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Research Paper

Phytotoxic interference of roots of Chenopodium ambrosioides against some weeds

Botany

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ABSTRACT

Chenopodium ambrosioides (Mexican tea or Indian wormseed), a native of tropical America, is an annual erect, profusely branched herb with camphoraceous smell. It has naturalized various parts of India up to an altitude of 2300m MSL. The present study investigated the nature of phytotoxic interference of C. ambrosioides against two agricultural weeds, Echinochloa crus-galli and Phalaris minor. Root extracts of C. ambrosioides were observed to be inhibitory towards germination and early growth measured in terms of root and shoot length and seedling dry weight of test weeds. A significant amount of water-soluble phytotoxins were present in root extracts. The observed growth reduction in seedling growth was concomitant with the amount of phenolic compounds in C. ambrosioides root extracts. The study concludes that root exudates of C. ambrosioides suppress the growth of weeds by releasing allelochemicals into the soil. Allelopathy seems to play a significant role in root-mediated negative interference of C. ambrosioides.

Introduction

Allelopathy refers to interference mechanism in which plant releases bioactive metabolites into surrounding environment that adversely affect the growth and establishment of other plants growing in vicinity (Anaya, 1999). Recently, allelopathy has been proposed as a novel mechanism for successful colonization and dominance of many invasive weeds in the alien environment (Bais, Vepachedu, Gilroy, Callaway, & Vivanco, 2003; Bais, Park, Weir, Callaway, & Vivanco, 2004; Kohli, Batish, Singh, & Dogra, 2006). Among various modes of release of allelochemicals (chemicals involved in allelopathy), i.e. root exudation, leachation from living or dead plant parts, residue decomposition, or volatilization, root exudates contribute maximum to the phytotoxins released in the rhizosphere (Bertin, Yang, & Weston, 2003). Roots being in direct contact with soil, and play a significant role in the belowground communications (Batish, Lavanya, Singh, & Kohli, 2007; Batish, Kaur, Singh, & Kohli, 2009). It is thus pertinent to explore role of roots in imparting phytotoxic / allelopathic effects to the invasive weeds.

Chenopodium ambrosioides L. (Mexican tea or Indian wormseed; Chenopodiaceae), a native of tropical America, is an annual herb with camphoraceous smell (Anonymous, 1992). The weed extensively grows along roadsides, vacant areas and also in agricultural fields and forms monocultures especially in wastelands. The aerial parts of weed possess golden yellow coloured volatile essential oil that is rich in monoterpenes (Anonymous, 1992). The broad spectrum biological activity of C. ambrosioides suggests that allelopathic interference might play an important role in determining the vegetation structure of plant community. In fact, little vegetation in its surroundings has been observed during active growing period. A preliminary study demonstrated that methanolic, water, and oil extract of C. ambrosioides suppress germination and growth of Lycopersicon esculentum, Beta vulgaris, Melilotus indicus and Sonchus oleraceus (Hegazy & Farrag, 2007). However, there is no report on phytotoxicity of weed due to roots. Based on these, it was hypothesized that the weed may also exhibit phytotoxicity through roots. Therefore, a study was planned to evaluate the phytotoxic interference of roots of C. ambrosioides against two weeds Echinochloa crus-galli and Phalaris minor.

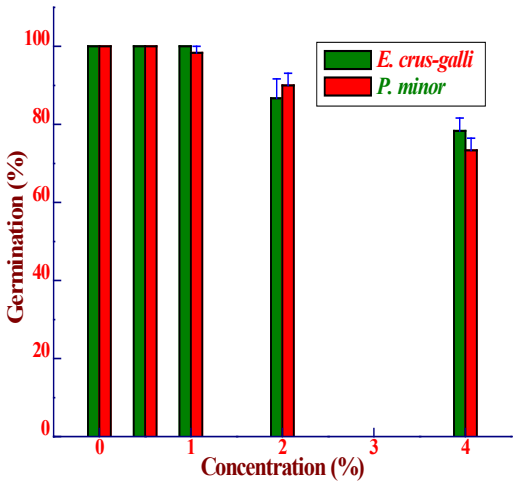
Methodology

The roots of freshly collected C. ambrosioides were separated, dried and powdered. Four gram root powder dipped separately in 100 ml of distilled water for 18 h at 25 ºC. The mixture was filtered through Whatman's filter paper # 1 and extracts thus obtained (4%; w/v) were diluted to obtain 2, 1 and 0.5% concentrations. The pre-imbibed seeds of two weeds i.e. Echinochloa crus-galli (barnyard grass) and Phalaris minor (little canary grass) were equidistantly placed on Whatman's filter paper (#1) moistened with 4, 2, 1 or 0.5% extracts or water (to serve as control) in 12 cm Petri dishes. The Petri dishes were kept in growth chamber maintained at controlled conditions as per Batish, Kaur, Singh, and Kohli (2009). After seven days, the number of seeds germinated was counted and root and shoot length and seedling dry weight measured. The total content of phenolics was estimated by using Folin–Ciocalteu reagent as per Batish et al. (2009). For each concentration, five replicates were maintained. All the experiments were performed in a completely randomized manner. The data were subjected to one-way analysis of variance and the mean values were separated at p≤ 0.05 applying post-hoc Tukey's test using SPSS/PC version 10 software.

Results

E. crus-galli showed 100% germination in control, and also at 0.5 and 1% root extracts of C. ambrosioides whereas in P. minor, germination was observed to be 100% in control and at 0.5% extract. At 2%, a reduction of ~13 and 10% was observed in seed germination of E. crus-galli and P. minor, respectively.

Fig. 1: Effect of root extracts of C. ambrosioides on % germination of test weeds.



The bar represents standard error.

Upon exposure to 4% root extracts, ~22 and 27% suppression was observed in germination of E. crus-galli and P. minor, respectively (Fig. 1). Root length of E. crus-galli compared to control, was inhibited by 34 and 53% (statistically significant at P≤0.05), respectively (Table 1). Likewise, root length of P. minor was suppressed by 13, 31 and 43% at 1, 2 and 4% root extracts. With the treatment of 0.5–4% extracts, shoot length of E. crus-galli and P. minor decreased in the range of 9– 44% and 4–50%, respectively (Table 1). A marked decrease was also observed in seedling dry weight of test weeds, however, it was insignificant in response to lower concentrations (Table 1). When exposed to 1, 2 and 4% concentrations of root extracts, dry weight of E. crus-galli declined by 18, 38 and 54%, and of P. minor by 13, 24, 46%, respectively (Table 1).

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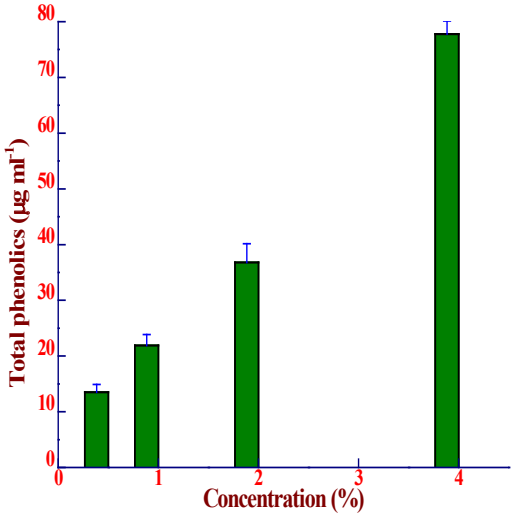
Table 1: Effect of root extracts of C. ambrosioides on the seedling growth of test plants.

Conc. (%)	Root length (cm)		Shoot length (cm)		Seedling dry weight (mg)	
	E. crus-galli	P. minor	E. crus-galli	P. minim	E. crus-galli	P. minor
0 (Control)	5.66±0.33 a	4.59±0.16 a	6.69±0.18 a	4.77±0.10 a	1.12±0.04 a	0.84±0.03 a
0.5	5.48±0.21 a	4.14±0.29 ab	6.12±0.28 a	4.56±0.25 a	1.01±0.03 a	0.82±0.04 a
1	5.26±0.21 a	3.98±0.33 ab	5.90±0.29 a	4.00±0.23 ab	0.92±0.08 a	0.73±0.04 ab
2	3.73±0.17 b	3.18±0.24 bc	4.70±0.37 b	3.22±0.21 bc	0.69±0.05 b	0.64±0.03 b
4	2.68±0.17 c	2.61±0.12 c	3.76±0.23 b	2.38±0.19 c	0.52±0.04 b	0.45±0.02 c

Values are mean ± s.e. (standard error)
Different alphabets within a column represent significance at p≤0.05 applying Tukey's test.

The total phenolic content root extracts exhibited a significant increase in total phenolic content with increasing concentrations (Fig. 2). Its content varied from 13.48±1.43 to 77.75±2.40 µg ml–1 at 0.5–4% root extracts, thus, showing an increase up to ~6 folds (Fig. 2). From the above results, it is clear that roots of C. ambrosioides are phytotoxic towards test weeds.

Fig. 2: Content of total phenolics (µg ml–1) in roots extracts of C. ambrosioides.



The bar represents standard error.

Discussion
The results clearly indicate that roots of C. ambrosioides release some bioactive metabolites that inhibit growth of other plants. Several studies have also demonstrated that some plants deleteriously affect the growth and development of nearby plants through roots (Bais, Weir, Perry, Gilroy, & Vivanco, 2006; Batish, Lavanya, Singh, & Kohli, 2007). In fact, root exudates are the largest inputs of potent allelochemicals into the soil rhizosphere and cause soil sickness (Bertin, Yang, & Weston et al., 2003). Ma, Wu, Bai, Zhou, Yuan, and Hou (2011) established that aqueous extracts (50 and 100 g/L) of Stellera chamaejasme roots significantly inhibited seed germination and seedling growth of Brassica napus, Sesamum indicum, Triticum aestivum and Zea mays. Root extracts and soil incorporated with root residues of other species of Chenopodium i.e. C. album and C. murale significantly reduced the seedling growth of Phaseolus aureus and Triticum aestivum and attributed this to the presence of water-soluble phenolic acids viz. ferulic acid, vanillic acid, p-coumaric acid and benzoic acid (Batish, Singh, Rana, & Kohli, 2006; Batish et al., 2007). Root exudates and residues of invasive weed Ageratum conyzoides suppressed growth of Oryza sativa by releasing phenolic allelochemicals namely p-coumaric acid, gallic acid, ferulic acid, p-hydroxybenzoic acid and anisic acid into the soil rhizosphere (Batish, Kaur, Singh & Kohli, 2009). In the present study, though the exact nature of inhibitory metabolites has not been explored, yet an appreciable amount of water-soluble phenolics was estimated from root extracts of C. ambrosioides. Under natural conditions, phenolics continuously enter into the immediate soil medium by C. ambrosioides roots through exudation or upon decomposition and enhance its interference potential. C. ambrosioides contains ascaridol rich volatile essential oil with broad spectrum of biological activity (Anonymous, 1992). Thus, study concludes C. ambrosioides interfere with growth and establishment of other plants by releasing water soluble allelochemicals.

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