

## ALLELOPATHIC POTENTIAL OF DOMINATING WEED SPECIES ON GERMINATION AND GROWTH OF SELECTED WINTER CROPS

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### Abstract

Experiments were conducted to investigate the allelopathic potential of some dominating weeds (*Coronopus didymus* L., *Trianthema portulacastrum* L., *Malvastrum coromandelianum* L., *Cirsium vulgare* (Savi) Ten. and *Chenopodium album* L.) on winter crops i.e., pea (*Pisum sativum* L.), spinach (*Spinacia oleracea* L.), wheat (*Triticum aestivum* L.) and barley (*Hordeum vulgare* L.). The effects of different concentrations (0.5%, 1% and 2%) of weeds' extracts were recorded using filter paper method. The extracts of *Malvastrum coromandelianum* and *Cirsium vulgare* significantly reduced the seed germination, hypocotyl and radicle growth of spinach. Hypocotyl and radicle growth of barley was highly inhibited under the influence of the extracts of *Chenopodium album* while the same species stimulated the seedling growth and germination of spinach at its all concentrations. The effects were found to be concentration dependent. The results have indicated that *M. coromandelianum* and *C. vulgare* are not suitable near other crops due to their adverse effects on crops. It was concluded that these species are not suitable in an intercropping system. Moreover, their plantation should be carefully assessed with in the crop field.

**Keywords:** allelopathy; barley; germination; pea; spinach; wheat; weeds

### Introduction

Allelopathy is inhibitory or stimulatory effect of one plant species on another surrounding plant species through the release of chemicals (Al-shatti *et al.*, 2014). Allelochemicals are secondary metabolites and these may be present in seeds, leaves, flowers, fruits, pollens, roots, rhizomes and stems of the plants (Pour & Farahbakhsh, 2012; Zeng *et al.*, 2008). These allelochemicals could be tannins, carotenoids, terpenes, saponins, flavonoids, steroids, phenols, and alkaloids. These may have beneficial or harmful effects on the plants growth (Saxena *et al.*, 2016). Allelochemicals have been successfully used to kill pathogens, weeds, as well as to increase plants growth and yield of plants (Scrivanti, 2010). Many weeds have close associated with crops fields, growing in their surroundings, where these weeds are not required. Weeds are not only growing in agriculture fields but also rapidly growing in forests, open field areas,

roadsides and tank bunds. Weeds compete with crops for nutrients, sunlight and space particularly during the early growth period then ultimately reduces the growth of crops (Wang *et al.*, 2022; Cousen, 1996). These usually have negative impacts like *Euphorbia helioscopia* and *Coronopus didymus* are causal agents for producing bad smell and taste of the milk. On the other hands, some weeds have many benefits like *Chenopodium album* and *Melilotus alba* are extensively used as leafy vegetables (FAO, 2013). From medicinal point of view, *Verbena officinalis*, *Solanum nigrum*, *Plantago* species and *Datura stramonium* have been used either as such or in the preparation of other medicines (Ahmad *et al.*, 2017).

Usually weeds have harmful effects on the growth of plants, because weeds release water soluble allelochemicals from their roots, stems,

rhizomes, leaves, seeds, fruits and flowers. These chemicals are the combination of different compounds such as ketones, fatty acids, amino acids, aldehydes, flavonoids, purines, phenolics and others which decrease the growth and yield of economically important crops (Novak & Novak, 2019; Zand *et al.*, 2007). Several studies have proved that these allelochemicals can be used as alternative source of synthetic herbicides to control the growth of weeds (Jamil *et al.*, 2009; Khanh *et al.*, 2006). Recently, numerous authors have evaluated the allelopathic effects of different weeds on the yield of crops. Bashar *et al.* (2023) studied the allelopathic potential of methanolic extracts of *Parthenium hysterophorus* L. on the growth of plants. Hassan *et al.* (2023) evaluated the allelopathic potential of *Trianthema portulacastrum* L. on the germination and seedling growth of *Triticum aestivum* L. Therefore, present study was focused on the weeds present in the fields of winter crops as well as to evaluate the allelopathic potential of these selected weeds (*Coronopus didymus* L., *Trianthema portulacastrum* L., *Malvastrum coromandelianum* L., *Cirsium vulgare* (Savi) Ten. and *Chenopodium album* L.) on the seed germination and seedling growth of winter crops (wheat, barley, pea and spinach).

## Materials and Methods

### Collection and Drying of the Plant Material:

Fully mature plants were collected from University of Education Lahore, and from different areas of Punjab, Kasur (31° 7' 7.6548" N & 74° 27' 47.7792" E) and Chunian (30° 58' 0N & 73° 58' 60E). The plants were washed thoroughly and air dried in shade at room temperature, then crushed into fine powder and separately stored in polythene bags.

### Preparation of Aqueous Extract:

For the preparation of plant aqueous extracts of different concentrations (0.5%, 1% & 2%) dried powder of plants were weighted 0.5 g, 1 g and 2 g respectively and were soaked in 100 mL distilled water in separate beaker and kept at room temperature (28 °C) for 24 hours. The solutions were then filtered by using Whatman No.1 filter paper into a conical flask and stored in a refrigerator for further use.

### Test plants:

The four important crops two from monocot (barley & wheat) and other from dicot (pea & spinach) were selected as test plants. The seeds of these crops were taken from Punjab Seed Corporation. The seeds were germinated during January to March to study the allelopathic potential of donor plant ((*Coronopus didymus* L., *Trianthema portulacastrum* L., *Malvastrum coromandelianum* L., *Cirsium vulgare* (Savi) Ten. & *Chenopodium album* L.) against them.

### Preparation of Medium for Germination:

For germination and growth bioassay filter paper was used as growth medium (Zoheir *et al.*, 2008). During this bioassay, double fold of filter paper was placed in Petri dishes. Ten seeds were placed in each petri dish. The Petri dishes were moistened with 1.5 ml of aqueous extracts while distilled water was used as a control.

### Germinations and Growth Records:

The petri dishes were maintained at room temperature and experiment was extended for a period of 7-10 days. During the whole experiment the numbers of germinated seeds were counted each day. After 7-10 days total germinated seeds were counted and also the radical and plumule length were measured. The non-germinated seeds, less

germinated seeds and the seeds with fungal attack were considered mortal.

#### Formulae used:

% Germination

$$= \frac{\text{Total number of germinated seeds}}{\text{Total number of seeds}} \times 100$$

% Inhibition or Stimulation

$$= 1 - \frac{\text{Root or Shoot length with treatment}}{\text{Root or Shoot length with control}} \times 100$$

#### Data analysis:

Data were analyzed by computerized software SPSS (Statistical Package for the Social Sciences) and Microsoft Excel. Single-factor ANOVA was performed to investigate the significance of activity (Steel *et al.*, 1997). Level of significance was 5%. Percentage germination, mortality and growth of plumule and radicle were represented by bar graph and line graph respectively.

### Results and Discussion

#### Effect of Weeds on the Seed Germination

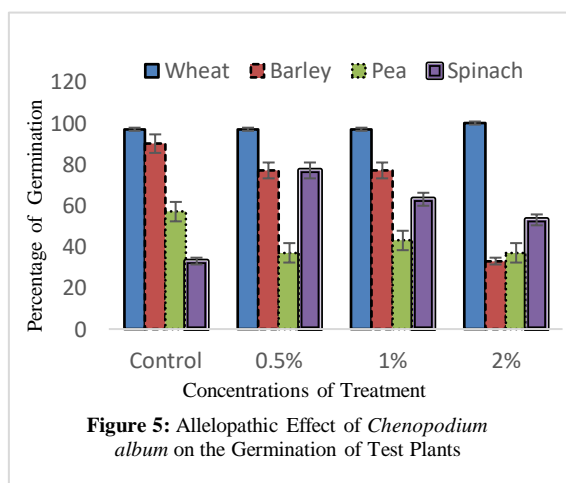
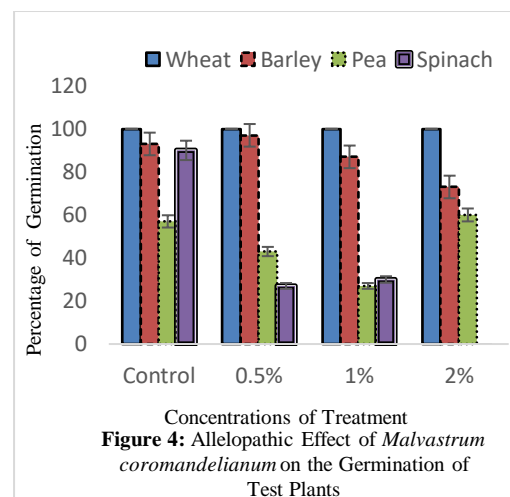
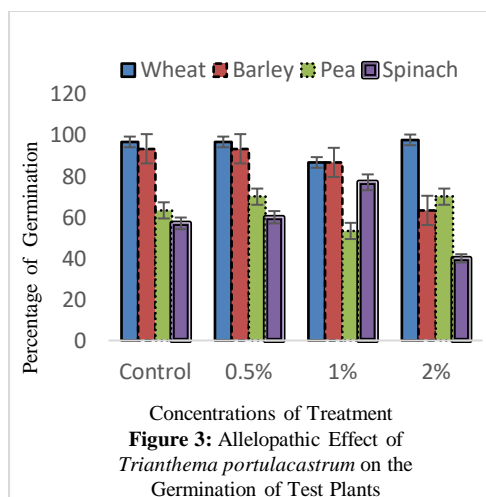
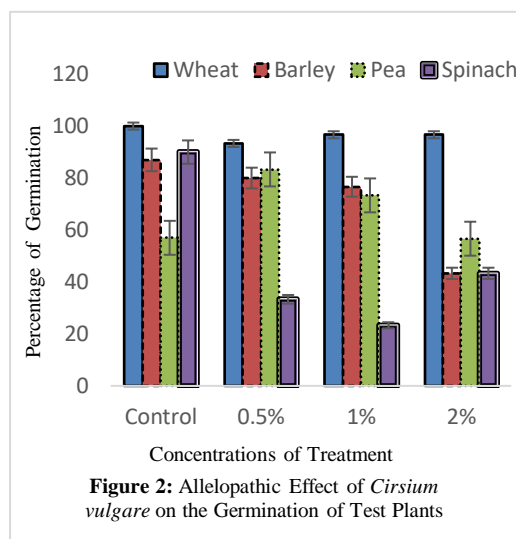
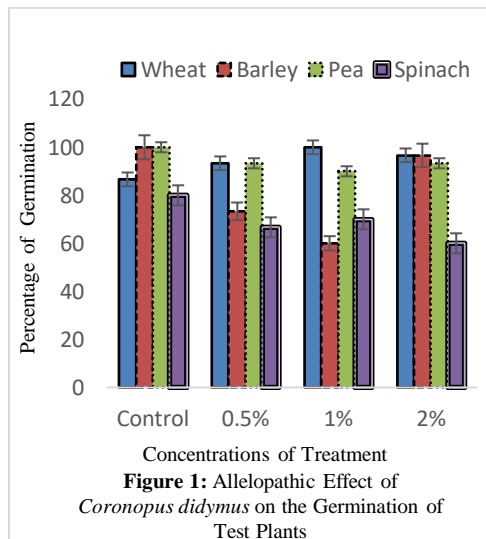
The most observable allelopathic effect in bioassays is reduction in seed germination (Khaliq *et al.*, 2013) and this reduction might be due to presence of allelochemicals (such as vanillic acid, gallic acid, ferulic acid, coumaric acid, caffeic acid flavonoids, phenolics and aldehydes) which interfere with cell division, cell elongation as well as cell differentiation processes (Macias *et al.*, 2020; Al-Wakeel *et al.*, 2007). In this study, aqueous extracts of *Coronopus didymus* reduced the seed germination of spinach (67%), barley (40%) and (7%) pea (Figure 1). The results found in the present investigation were in consistent with the findings of Khaliq *et al.* (2013). They reported that the seedling

growth of wheat was inhibited with increasing concentration of *C. didymus*. The inhibitory effect might be due to the imbibition of allelochemicals causing the embryo's death, which lead to alter cell membrane permeability, respiration process, conformation of enzymes and reduced water absorption by seeds (Hassan *et al.* 2023; Zeng *et al.*, 2001). It was observed that the aqueous extracts of *Cirsium vulgare* slightly enhanced the seed germination of pea while suppressed the seed germination of barley (55%) and spinach (74%) at higher concentration (Figure 2). These results were supported by Szabo *et al.* (2015). They found that *Cirsium arvense* exhibited a strong inhibition on seed germination of maize. Seed germination of plant species might be affected by death of embryo, block protein synthesis and cell division, growth inhibiting hormones and enzymes (Kandhro *et al.*, 2015; Nandula *et al.*, 2006; Koger *et al.*, 2004).

Aqueous extract of *Trianthema portulacastrum* showed 32% inhibition on the seed germination of barley and stimulated seed germination of wheat, spinach and pea (Figure 3). Present results were in consistence with the results of Hassan *et al.* (2023) as they evaluated that extracts of *Trianthema portulacastrum* L. reduced the seed germination of wheat while Sherif and Gharieb (2011) observed stimulation in the germination of green amaranth under the influence of aqueous extracts of *T. portulacastrum*. The stimulation might be due to the allelochemicals, which enhanced protein synthesis through stimulating the amino acid incorporation into protein wheat spinach and pea's seedlings (Inderjit & Nayyar, 2002). Seed germination of barley, pea and spinach was suppressed by the extract of *Malvastrum coromandelianum* while seed germination of wheat was neither stimulated nor inhibited by the extract of same species (Figure 4). Aqueous extract of *Chenopodium album* enhanced

the seed germination of wheat and spinach but suppressed the seed germination of both barley and pea. Highly stimulatory effect (90%) was found in spinach under the influence of 1% concentration of

*Chenopodium album* (Figure 5). This stimulation might be due to the presence of some growth promoting substances along with many other substances (Yamada *et al.*, 2010).



In contrast to this, Johani *et al.* (2012) observed the suppressive effects of *Chenopodium album* on seed germination of barley. It might be inferred that allelopathic effects of *Chenopodium album* are species dependent and the degree of allelopathic interference could even vary within a species due to the presence of chemical compounds like bibenzyls, flavonoids and terpenoids etc. (Soltys *et al.*, 2013).

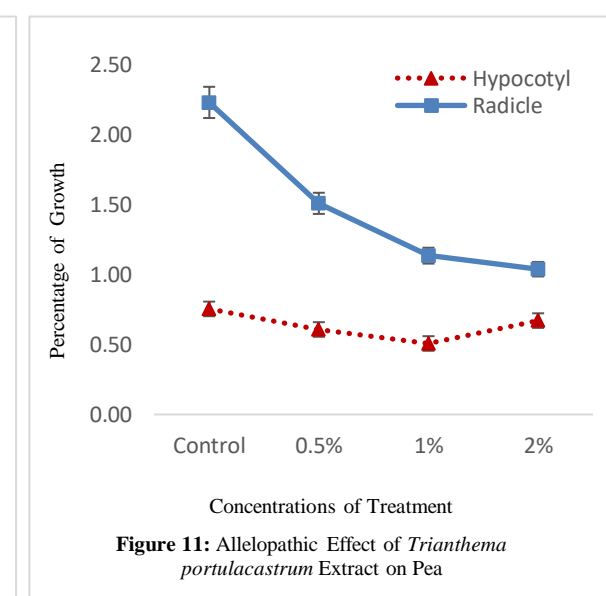
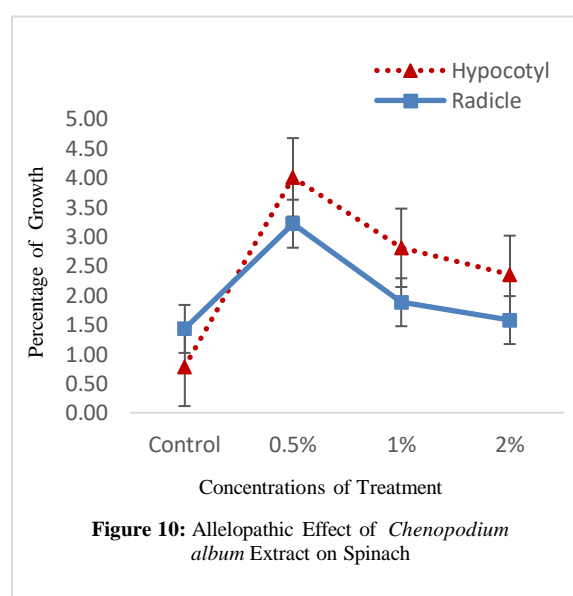
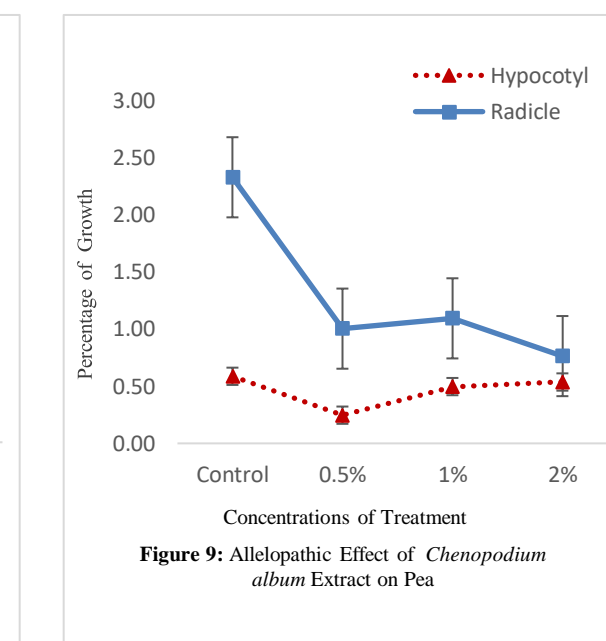
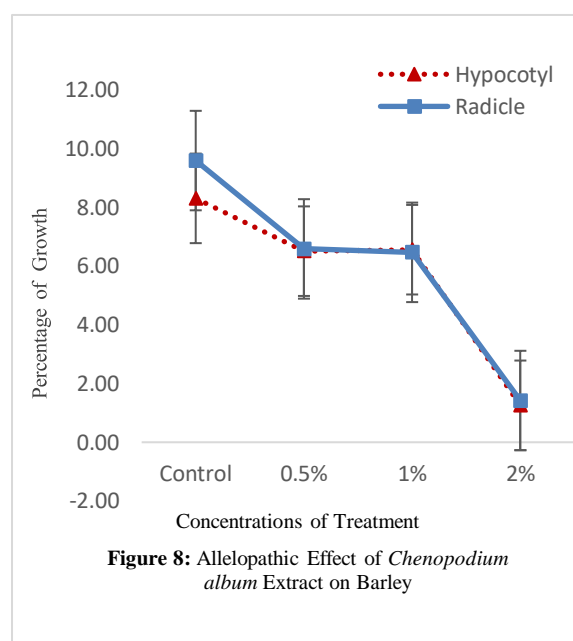
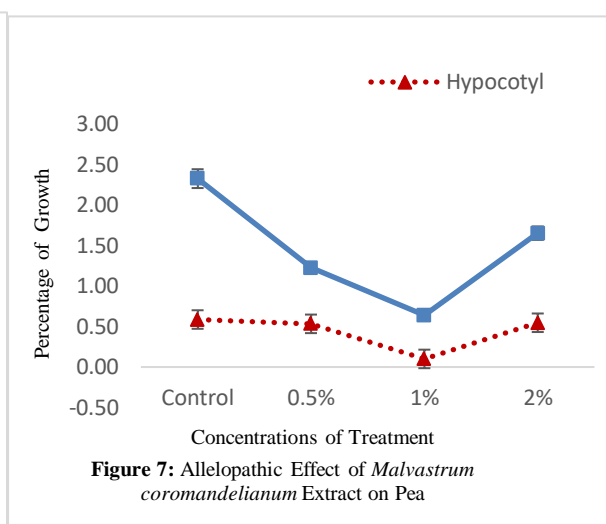
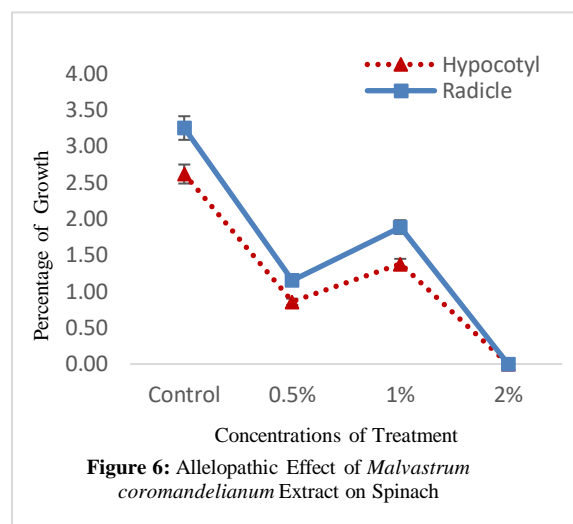
### Effect of Weeds on the Seedling Growth

Aqueous extract of *Malvastrum coromandelianum* significantly suppressed (100%) growth of both radicle ( $p=0.02$ ) and hypocotyl ( $p=0.01$ ) of spinach at 2% concentration (Figure 6) and inhibited (80% & 72%) hypocotyl and radicle growth of pea at 1% concentration (Figure 7). Similar results were observed by Singh (2021), who noted reduction in seedling growth of pea by the extracts of *Ageratum conyzoides*, this reduction in growth might be due to phenolic acid such as gallic, anisic, p-hydroxybenzoic and ferulic acid. Aqueous extracts of *Chenopodium album* significantly inhibited the seedling growth of barley ( $p=0.00$ ) and pea and inhibitory effect was concentration dependent (Figure 8 & 9). These results were supported by Majeed *et al.* (2012), they observed strong inhibitory effects of *Chenopodium* on the growth of wheat. This inhibition might be due to cinnamic acid amides present in *Chenopodium album* (Cutillo *et al.*, 2003). Spinach growth was found to be highly stimulated (100%) by the extract of *Chenopodium album* at lower concentration (Figure 10). According to Reinhardt *et al.* (1994), aqueous extracts of *C. album* was also found to be stimulatory against the radicle growth of tomato at its lower concentration. They stated that the stimulation in growth might be due to stimulatory

effects of allelochemicals. Aqueous extracts of *Trianthema portulacastrum* stimulated the hypocotyl growth while inhibited the radicle growth of all test plants but only suppressed both hypocotyl and radicle growth of pea (Figure 11). These results were in consistent with the results of Mubeen *et al.* (2011). They also found maximum reduction in seedling growth of rice by the aqueous extract of *T. portulacastrum*. The reduction in hypocotyl and radicle length might be due to water soluble inhibitors that could inhibit the functioning of indole acetic acid and gibberellic acid and inhibits cell division (Kil & Yun, 1992).

### Conclusion

The results have provided the evidence that aqueous extract of *Chenopodium album* exhibited more stimulatory effect against the seed germination and seedling growth of spinach. While aqueous extracts of *Malvastrum coromandelianum* and *Cirsium vulgare* significantly inhibited the seedling growth and seed germination of spinach. *Chenopodium album* extracts also significantly inhibited the seedling growth of barley. Variation in results have indicated that the selected weeds possessed allelopathic potential which was largely dependent on the type of weed as well as the type of crop growing in its surroundings. Therefore, it seems essential to check the allelopathic compatibility of crops with their surrounding plants before introducing them to intercropping system. Moreover, the current results were purely obtained under laboratory conditions. Hence, the assessment of allelochemical activities of dominating weeds under field conditions is imperative for future recommendations.



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## Conflict of Interests

Authors declare no conflict of interest.

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## Author's Contribution

Aqsa Perveen collected data and wrote the manuscript, Madiha Rashid supervised and designed the experimentation, Maliha Nawaz Mokhal did formal data analysis and Naveed Ul Hassan reviewed and edit the manuscript.

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