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ALLELOPATHIC MANAGEMENT OF SOME NOXIOUS WEEDS BY THE AQUEOUS EXTRACTS OF *PARTHENIUM HYSTEROPHORUS* AND *CARTHAMUS OXYACANTHA*

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Key words: allelopathy, early seedling growth, germination, phytotoxicity, *Triticum aestivum*, weed management.

Abstract

Weed occurrence in cultivated fields may cause significant losses of agricultural crops as a result of competition and allelopathic stress. In this study, 100 g l^{-1} aqueous extracts of leaves and roots of two wild plants *Parthenium hysterophorus* and *Carthamus oxyacantha* were evaluated for their effect on germination, seedling growth and biomass of commonly occurring weeds in wheat fields (*Chenopodium album*, *Lepidium didymium*, *Phalaris canariensis* and *Rumex dentatus*). Negative allelopathic effect of *P. hysterophorus* and *C. oxyacantha* were observed on test weeds, however, 100 g l^{-1} leaf and root extracts of *P. hysterophorus* had a more drastic effect on the weeds than *C. oxyacantha*. The sensitivity of subject weeds to allelopathic stress were recorded in the order *Lepidium didymium* > *Rumex dentatus* > *Chenopodium album* > *Phalaris canariensis*. The study suggests that *P. hysterophorus* possesses phytotoxic activities and may serve as a potential candidate in natural weed management strategies.

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ALLELOPATYCZNE ZWALCZANIE NIEKTÓRYCH SZKODLIWYCH CHWASTÓW ZA POMOCĄ WODNYCH EKSTRAKTÓW Z *PARTHENIUM HYSTEROPHORUS* I *CARTHAMUS OXYACANTHA*

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Słowa kluczowe: allelopatia, wczesny wzrost siewek, kiełkowanie, fitotoksyczność, *Triticum aestivum*, zwalczanie chwastów.

Abstract

Występowanie chwastów na polach uprawnych może powodować znaczne straty plonów roślin uprawnych w wyniku konkurencji i stresu allelopatycznego. W badaniu oceniano wpływ wodnych ekstraktów z liści i korzeni w stężeniu 100 g l^{-1} dwóch dziko rosnących roślin *Parthenium hysterophorus* i *Carthamus oxyacantha* na kiełkowanie, wzrost siewek i biomasę powszechnie występujących chwastów na polach pszenicy (*Chenopodium album*, *Lepidium didymium*, *Phalaris canariensis* i *Rumex dentatus*). *P. hysterophorus* i *C. oxyacantha* oddziaływały allelopatycznie negatywnie na testowane chwaty. Przy czym ekstrakty w stężeniu 100 g l^{-1} z liści i z korzeni *P. hysterophorus* wykazywały silniejszy negatywny wpływ na chwasty niż z *C. oxyacantha*. Wrażliwość chwastów na stres allelopatyczny wyglądała następująco: *Lepidium didymum*> *Rumex dentatus*> *Chenopodium album*> *Phalaris canariensis*. Z badań wynika, że *P. hysterophorus* ma działanie fitotoksyczne i może być używany w strategiach zwalczania chwastów metodami naturalnymi.

Introduction

Weeds are undesirable plants that appear in cultivated fields and which impart drastic effects on the growth and production of agricultural crops corresponding to more than 30% annual yield losses (WALSH et al. 2012, GABA et al. 2014). In the large agro-farming system, mechanical control of weeds seems impractical and farmers have no choice but to use herbicides for suppression of weeds. However, in recent years increased resistance shown by weeds to herbicides and their effect on ecosystem has drawn grave concerns about the sustainability of agricultural practices (TRANEL and WRIGHT 2002, SINGH et al. 2003, SJOLLEMA et al. 2014). Thus there is an increasing shift in research for working out the natural solution of weed control than the exhaustive use of herbicides.

Allelopathy, which primarily manipulates the release of secondary compounds from certain plant parts with interactive potentials with other plants, seems an ideal natural solution to herbicide application for weed control (JABRAN et al. 2015). Plants which possess allelopathic properties may serve as ideal sources for weedicides compounds of natural origin. WESTON (2005) outlined that all plants possess diverse allelochemicals with structural and functional diversity and they may be potentially exploited as herbicides. In earlier studies, allelopathic suppression of different weeds by sorghum extracts (CHEEMA and KHALIQ 2000), turnip-rape mulch (PETERSEN et al. 2001), barley and rye (DHIMA et al. 2006), rice, mustard, sorghum and sunflower (JABRAN et al. 2010), rye mulch (SMITH et al. 2011), spring vetch, mustard and radish (KUNZ et al. 2016), maize, barley and sorghum (JABRAN 2017), velvet bean (TRAVLOS et al. 2018) and buckwheat (WIRTH et al. 2018) have been well established, canary grass (*Phalariscanariensis*), swine cress (*Lepidium didymium*), goosefoot (*Chenopodium album*) and toothed dock (*Rumex dentatus*) are noxious weeds commonly prevalent in fields of cultivated crops particularly in wheat fields. These weeds may serve as potential competitors for resources with cultivated crops and may correspond to significant yield losses. Owing to hazardous effects of herbicide application, ecological friendly approaches are needed to suppress these weeds. The aim of this experiment was therefore to evaluate the allelopathic potentials of two allelopathic plants namely *Parthenium hysterophorus* and *Carthamus oxyacantha* on germination and growth of four weed species.

Materials and Methods

Whole plant specimen of *Parthenium hysterophorus* and *Carthamus oxyacantha* were collected at the flowering stage during 2017 from different fields in Peshawar. Plants were separated into leaves and roots and were dried in shade. Dried materials were finely ground with an electric grinder and sieved through a fine muslin cloth. 100g l^{-1} aqueous extracts of leaf and root parts of *P. hysterophorus* and *C. oxyacantha* were prepared by soaking the appropriate amount of dried powder in distilled water for 24 hours at room temperature (25±2°C).

Viable seeds of four weed species (*Phalaris canariensis, Lepidium didymium, Chenopodium album and Rumex dentatus* were obtained from Weed Science Research Department, Agriculture University Peshawar. 15 seeds of each weed species were put in Petri dishes containing filter paper. The aqueous extracts of dry leaf and roots were separately provided to Petri dishes @ 5ml. Distilled water (5 ml) was used as control treatment. Treatments were: T1LE (leaf extract of *P. hysterophorus*), T1RE (root extracts of *P. hysterophorus*), T2LE (leaf extracts of *C. oxyacantha*) and T2RE (root extracts of *C. oxyacantha*).Petridishes were kept at room temperature (25±2ºC). at Department of Botany, Qurtuba University during September 2017. The experimental arrangement was completely randomized, each Petri dish being replicated five times. Germination percentage, seminal root length, and hypocotyl lengths were recorded in each treated-Petri dish. Seeds were considered as germinated when radicle length attained a length of 2 mm.The experiment lasted for ten days since the initial recording of germination data. 10-day old seedlings were dried in an oven and dry biomass of each weed species was calculated against the applied aqueous extracts. Data analysis was carried out through Excel sheet using Analysis of variance. Least significant difference test was used at $p \leq 0.05$ to differentiate between significant and non-significant results.

Results

Germination of four weeds species in control treated Petri dishes was 100% but significant retardation was observed for each weed species in respect to leaf and root aqueous extract application of the two allelopathic plants. Germination was reduced to 35, 60, 73 and 90% in *L. didymium*, *R. dentatus*, *C. album* and *P. canariensis* respectively by leaf extract of *P. hysterophorus* (T1LE) followed by almost same pattern of inhibition by root extracts (T1RE) which revealed 41, 68, 75, 98% germination of stated weeds (Figure 1).

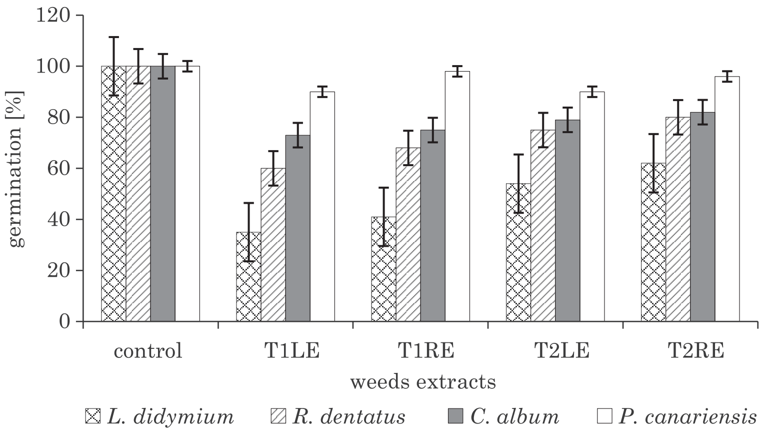

Fig. 1. Effect of aqueous extracts of allelopathic plants on germination four weeds: T1LE (dry leaf extracts of *P. hysterophorus*), T1RE (dry root extracts of *P. hysterophorus*), T2LE (dry leaf extracts of *C. oxyacantha*), T2RE (dry root extracts of *C. oxyacantha*)

Leaf extracts of *C. oxyacantha* (T2LE) resulted in 54, 75, 79 and 90% while root extracts (T2RE) caused 62, 80, 82 and 96% germination in *L. didymium*, *R. dentatus*, *C. album* and *P. canariensis* respectively when compared to control where germination was maximum (100%). It was clearfrom the results that leaf extracts of *P. hysterophorus* were more phytotoxic than other parts and *L. didymium* was the most susceptible species than other weeds.

Seminal root length (SRL) of four weeds showed variation in control conditions as well as in extracts treated conditions. Control condition revealed that maximum SRL (22 mm) was recorded in *P. canariensis* followed by *R. dentatus* (17 mm) while *C. album* and *L. didymium* showed 15 and 12 mm respectively. In each weed species, SRL was significantly lowered by the applied aqueous extracts except for leaf and root extracts of *C. oxyacantha* which did alter the studied parameter to a significant extent. Lowest SRL 4 and 7 mm were observed in L. didymium by leaf and root extracts of *L. didymium* respectively when compared to control 12 mm (Figure 2).

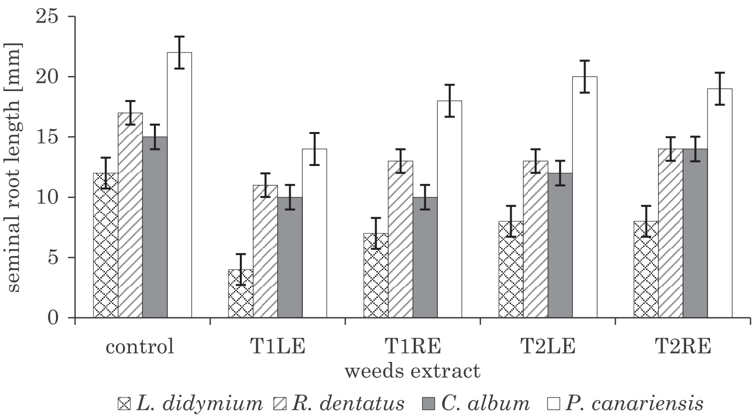

Fig. 2. Effect of aqueous extracts of allelopathic plants on seminal root length (SRL) of four weeds: T1LE (leaf extracts of *P. hysterophorus*), T1RE (root extracts of *P. hysterophorus*), T2LE (leaf extracts of *C. oxyacantha*), T2RE (root extracts of *C. oxyacantha*)

Different results were obtained for hypocotyl growth of four weeds under different treatments. Under control conditions, hypocotyl length for *L. didymium*, *R. dentatus*, *C. album* and *P. canariensis* was recorded as 9, 13, 10 and 18 mm respectively which was drastically reduced to 3,7, 6 and 12 mm by T1LE while to 6,9,7 and 15 mm by T1RE respectively (Figure 3). Leaf and root extracts of *C. oxyacantha* had also a negative effect on this parameter of weeds such as *L. didymium*, *R. dentatus,* and *C. album*, however, T2LE and T2RE had no effects on hypocotyl growth of *P. canariensis* where results were nearly consistent with control treatment. Again, highest phytotoxicity was exhibited by T1LE and maximum resistance was shown by *P. canariensis.*

Results for dry biomass of four weed seedlings are depicted in Figure 4. It was evident that the studied parameter was significantly declined by T1LE and T1RE in all weed species. In contrast, T2LE and T2RE had only drastic effects on dry biomass of *L. didymium* and *R. dentatus* but caused no changes in the other two weeds. Maximum dry biomass 98, 131, 122 and 143 mg for *L. didymium*, *R. dentatus*, *C. album* and *P. canariensis* respectively were found in control which gradually decreased under T1LE and T1RE. On the other hand, T2LE and T2RE were found comparatively less toxic to weeds for their dry biomass when compared to T1LE and T1RE. Profound effects were evident in weed *L. didymium* where dry biomass was reduced to 70 and 78 mg respectively against 98 mg in control (Figure 4).

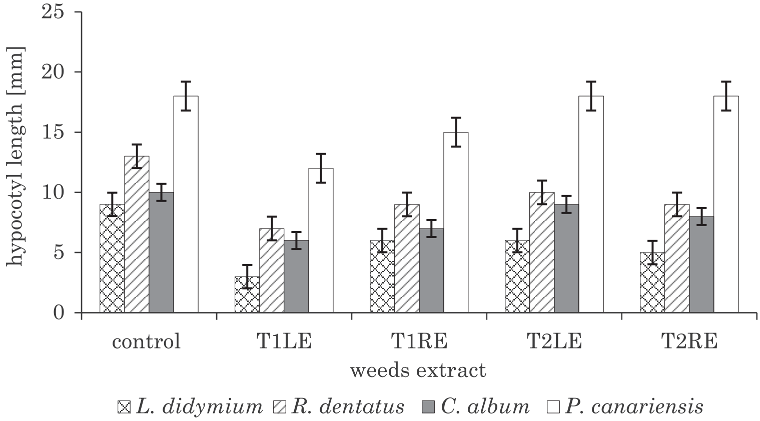

Fig. 3. Effect of aqueous extracts of allelopathic plants on hypocotyl length of four weeds: T1LE (leaf extracts of *P. hysterophorus*), T1RE (root extracts of *P. hysterophorus*), T2LE (leaf extracts of *C. oxyacantha*), T2RE (root extracts of *C. oxyacantha*)

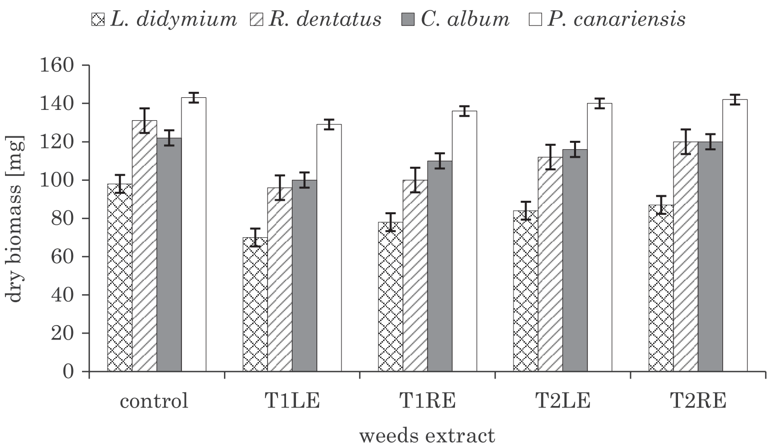

Fig. 4. Effect of aqueous extracts of allelopathic plants on dry biomass of four weeds: T1LE (leaf extracts of *P. hysterophorus*), T1RE (root extracts of *P. hysterophorus*), T2LE (leaf extracts of *C. oxyacantha*), T2RE (root extracts of *C. oxyacantha*)

Discussion

Decreased germination, seminal root and hypocotyl length and retarded biomass of four weeds in response to aqueous leaf and root extracts of *P. hysterophorus* and *C. oxyacantha* suggest that these plants are actively allelopathic. The greater phytotoxic activity of *P. hysterophorus* than *C. oxyacantha* also indicate that former plant possesses toxic and inhibitory compounds presumably in higher concentration in leaves than roots. It may be asserted that potential allelopathic compounds present in *P. hysterophorus* and *C. oxyacantha* were water soluble and capable of causing retardation in germination and other growth characters of test weeds. Germination of plants is affected by many factors. External conditions such as water availability, pH, temperature, and light while internal factors such as the state of embryo, hormones, and enzymes play a key role in seed germination (Koger et al. 2004, Nandula et al. 2006). Thus it could be assumed that the imposed allelopathic stress in this study could have influenced one or more factors controlling germination of seeds. Our results are generally supported by earlier works which demonstrated that extracts of *P. hysterophorus* had detrimental effects on seed germination weeds and cultivated crops (Batish et al. 2002, Maharjan et al. 2007, Shikha and Jha 2016).

Successful germination of seeds results in the emergence of seminal root and hypocotyl. Seminal root is the first part of the seedling to respond to chemical changes in the prevailing conditions which will influence the growth of hypocotyl as a result of water and mineral absorption. If seminal root finds its surrounding environment appropriate, it will proceed to normal water and mineral uptake resulting in boosted growth which could be observed in hypocotyl as well. However, if the surrounding environment imposes stress conditions, water and mineral absorption capacity of seminal root will be challenged with consequent abnormal growth patterns. In our result, allelopathic extracts of both plants suppressed seminal root length, hypocotyl growth and dry biomass of four weeds which may be assigned to the presence of allelochemicals in extracted parts and their toxic effect on the studied parameters. It may be elucidated that allelochemicals of donor plants cause changes in the permeability of cell membrane of the receiving plants, pH changes in the surrounding of radicle, enzymatic dysfunction and abnormalities in mineral and water absorption which could result in reduced root and shoot length (Gatti et al. 2010, Majeed et al. 2012, Muhammad and Majeed 2014, Majeed et al. 2017, Siyar et al. 2017a,b). Reduced seminal root and hypocotyl length may also be correlated to reduced dry biomass. In previous studies, suppressed radicle, hypocotyl growth and dry biomass of chickpea and radish (SINGH et al. 2003), sugarcane (FERNANDEZ et al. 2015), different weeds of wheat and rice fields (AFRIDI and KHAN 2015), *Rumex dendatus* and *Avena fatua (*ANWAR et al. 2016) have been observed in response to allelopathic effects of *P. hysterophorus*, although reports on the allelopathic activities of *C. oxyacantha*are lacking in review.

Conclusion

The results of this study conclude that germination, seminal root length, hypocotyl length and dry biomass of *P. canariensis, L. didymium*, *C. album* and *R. dentatus* were significantly retarded by the application of aqueous leaf and root extracts of *P. hysterophorus* and *C. oxyacantha*. The most sensitive weed to the allelopathic stress was found to be *L. didymium* while *P. canariensis* exhibited some tolerance. Leaf and root extracts of *P. hysterophorus* exhibited maximum phytotoxic effects on the studied attributes than and *C. oxyacantha* which suggests its potential role in natural weed management strategies.

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