POTENTIAL USE OF *Coronopus didymus* (L.) SM. IN PARTHENIUM MANAGEMENT

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ABSTRACT

This study aimed to assess a brassicaceous weed *Coronopus didymus* (L.) Sm. as a source of potential natural herbicides for management of an alien weed parthenium (*Parthenium hysterophorus* L.). Initially, the effect of aqueous leaf, stem, root and flower extracts (0, 0.5, 1.0, 1.5, 2.0, 2.5, 3.0, 3.5, 4.0%) of the weed was checked on germination and growth of the target weed. Leaf and stem extracts showed the best herbicidal activity and a 2.5% extract of the each plant part completely inhibited germination of parthenium seeds. The lowest extract concentration (0.5%) of leaf and stem reduced germination by 56 and 46%, shoot length by 43 and 12%, root length by 59 and 62%, and biomass of whole plant by 44 and 15%, respectively. Root and flower extracts were less herbicidal and reduced parthenium germination by 23–52% and 33–56%, respectively. In a pot experiment, soil was incorporated with 0.2, 0.4, 0.6, 0.8, 0.10, 1.2% (w/w) crushed dry biomass of *C. didymus,* parthenium seeds were sown after one week and the effect of amendment on germination and plant growth was recorded after 45 days of sowing. All the doses of soil amendment significantly suppressed root length by 21–48% over control. A 1.2% soil amendment significantly reduced biomass of parthenium seedlings by 23%. This study concludes that leaf and stem extracts of parthenium possess potent herbicidal potential for control of parthenium.

Keywords: Alien weed, Brassicaceae, *Coronopus didymus,* natural herbicides, *Parthenium hysterophorus*.

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INTRODUCTION

Parthenium hysterophorus L. belongs to family Asteraceae, is an invasive weed native to the South, North and Central American tropics (Cowie *et al*., 2020). It was accidentally introduced in Indian subcontinent and spread rapidly due to its excessive reproductive potential, fast growth rate, aggressive nature, adaptive behavior and efficient utilization of available resources (Kanaujiya *et al*., 2018). In Pakistan it is not only found in cultivated sites but also very common in bare lands, forming huge, roadsides, pure patches, paved surfaces, water channels and disturbed places with no other vegetation in its vicinity (Zareen *et al*., 2018). It is an annual weed germinates all the year when gets appropriate soil moisture level with adverse effects on ecosystem, plant biodiversity, crop production and animal husbandry (Hussain *et al*., 2017). Being aggressive in nature, it dominates indirectly or directly over the indigenous plant population with the production of noxious chemicals that knock down the chlorophyll production, photosynthesis, respiration and protein synthesis (Jayaramiah *et al*., 2017).

Parthenium produces water soluble toxins that can cause serious health hazards such as respiratory difficulties and allergic responses in susceptible humans (Nyasembe *et al*., 2015). The known prevailing lethal components are vanillic acid, caffeic acid, chlorogenic acid, anisic acid, benzoic acid, p-coumaric acid, ferulic acid and particularly parthenin (Kapoor *et al*., 2016). An individual Parthenium plant flowers for several months with a total production of 0.015 to 0.025 million seeds serving as the main source of further dispersal (Bajwa *et al*., 2017). Its management through the use of chemical herbicides available in the market is not recommended to the growers because of increased awareness on their hazardous effects on the environment. There is a need to develop alternative control strategies that are safe in use to the consumers and growers (Ojija *et al*., 2019).

Plant based natural products are a rich source of bioactive compounds that are environmentally safe than the synthetic chemicals for the management of noxious weeds (Mishra *et al*., 2018). Many cultivated and non-cultivated species of family Brassicaceae are known to have herbicidal properties (Kim *et al*., 2016). *Coronopus didymus* is an unpalatable annual wild herb grows spontaneously during winters along the roadsides with profusely branched plant system exhibiting excessive growth biomass (Sidhu *et al*., 2017). It is commonly used in folk medicines for the treatment of ulcers, wounds, bruises, muscular pain, gastric illness, arthrosis, bronchitis, inflammations and allergies (Noreen *et al*., 2017). It produces putative allelochemicals and secondary metabolites known as glucosinolates being released into the environment with detrimental effects on neighboring hazardous plant species (Noreen *et al*., 2016). In agro-ecosystem, the release of allelochemicals have implications in suppressing the growth of unwanted plants by interfering their biochemical and physiological processes (Kong *et al*., 2019). Literature is not available on the possible allelopathic interference of *C. didymus* on *P. hysterophorus*. Therefore, the objective of the present study was to explore the allelopathic potential of *C. didymus* against the germination dynamics and seedling growth of invasive parthenium weed.

MATERIALS AND METHODS

Laboratory bioassays

Fresh plant material of *C. didymus* was collected and washed thoroughly with distilled water. Plants were separated into roots, stems, leaves and flowers. Fresh biomass of each plant part (equivalent to 4 g dry material) was crushed into 100 mL of distilled water and filtered through muslin cloth followed by two layers of filter paper. The obtained stock solution 4% w/v was further diluted to prepare eight different concentrations *viz.* 0.5, 1.0, 1.5, 2.0, 2.5, 3.0, 3.5, 4.0%. Parthenium seeds, 25 in each 9-cm Petri plate, were placed on double layer of filter papers at an appropriate distance and moistened with 3 mL of different concentrations of each part of *C. didymus* aqueous extracts. Four replicates of each treatment were prepared simultaneously with a control and incubated at 25°C for 7 days. The experiment was checked on regular basis. After 7 days, the number of germinated seedlings, shoot length, root length and plant fresh biomass were recorded.

Pot trial

Plastic pots of 6-cm diameter were filled with sandy loam soil and amended with different doses *viz.* 0.2, 0.4, 0.6, 0.8, 0.10, 1.2% of sun dried *C. didymus* whole plant biomass with a control having four replicates of each treatment. All the pots were watered and left for 7 days. Thereafter, 10 seeds of parthenium in each pot were sown and the whole experiment was kept in a green house in a completely randomized fashion. After 45 days, the plants were harvested and the data regarding germination percentage, shoot length, root length and dry plant biomass were recorded.

Statistical analysis

All the data were subjected to ANOVA followed by application of LSD test at $P \leq 0.05$.

RESULTS AND DISCUSSION

Laboratory bioassays

ANOVA revealed that the effect of plant parts (P), extract concentrations (C) as well as P × C was highly significant ($P \leq 0.001$) for germination as well as for all the growth related parameters (Table 1). Among the four types of extracts, leaf and stem extracts were highly inhibitory against germination and growth of parthenium. A 2.5% concentration of both of these aerial parts completely inhibited germination of parthenium. Lower concentrations (0.5 to 2.0%) of leaf and stem reduced germination by 50–85% and 46–87%, shoot length by 43–99% and 12–81%, root length by 59–99% and 62–95%, and plant biomass by 44–86% and 15–95%, respectively (Fig. 1). Khaliq *et al.* (2013a) evaluated inhibitory potential of different parts of *C. didymus* against germination and seedling growth of wheat, and found leaf extract the most inhibitory one. A 10% leaf extract caused 59% reduction in germination. Noreen *et al.* (2016) identified three flavonoids in aerial parts of *C. didymus.* Previously, Javaid *et al.* (2010) reported that flavonoids isolated from mango leaves reduced germination of parthenium. Likewise, Da Silva *et al.* (2013) demonstrated that flavonoids isolated from *Derris urucu* leaves reduced germination of various weed species. In addition to that, *C. didymus* also contains various phenolic compounds (Noreen *et al.,* 2017), which could be responsible for reduced germination of parthenium (John, 2012).

Root and flower extracts were comparatively far less inhibitory to germination and seedling growth of parthenium as compared to leaf and stem extracts. None of the concentration of these two extracts completely arrested parthenium germination. There was 23–54% and 33–56% reduction in germination of parthenium due to various concentrations (0.5 to 4.0%) of root and flower extracts over control. Likewise, root and flower extracts suppressed shoot length by 0–33% and 0–36%, root length by 34–51% and 10–43%, and plant biomass by 11–43% and 12–43%, respectively, over control. Adverse effect of the extracts on root length and plant biomass of parthenium was generally significant but the effect on shoot length was nonsignificant (Fig. 1).

Soil amendment

Six doses of *C. didymus* (0.2 to 1.2%) dry biomass were used as soil amendment to check allelopathic effect of the weed on parthenium germination and growth. All the doses significantly reduced germination by 29–65% over negative control (Fig. 2A). Khaliq *et al.* (2013a) reported that soil application of *C. didymus* at 12 g and 16 g kg^{-1} soil reduced germination of rice by 60% and 74%, respectively.

Different growth parameters showed variable response to soil amendment. The lowest dry biomass dose (0.2%) stimulated shoot length and there was 38% increase over control. By contrast, rest of the soil amendment treatments had insignificant effect on shoot length (Fig. 2B). There are many reports in literature regarding growth stimulation due to lower doses of allelochemicals (Malik and Williams, 2005; Peng, 2019). Javaid *et al.* (2008) reported a significant increase in pod length of mungbean due to 1% amendment of fresh biomass of an allelopathic weed parthenium while higher doses adversely affected this parameter. In the present study, the highest dose of dry biomass used was 1.2% that had no significant adverse effect on shoot length. It is highly likely that parthenium shoot growth can be significantly reduced if higher doses than 1.2% are tried. In contrast to shoot length, root length of parthenium was significantly suppressed by all the soil amendment doses. Different doses of dry biomass reduced this parameter by 21–34% over control (Fig. 2C). Different response of shoot and root growth to allelopathic stress of the same weed might be attributed to the fact that roots are in direct contact with allelochemicals released by the decomposing plant materials that have more severe effect on root growth than on shoot growth (Noor and Khan, 1994). Whole plant biomass of parthenium was variably reduced by 13–28% over control due to 0.2 to 1.2% doses of dry biomass of *C. didymus* (Fig. 2D). Earlier, application of *C. didymus* residues at 16 g kg^{-1} soil reduced seedling dry biomass of rice by 59% (Khaliq *et al.,* 2013b). Members of family Brassicaceae possess glucosinolates which after releasing into the soil, suppress germination and growth of other plant species (Bialy *et al.,* 1990). In addition, after degradation in the soil, these compounds are converted into other compounds such as isothiocyanates and nitriles which are known to interfere with biochemical and physiological processes of other plant species (Weston and Duke, 2003).

CONCLUSION

Results of lab and pot studies clearly indicate that extracts of leaf and stem, and dry biomass of *C. didymus* have the potential to control germination and growth of noxious parthenium weed. However, further studies are required to assess the herbicidal and allelopathic potentials of higher doses of dry biomass *C. didymus* as soil amendment than 1.2%. Moreover, further studies are also suggested to use extracts of aerial parts of this weed as foliar spray for the control of parthenium plants at different growth stages.

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Table-1. ANOVA for the effect of different concentrations of aqueous extracts of different parts of *Coronopus didymus* on germination and seedling growth of parthenium in laboratory bioassays.

Trait	df	**Mean squares**			
		Germination	Shoot length	Root length	Plant biomass
Part assayed (P)	3	5454*	1551*	1175*	13539*
Concentration (C)	8	3722*	295*	321*	4986*
P × C	24	227*	76*	36*	561*
Error	108	18	9.3	5.3	36.4
Total	143				

*, significant at P≤ 0.001.

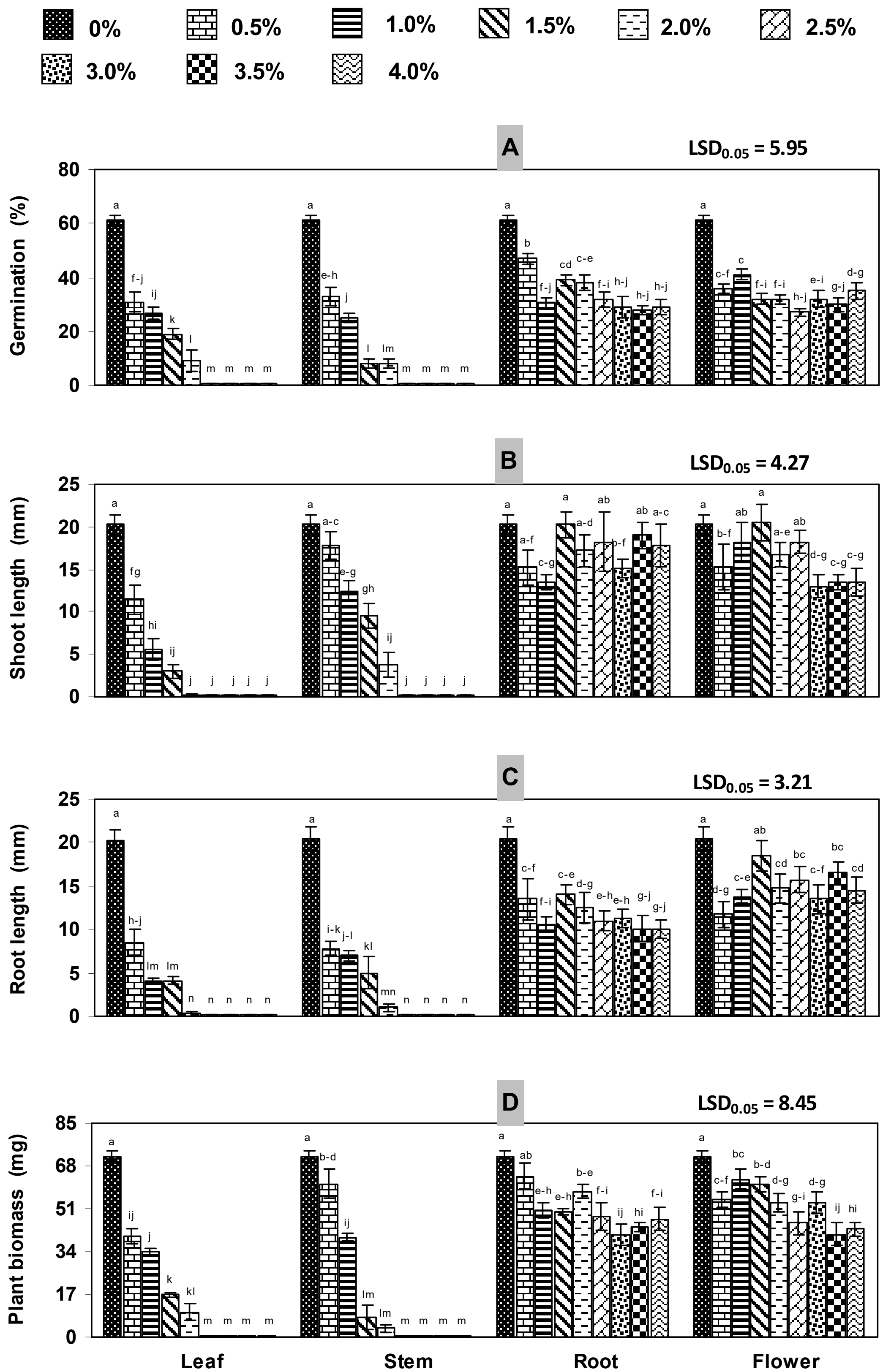

Fig. 1. Effect of different concentrations of aqueous extracts of different parts of *Coronopus didymus* on germination and seedling growth of parthenium in laboratory bioassays. Vertical bars show standard errors. Bars with different letters show significant difference (P≤0.05) as determined by LSD Test.

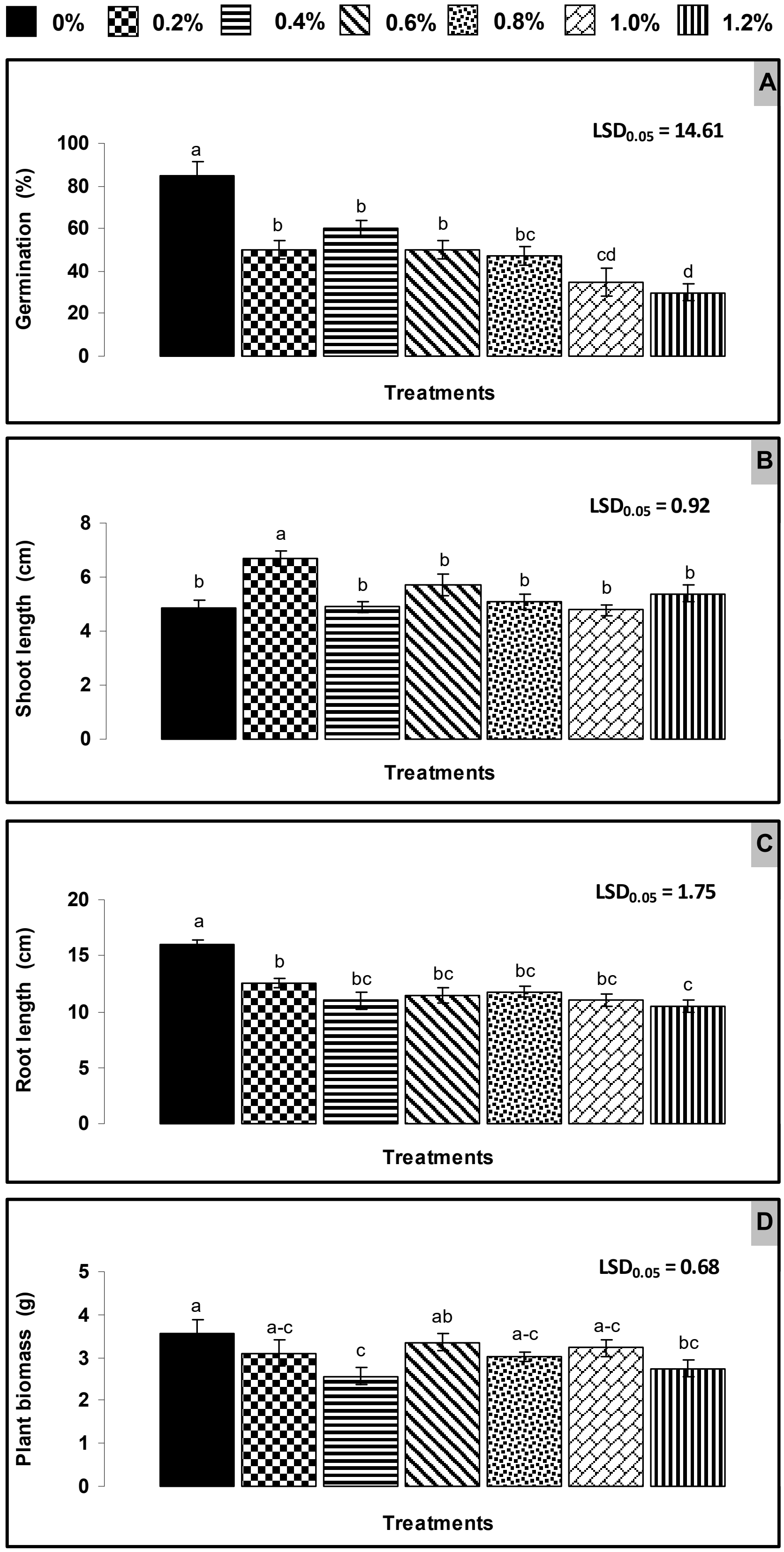

Fig. 2. Effect of soil amendment with different doses of *Coronopus didymus* dry biomass on seed germination and plant growth of parthenium. Vertical bars show standard errors of means of four replicates. Values with different letters at their top show significant difference (P≤0.05) as determined by LSD Test.