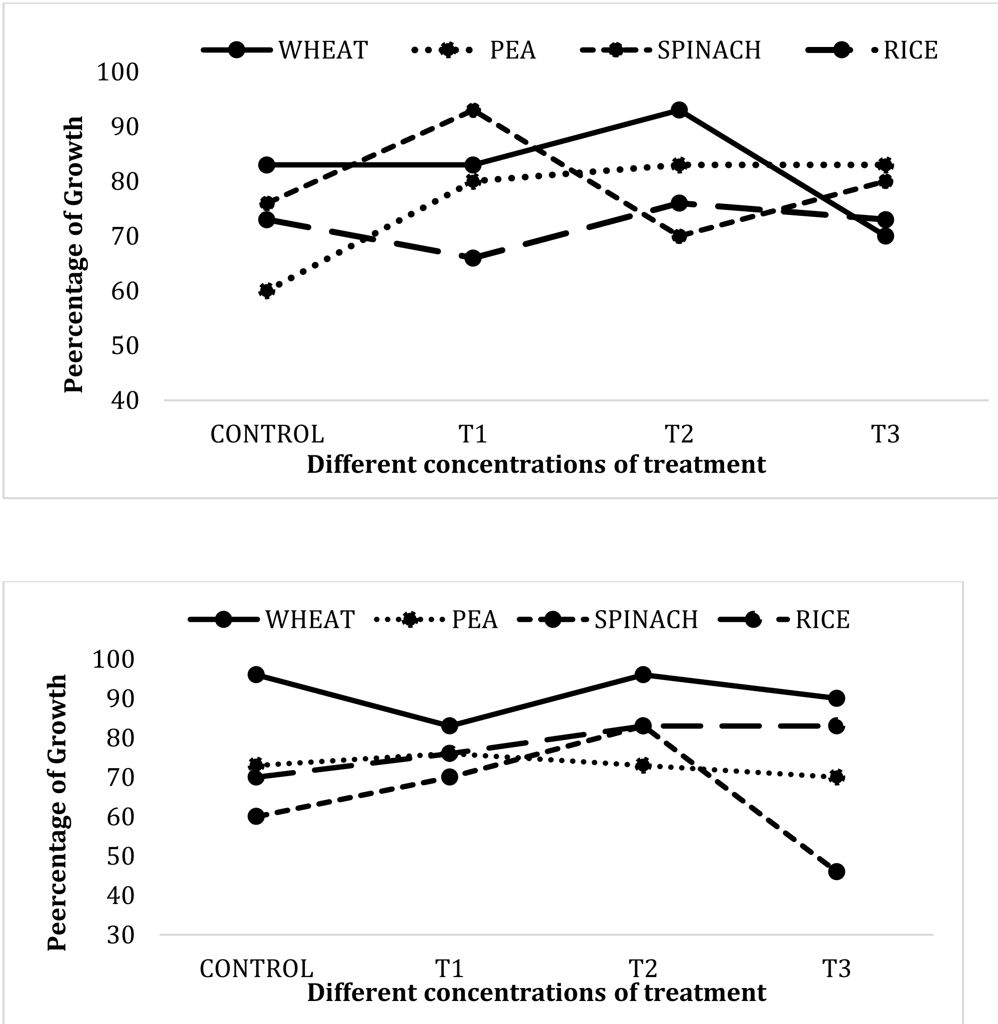


Figure 2: Effect of a) *Putranjiva roxburghii* b) *Euphorbia prostrata* on germination of test plants

EFFECT ON SEEDLING GROWTH OF TEST PLANTS

The aqueous extracts of different donor plants usually show wide range of activities as partial and complete inhibition, which may indicate the presence of certain allelochemicals causing inhibition (Hussain *et al*., 2020; El-Shora *et al*., 2022). According to Singh *et al*. (2021), plants directly affect other plants either positively or negatively through exuding chemical substances. Medic *et al*. (2022) have indicated that the highest level of allopathic suppression was arose when maximum level of phytotoxin coincided with early stages of plant growth.

There were significant phytotoxic effects of *Putranjiva roxburghii* on hypocotyl and radicle lengths of rice (Table 1; Figure 3a-d). These results were in accordance with the findings of *Putranjiva roxburghii* effects on chickpea (Oraon *et al*., 2020). Allelochemicals present in the aqueous extracts of plant species affect different physiological processes through their effects on enzymes responsible for phytohormone synthesis and they might cause inhibition of nutrients and ion absorption by affecting plasma membrane permeability (Ain *et al*., 2023). In this study results have inferred that phytotoxic compounds might be present in *P. roxburghii* which inhibited the germination and growth of crop plants.

The present results corroborated with the findings of Staszek *et al*. (2021), representing that the allelochemicals from *Putranjiva roxburghii* performed their inhibitory action via reactive oxygen species (ROS) overproduction, which subsequently resulted in oxidative stress. The indirect mechanism is in support of present findings that oxidative stress plays a vital role in plant growth inhibition caused by allelochemicals. This study reported similar results to previous studies, which showed that *Putranjiva roxburghii* had some allelopathic potential for inhibiting seed germination. Nazli *et al*. (2021) found key allelochemicals including gallic acid, ellagic acid, and gallocatechin, in *P. roxburghii*. These may generate an inhibitory effect. Additionally, Macêdo *et al*. (2022) stated that these compounds hinder plant physiological processes by suppressing enzyme activity, causing disruption of cell membrane activity, and changing hormonal balance. These mechanisms may explain the decreased seed germination observed in this study and likewise support the allelopathic effect of *P. roxburghii*.

P. roxburghii also showed significant suppression in seed germination of pea at various concentrations (Table 1). Similarly, Zareen *et al*. (2022) Allelopathic potential of summer weeds on germination and growth performance of wheat and chickpea. Similarly, Zareen *et al*. (2022) found that the allelopathic potential of summer weeds had negative effects on wheat and chickpea germination and growth performance, which supports our results for the antagonistic effects found in the current research. In present piece of work, maximum germination inhibition was recorded in rice by *Euphorbia milii.* According to Yan *et al*. (2022), the mechanism of inhibition of the growth and of the accumulation of fresh biomass in the primary seedling of the seeds had resulted from the effect of allelochemicals and could be explained by reduced cell division rate or by the elongation of the cells. In another study, revealed that allelochemicals from *Euphorbia milii* are compounds that may be released by plants extracts that can damage the seed membrane system, leading to reduced germination rates (Ogah *et al*., 2020; Vashishth *et al*., 2023).

Aqueous extract of *Euphorbia helioscopia* showed more inhibitory effects against the seed germination of all test plants (pea, wheat, rice and spinach) at all concentrations (Table 2; Figures 3e-f and Figure 4a-b). The results of present study have corroborated the findings of Tanveer *et al*. (2010), who reported that the aqueous extracts of *E. helioscopia* suppressed germination and seedling growth of lentil, chickpea and wheat. Anwar *et al*. (2017) and Deepti *et al*. (2023) also results were reported. Moreover, delay in seed germination and lower germination index with leaf extracts of *E. helioscopia* compared with other plant part extracts could be attributed to a more inhibitory effect of allelochemicals present in leaves. As stated in the previous study, the heliosterpenoids A and B from *E. helioscopia* studied by Mai *et al*. (2017) act as allelochemicals that inhibit the seed germination process by affecting water uptake and cellular processes necessary for dormancy release (Samajdar *et al*., 2018).

Table 1. Effect of *Putranjiva roxburghii* on Seedling Growth of Test Plants

Test Species	Measurement of Seedling Growth of Test Plants (cm)							
	Control		1%		3%		5%	
	H	R	H	R	H	R	H	R
Wheat	5.71^{**}	5.47^{**}	5.07^{*}	4.66^{*}	4.87^{ns}	4.21^{*}	3.86^{ns}	4.03^{ns}
Pea	3.35^{**}	5.61^{**}	1.96^{**}	5.56^{**}	1.31^{**}	5.12^{**}	1.24^{**}	2.15^{**}
Spinach	2.73^{**}	3.45^{**}	2.21^{**}	1.97^{*}	1.91^{**}	1.88^{*}	1.79^{**}	1.39^{ns}
Rice	3.38^{**}	4.71^{**}	1^{ns}	2.99^{ns}	0.9^{ns}	2.44^{ns}	0.73^{ns}	2.05^{ns}

Key: H = Hypocotyl, R = Radicle, ** = highly significant, * = significant, ns = non-significant

Table 2. Effect of *Euphorbia helioscopia* on Seedling Growth of Test Plants

Test Species	Measurement of Seedling Growth of Test Plants (cm)							
	Control		1%		3%		5%	
	H	R	H	R	H	R	H	R
Wheat	8.71^{**}	9.1^{**}	7.58^{**}	7.49^{**}	7.20^{**}	7.10^{**}	7.12^{**}	6.99^{**}
Pea	2.31^{**}	5.93^{**}	0.37^{ns}	4.73^{**}	0.25^{ns}	4.37^{**}	0.15^{ns}	3.24^{**}
Spinach	5.41^{**}	5.88^{**}	2.69^{ns}	3.40^{*}	2.22^{ns}	3.21^{*}	1.11^{ns}	2.15^{ns}
Rice	3.41^{**}	4.73^{**}	1.2^{ns}	2.75^{ns}	1.02^{ns}	2.44^{ns}	0.22^{ns}	1.53^{ns}

Key: H = Hypocotyl, R = Radicle, ** = highly significant, * = significant, ns = non-significant

Table 3. Effect of *Euphorbia prostrata* on Seedling Growth of Test Plants

Test Species	Measurement of Seedling Growth of Test Plants (cm)							
	Control		1%		3%		5%	
	H	R	H	R	H	R	H	R
Wheat	7.64^{**}	7.79^{**}	7.21^{**}	7.43^{**}	6.7^{**}	7.11^{**}	5.7^{**}	3.56^{ns}
Pea	1.66^{**}	7.01^{**}	0.9^{*}	6.06^{**}	0.27^{ns}	5.45^{**}	0.19^{ns}	5.13^{**}
Spinach	4.30^{**}	5.35^{**}	2.85^{**}	4.99^{**}	2.51^{**}	4.05^{**}	2.08^{**}	3.11^{**}
Rice	3.77^{**}	5.32^{**}	3.60^{**}	4.73^{**}	3.06^{**}	4.60^{**}	1.35^{ns}	3.56^{**}

Key: H = Hypocotyl, R = Radicle, ** = highly significant, * = significant, ns = non-significant

Aqueous extract of *Euphorbia. prostrata* showed more inhibitory effects against the growth of all test plants studied at all concentrations except wheat (Table 3; Figure 4 c-f). *E. prostrata* displayed significant suppression in pea growth. The observations were confirmatory with the findings of Tanveer *et al.* (2010) and Shanee *et al.* (2011) who reported that leaf extract of another species of *Euphorbia* (*E. helioscopia*) had great inhibitory effects on seedling vigor index of wheat, chickpea and lentil Shanee *et al.* (2011). Plant extract of *E. helioscopia* showed inhibitory effect on radicle length of test plant species. Similar effect of plant extract was observed on radicle length of plants in soil as compared to their respective control by Seifu *et al*. (2023). There was a detectable impact on the growth by the weed which explained that inhibitory compounds in soil might also cause marked suppression or inhibit growth of plant. Among all donor plant species, *E. milii* exhibited more stimulatory effects for all the test plants except rice (Table 4; Figure 5 a-d). Rice possessed more sensitive growth response against all donor plants except *E. prostrata* that showed significant stimulation in rice seedlings. These results were in accordance with those of Mamude *et al*. (2023). Aqueous extract from Stapleton leaves on the germination of seeds and the growth of the first seedlings of two selected crops. Similarly, Ain *et al.* (2023) reported that plumule growth was influenced more severely than radical growth. Akter *et al*. (2023) found significant allelopathic inhibition of shoot growth of wheat and barley and other crop species with *Parthenium* plant extract.

The comparative allelopathic potential of *Euphorbia milii* exhibited stimulatory effects for all the test plants except rice Figure. While the growth of rice seedlings negatively affected by *Euphorbia milii* at all concentrations. These results were like the findings of Channappagoudar *et al.* (2010). They reported the inhibitory effects of the extracts of *Cyperus rotundus* and *Commelina benghalensis* on the germination, seedling length, and seedling vigor index of wheat, sorghum, green gram, and soybean. Dongre and Yadav (2005), Stavrianakou *et al*. (2004) and Agarwal *et al*. (2002) also reported the inhibitory effects of above-mentioned plants on wheat, pea and lentil. The presence of inhibitory chemicals in higher concentrations in the leaves might be the reason for differential behavior of the extracts and maximum reduction in seedling growth (Shukla *et al*., 2003).

CONCLUSION

It was concluded that the inhibitory potential of *Euphorbia helioscopia* on the germination and growth of crop plants was higher as compared to other species. Moreover, the integration of plant extract in soil could be both stimulatory or inhibitory based on type of species grown with it. Therefore, a complete examination regarding the effects of allelopathic species is required before introducing them in agricultural system.

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AUTHOR'S CONTRIBUTION

HUA conducted the experiments. MR supervised the research. MI collected the data. NK and AI analyzed the data. ZM and MA reviewed and edited the manuscript.

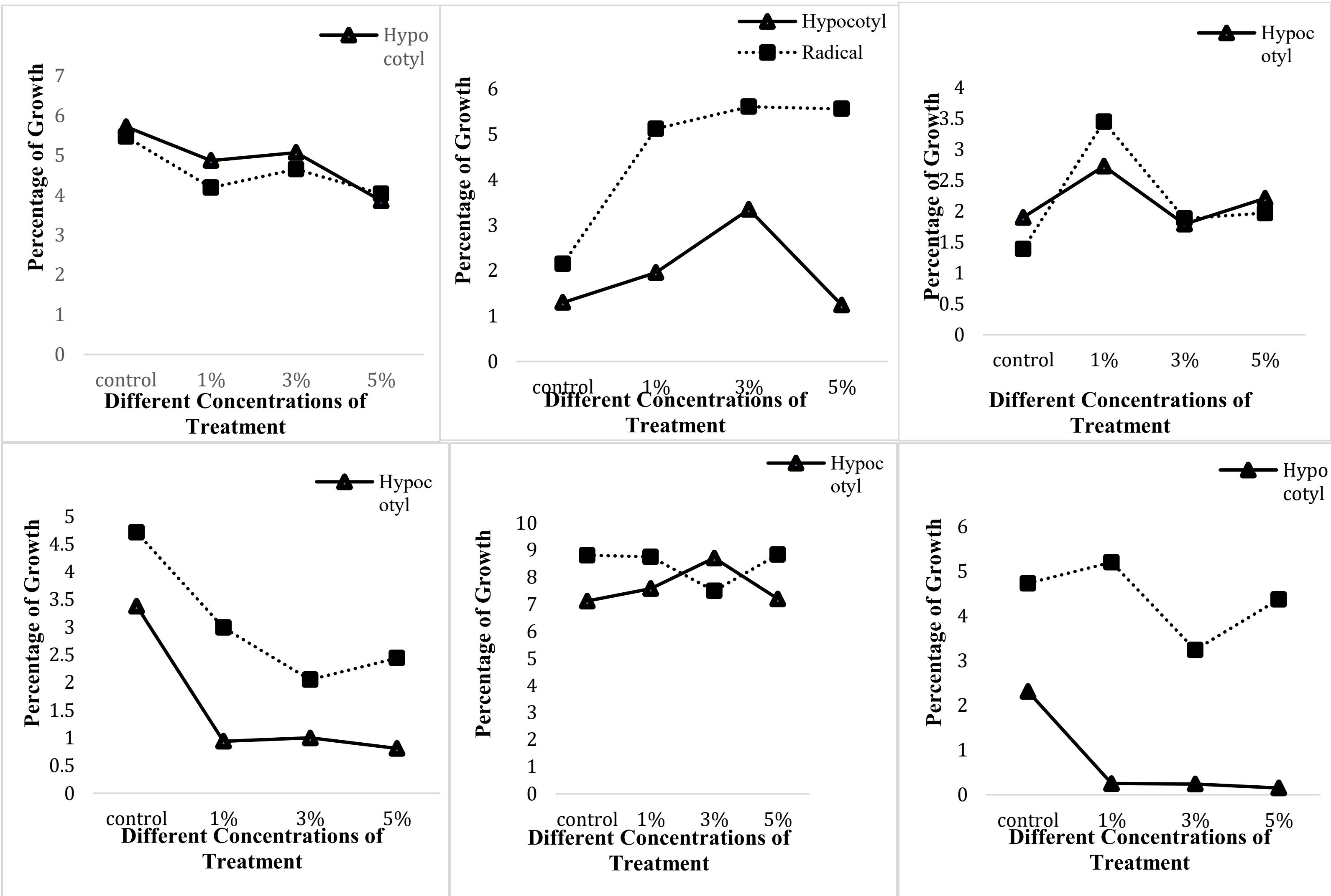

Figure 3: Allelopathic Effect of (a) *Putranjiva roxburghii* on Wheat (b) *Putranjiva roxburghii* on Pea (c) *Putranjiva roxburghii* on Spinach (d) *Putranjiva roxburghii* on Rice (e) *Euphorbia helioscopia* on Wheat (f) *Euphorbia helioscopia* on Pea

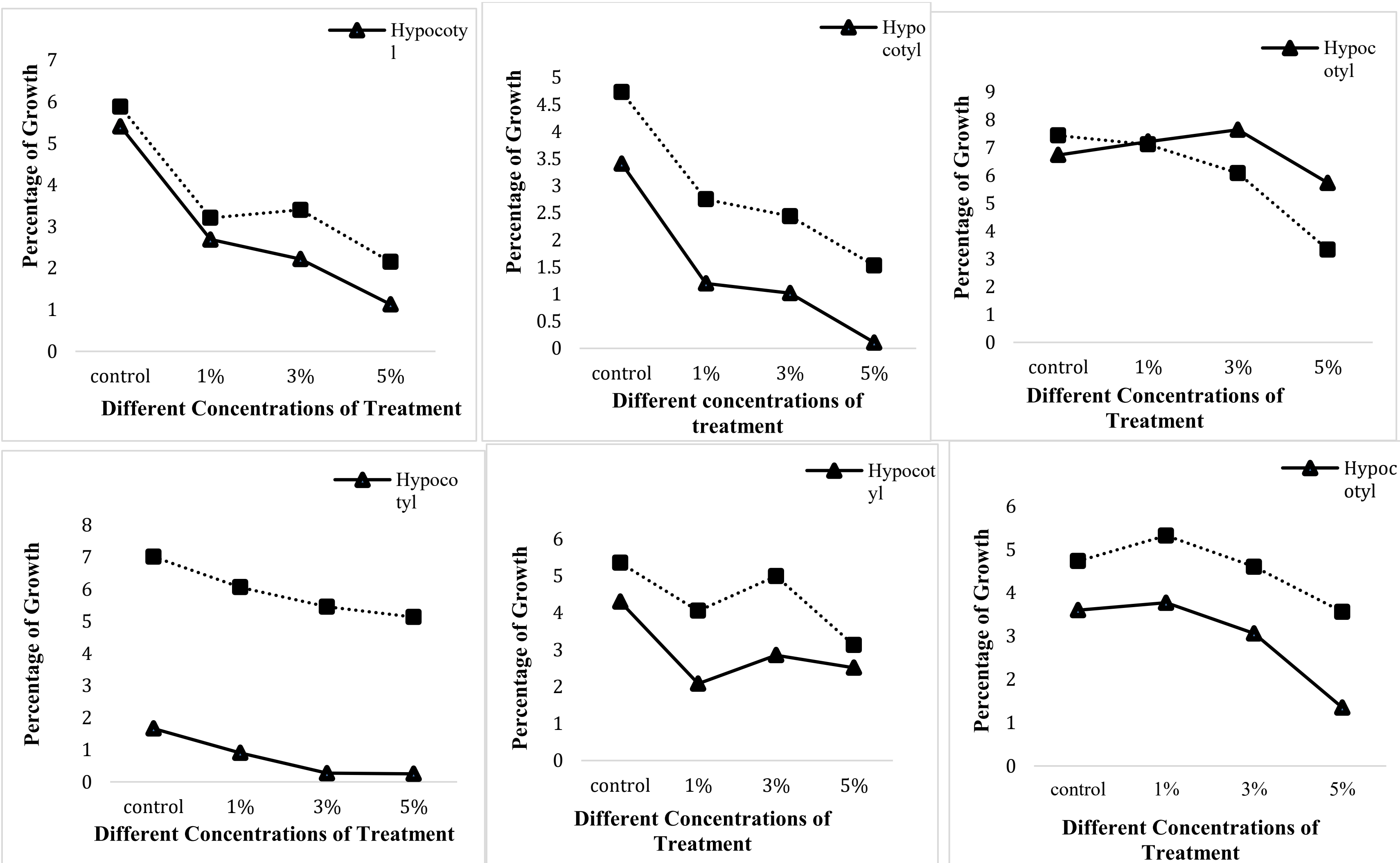

Figure 4: Allelopathic effect of (a) *Euphorbia helioscopia* on Spinach (b) *Euphorbia helioscopia* on Rice (c) *Euphorbia prostata* on Wheat (d) *Euphorbia prostata* on Pea (e) *Euphorbia prostata* on Spinach (f) *Euphorbia prostata* on Rice

Table 4. Effect of *Euphorbia milii* on Seedling Growth of Test Plants

Test Species	Measurement of Seedling Growth of Test Plants (cm)							
	Control		1%		3%		5%	
	H	R	H	R	H	R	H	R
Wheat	10.87**	10.55**	9.85**	9.65*	8.59**	7.29*	4.88ns	6.9ns
Pea	1.73**	7.01**	0.41ns	5.80**	0.23ns	5.53**	0.17ns	5.45**
Spinach	6.92**	5.07**	4.94*	3.99**	3.38*	3.51**	1.96ns	2.2**
Rice	2.44**	4.07**	1.73*	3.14*	0.41*	3.02*	0.16ns	1.61*

Key: H = Hypocotyl, R = Radicle, ** = highly significant, * = significant, ns = non-significant

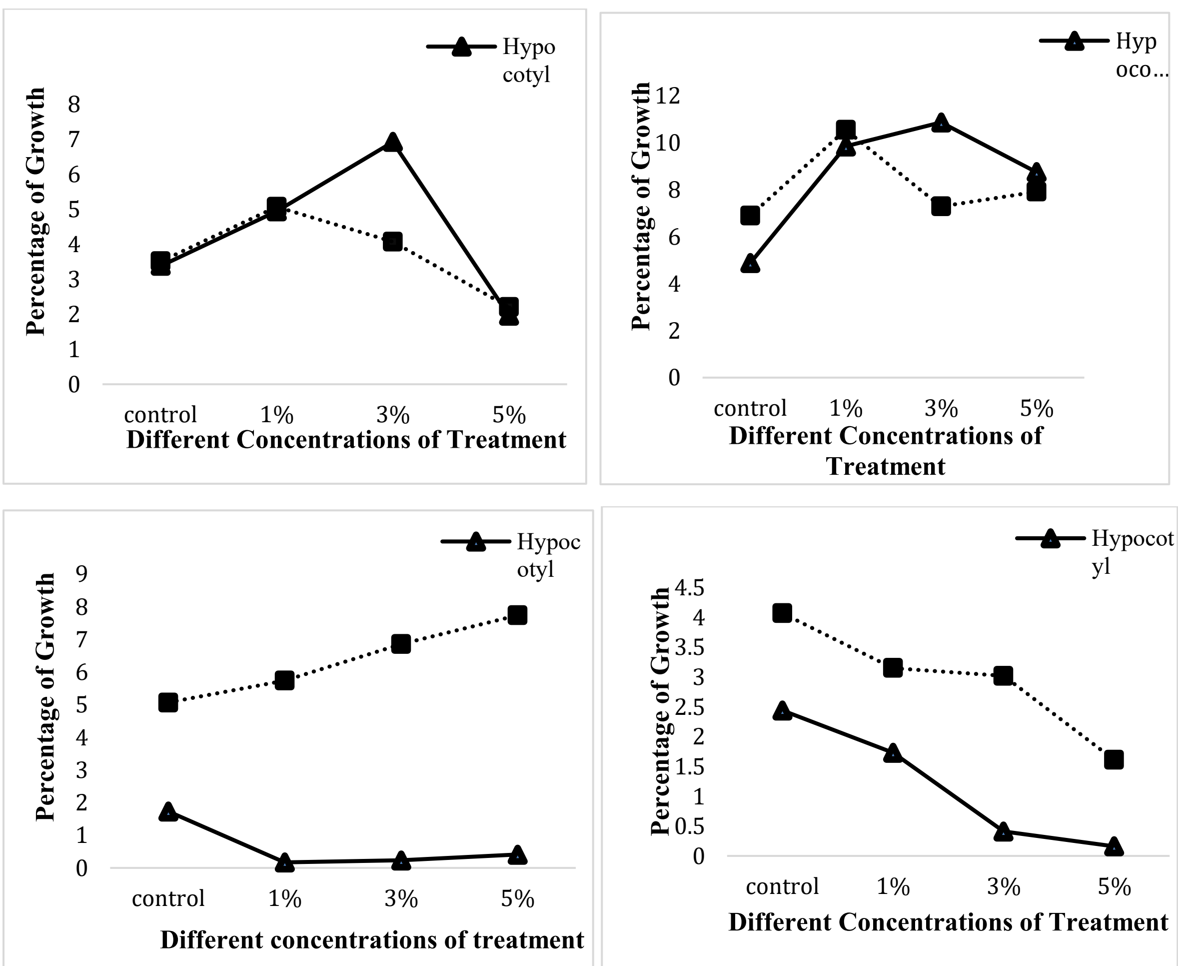

Figure 5: Allelopathic Effect of (a) *Euphorbia milii* on Spinach (b) *Euphorbia milii* on Wheat (c) *Euphorbia milii* on Pea (d) *Euohorbia milii* on Rice

CONFLICT OF INTREST

Authors declare no conflict of interest.

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