PLANTA DANINHA

SOCIEDADE BRASILEIRA DA CIÊNCIA DAS PLANTAS DANINHAS

SBCPD

<http://www.sbcpd.org>

ISSN 0100-8358 (print)
1806-9681 (online)

Article

HERBICIDAL POTENTIAL OF SOME DRY LAND PLANTS AGAINST *Lathyrus aphaca* (L.), WINTER SEASON WEED

Potencial Herbicida de Plantas de Regiões Áridas Contra ***Lathyrus aphaca*** *(L.), uma Planta Daninha de Inverno*

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ABSTRACT - Dry land plants owing to their capability to grow under stressful environment have shown higher allelopathic potential as compared to cultivated plants. An experiment was conducted to investigate the herbicidal potential of aqueous extracts of four dry land plants viz. fruit and vine of *Citrullus colocynthis*, and above ground parts of *Rhazya stricta*; *Crotalaria burhia* and *Calligonum polygonoides*, with four concentrations (25, 50, 75 and 100%) of initially prepared extracts against *Lathyrus aphaca,* a common weed of wheat in the studied region. These plants were collected from dry land area (30.03° N and 70.38° E, 129 m above sea level, almost desert conditions) of Dera Ghazi Khan, Punjab, Pakistan. All the four plants exhibited pronounced herbicidal potential with 9 to 91% suppression of different parameters in *L. aphaca*). Maximum inhibition was recorded in germination (36-91%). Significant suppression in leaf count (9-65%), shoot length (12-59%), root length (4-62%), shoot fresh weight (17-71%), root fresh weight (10-60%), shoot dry weight (15-72%), root dry weight (13-64%), and nodule numbers (34-89%) was also observed. The highest inhibition was exhibited by *R. stricta* followed by *C. colocynthis*: fruit. However, in case of nodulation maximum suppression was produced by *C. burhia* extract. Least suppressant activity was observed for the *C. polygonides* extract. These results encourage the potential use of locally available dry land plants possessing strong allelochemical properties for nonchemical control of weeds ultimately reducing reliance on chemical control.

Keywords: allelopathy, *Citrullus colocynthis*, *Crotalaria burhia*, *Calligonum polygonoides*, dry land plants, *Rhazya stricta*.

RESUMO - Plantas de regiões áridas têm maior potencial alelopático do que plantas cultivadas à medida que crescem sob um ambiente estressante. Foi realizado um experimento para investigar o potencial herbicida de extratos aquosos de quatro plantas terrestres secas, incluindo frutas e videiras ***Citrullus colocynthis****, e partes acima do solo das plantas* ***Rhazya stricta****,* ***Crotalaria burhia*** *e* ***Calligonum polygonoides****, com quatro concentrações (25%, 50%, 75% e 100%) de extratos inicialmente preparados contra a ervilhaca-silvestre, uma planta daninha comum de trigo na região estudada. Estas plantas foram recolhidas da área de terra seca (30,03° N e 70,38° E, 129 m metros acima do nível do mar – condições quase desérticas) de Dera Ghazi Khan, Punjab, Paquistão. Todas as quatro plantas exibiram potencial herbicida pronunciado, com 9% a 91% de supressão de diferentes parâmetros na planta daninha* ***L. aphaca****. Foi observada inibição máxima na germinação (36-91%). Observou-se também supressão significativa na contagem de folhas (9-65%), comprimento do tiro (12-59%), comprimento da raiz (4-62%), peso fresco do caule (17-71%), peso fresco da raiz (10-60%), peso seco*

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Received: October 31, 2016
Approved: May 14, 2018

Planta Daninha 2020; v37:e020171297

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Doi: 10.1590/S0100-83582020380100001

*do caule (15-72%), peso seco da raiz (13-64%) e número de nódulos (34-89%). A inibição máxima foi apresentada por **R. stricta** seguida de **C. colocynthis**: frutos. Ao contrário, em caso de nodulação, supressão máxima foi produzida pelo extrato de **C. burhia**. Foi observada a menor supressão para o extrato de **C. polygonoides**. Esses achados encorajam o uso de plantas terrestres secas disponíveis localmente com forte potencial de alelopatia, que podem ser usadas no controle não químico de plantas daninhas e, portanto, reduzir a dependência do controle químico.*

Palavras-chave: alelopatia, *Citrullus colocynthis*, *Crotalaria burhia*, *Calligonum polygonoides*, plantas de regiões áridas, *Rhazya stricta*.

INTRODUCTION

Herbicides cause a significant inhibition in growth of wheat plants (Fedtke, 1973). Phytotoxic effects include reduction in plant height, root length, nodulation (in legumes) (Singh and Wright, 1999; Drew et al., 2007; García-Garijo et al., 2014), carotenoid, chlorophyll content, and grain protein concentration (in cereals) (Mitra and Raghu, 1998). Moreover herbicides also have potential to induce oxidative stress leading to leave withering of crop plants (Varshney et al., 2012). Due to environment-friendly and sustainable approach, crop allelopathy is gaining attention of the weed researchers worldwide (Fragasso et al., 2013; Jabran et al., 2015). It can also eliminate the problems raised by synthetic chemicals (Duke, 2010; Arora et al., 2015; Cheng and Cheng, 2015; Yazlik and Uremis, 2016). Sustainable agriculture demands the execution of economically feasible and environment-friendly techniques to control weeds. Natural phytotoxic products have a great potential to be used either directly as water extracts combined with reduced herbicide application in weed management (Iqbal and Cheema, 2007; Farooq et al., 2011; Wezel et al., 2014; Nichols et al., 2015) as well as for the discovery of new molecular target sites for herbicides (Duke, 2010; Cheng and Cheng, 2015). Allelochemicals have too short half-life as compared to synthetic pesticides (Batish et al., 2001; Kalinova, 2010; Farooq et al., 2011; Jabran et al., 2015). The role of allelopathy in crop production can be improved through identification of allelopathic plants, especially wild plants abundantly found in specific regions. Discovery of new allelochemicals and their mode of action can be very helpful in non-chemical weed control.

Desert or dry land conditions favor production of allelochemicals due to some ecological factors like water or mineral stresses, or grazing as well as other factors such as low leaching rates, reduced activity of soil microflora that improves or enhance the retention of allelochemicals (Tang et al., 1995). However, low organic matter in sandy soils of arid and semiarid areas causes a slow release of allelochemicals. Environmental stresses including light, nutrient, pH, salinity, ultraviolet radiation, temperature etc., significantly influence production of allelochemicals, through modification in metabolism by strengthening the competitive ability of allelopathic species (Tang et al., 1995; Li et al., 2009; Wang and Tang, 2016), The plant growing under these stressed conditions may exhibit higher allelopathic potential and can be explored for their herbicidal potential. The search for new plant-derived chemicals should thus be a priority in current and future efforts toward sustainable conservation and rational utilization of biodiversity (Batish et al., 2001; Albuquerque et al., 2010). Many of the dry land plants have been reported as allelopathic potential. *Rhazya stricta*, *Cirtullus colocynthis, Calligonum polygonoides* and *Crotalaria burhia* are typical plants found as shrubs in deserts throughout the arid zones of world including Pakistan (Yates et al., 2014; Bukhari et al., 2017). *R. stricta* Decne (Apocynaceae family) is an erect shrub and common in the dry land areas of Pakistan as well as India (Khan and Khan, 2007; Marwat et al., 2012). Allelochemicals obtained from different plants and their parts have potential to serve as environment-friendly fungicides, herbicides, insecticides and plant growth regulators, thus have vital role in sustainable agriculture (Cheng and Cheng, 2015). Different plant part of *R. stricta* especially leaves have been reported in many biological activities like pharmacological, toxicological(Adam, 1998),herbicidal (Al-Mutlaq, 2001; Al-Mutalaq et al., 2002) ,insecticidal (El Hag et al., 1999; El Nadi et al., 2001), fungicidal (Khan and Khan, 2007), antimicrobial (Bashir et al., 1994; Mariee et al., 1988), and nematicidal activities (Marwat et al., 2012).

C. polygonoides (L.), commonly known as Phog, is an arid shrub of the natural vegetation cover of the Thar Desert with many ethnic uses viz. fodder, fuel and food (Khan et al., 2003; Arora and Ramawat, 2013). *C. colocynthis* L. belongs to family cucurbitaceae and it produces bitter flavoured fruits about the size of cantaloupe and seeds rich in oil and protein. It showed antimicrobial (Mariee et al., 1988; Gurudeeban et al., 2011), medicinal (Najafi et al., 2010), insecticidal (Shaalan et al., 2005; Najafi et al., 2010), and allelopathic activity. *C. burhia* is a low under shrub, 30–60 centimeters tall and found in Tropical and subtropical regions (Naseem et al., 2006). Naseem et al. (2006) reported the presence of glycosides, bound anthraquinones and saponins in *C. burhia*. Present study was aimed to investigate the herbicidal potential of these dry land plants against *Lathyrus aphaca*, *a* common weed in wheat fields in Pakistan (Tanveer et al., 2012). The projected results would be helpful in sustainable weed control in the region and reduce reliance on chemical control.

MATERIALS AND METHODS

Plants of *C. colocynthis, R. stricta*, *C. burhia* and *C. polygonoides* were collected from the dry land area of Dera Ghazi Khan, Punjab, Pakistan situated at 30.03° N and 70.38° E, 129 m above sea level (Iqbal et al., 2018). The fruit and vine of *C. colocynthis* and all above-ground parts (leaves and stem) of *R. stricta*, *C. burhia* and *C. polygonoides* were dried under shade and chopped into small pieces of 1 cm. These plant materials were soaked in distilled water at 10 g/100 mL for 24 hours. Subsequently, extracts were sieved with 20 and 60 mesh sieve. Crude extract was boiled to concentrate it up to 20 times. This extract was considered as 100% concentration. Lower concentrations of 75%, 50% and 25% were prepared by diluting it with distilled water.

Pots of 6.2 cm diameter and 9.8 cm deep were used for experiment. Initially, the soil of these pots was soaked with 20 mL of distilled water for 10 minutes. Ten seeds of *L. aphaca* were sown per pot and a thin layer of soil was placed on seeds (Iqbal et al., 2018). Ten milliliters of aqueous extract of different concentrations were poured in the pots. Pots were frequently irrigated (when required) with equal amount of tap water. After completion of germination, plants were counted manually to calculate germination percentage. After 45 days of sowing, plants were harvested and data regarding number of leaves, shoot and root fresh and dry weights, and nodule numbers were recorded. Number of leaves were manually counted, whereas shoot and root lengths (cm) were measured with meter rod. Fresh and dry weights (g) of shoot and root were recorded with digital weighing balance.

Data were analyzed by using statistical software package” MSTAT C” (Bricker, 1989) and treatment means were separated by using LSD test at 1% probability.

RESULTS AND DISCUSSION

All tested plant extracts effectively suppressed *L. aphaca* germination with varying level of inhibition (Table 2). Complete inhibition (100%) was observed with *R. stricta* at 100% concentration and was statistically similar to all other plant extract at highest concentration (100%) except *C. polygonides* (Table 2). *R. stricta* aqueous extract was found the most effective in suppressing *L. aphaca* germination followed by *C. colocynthis* (Table 1). *C. polygonoides* was found the least effective in suppressing germination. Germination inhibition increased with increasing concentration of plant extracts and 100% inhibition was observed with higher concentration of extract (Table 1).

R. stricta extract (100% concentration) completely suppressed leaf count of *L. aphaca* and was statistically similar to extract of *C. colocynthis* (both vine and fruit water extracts) at similar concentration (Table 2). The highest leaf count observed in *C. burhia* at 25 and 50% concentration was statistically similar with extract of *C. polygonides* at 25-75% concentration. *R. stricta* was the highest inhibitor followed by *C. burhia* (Table 1). *C. polygonides* was the least suppressive. Generally inhibitory effect of plant extract on *L. aphaca* which gradually increased with the increasing concentration of plant extract (Table 1).

The interactive effect of shoot length and shoot fresh weight of *L. aphaca* was insignificant (Table 2). However, individual treatments were found to be effective in suppressing *L. aphaca* (Table 1). The inhibitory effect of *R. stricta* on shoot length was not only the highest but also similar to *C. colocynthis* (vine). However, the highest inhibition which was statistically at par

Table 1 - Herbicidal potential of some dry land plants against *Lathyrus aphaca* (Individual treatments)

Treatment	Germination (%)	Leaf count	Shoot length (cm)	Root length (cm)	Shoot fresh weight (g)	Root fresh weight (g)	Shoot dry weight (g)	Root dry weight (g)	Nodule number
Mean comparison of different dry land plants extracts on *Lathyrus aphaca*									
E1	37 c	16.27c	4.84 b	11.02 b	10.41 b	9.65 b	2.05 b	2.04 bc	7.25 ab
E2	39 bc	17.89 c	4.62 bc	11.37 b	10.75 b	11.13 ab	2.22 b	2.28 ab	6.52 b
E3	24 d	12.75 d	3.51 c	10.42 b	12.91 ab	7.62 c	2.01 b	1.78 c	7.36 ab
E4	43 b	25.95 b	5.51 b	12.26 b	14.93 ab	11.86 a	3.03 a	2.62 a	5.45 c
E5	53 a	30.02 a	6.93 a	15.53 a	18.84 a	12.43 a	3.11 a	2.55 a	7.99 a
LSD (P)	2.41	1.29	2.43	5.10	7.37	1.96	0.38	0.38	1.03
Mean comparison of different dry land plants extracts concentration on *Lathyrus aphaca*									
C1	86 a	29.41 a	7.11 a	15.94 a	21.30 a	14.91 a	3.76 a	3.33 a	14.16 a
C2	55 b	26.90 b	6.23 ab	15.35 a	17.74 ab	13.43 a	3.21 b	2.88 b	9.33 b
C3	31 c	23.37 c	5.46 b	14.61 a	13.63 bc	11.38 b	2.72 c	2.41 c	6.40c
C4	15 d	12.87 d	3.70 c	8.62 b	8.96 cd	6.99 c	1.68 d	1.45 d	3.16d
C5	8 e	10.34 e	2.92 c	6.09 c	6.20 d	5.97 c	1.05 e	1.19 e	1.50e
LSD (P)	6.87	2.50	0.89	2.45	6.53	1.65	0.45	0.23	1.51

E1; *Citrullus colocynthis* (fruit extract), E2; *Citrullus colocynthis* (wine extract), E3; *Rhazya stricta*, E4; *Crotalaria burhia*, E5; *Calligonum polygonoides*; C1; Control (Distilled water), C2;25% concentrated extract, C3; 50% concentrated extract, C4; 75% concentrated extract, C5;100% concentrated extract. NS: non-significant. Means sharing a letter in common are statistically similar at 1% probability.

Table 2 - Herbicidal potential of some dry land plants against *Lathyrus aphaca* a winter weed (Interaction of extracts with concentration)

Treatment	Germination (%)	Leaf count	Shoot length (g)	Root length (g)	Shoot fresh weight (g)	Root fresh weight (g)	Shoot dry weight (g)	Root dry weight (g)	Nodule number
E1C1	68 cd	26.48 c-e	6.64	14.50 a	18.20	14.06 ab	3.53 a-c	3.15 a-c	13.89 ab
E1C2	68 cd	23.65 d-f	5.56	14.17 ab	11.92	12.58 a-d	2.52 f-h	2.65 c-f	10.99 c
E1C3	30 gh	20.40 f-h	5.30	13.78 ab	10.93	11.03 b-e	2.10 h	2.29 e-h	6.00 f
E1C4	15 i-k	7.91 j	3.97	7.91 cd	7.15	7.18 gh	1.35 i	1.38 j-l	3.65 g
E1C5	5 l	2.93 kl	2.76	4.77 de	3.88	3.42 ij	0.76 i-k	0.75 lm	1.73 h-j
E2C1	98 a	29.23 a-c	6.50	16.38 a	16.15	14.80 a	3.88 ab	3.32 ab	13.60 ab
E2C2	60 de	27.95 bc	6.29	16.01 a	14.88	13.33 a-c	3.28 b-d	2.95 a-d	8.43 d
E2C3	25 hi	22.81 e-g	5.88	14.84 a	12.58	12.53 a-d	2.57 e-h	2.49 d-h	6.43 ef
E2C4	5 l	5.62 i-k	2.61	6.52 c-e	6.50	6.00 hi	1.20 ij	1.18 kl	2.77 g-i
E2C5	5 l	3.88 i-l	1.84	3.12 ef	3.62	9.00 e-h	0.20 kl	1.48 i-k	1.36 ij
E3C1	88 b	30.88 ab	6.23	17.68 a	18.48	15.10 a	3.59 a-c	3.45 a	15.29 a
E3C2	20 ij	18.96 gh	5.77	15.91 a	27.47	13.20 a-c	3.26 b-d	2.91 a-e	12.19 bc
E3C3	8 kl	12.35 i	4.02	14.89 a	14.68	8.26 e-h	2.60 e-h	2.09 f-i	7.86 de
E3C4	3 l	1.56 kl	1.55	3.59 ef	3.95	1.52 i-k	0.58 i-l	0.45 mn	1.46 ij
E3C5	0 l	0.00 l	0.00	0.00 f	0.00	0.00 k	0.00 l	0.00 n	0.00 j
E4C1	88 b	27.80 bc	6.47	14.13 ab	18.18	15.37 a	3.86 ab	3.36 a	14.21 a
E4C2	58 e	32.62 a	6.12	14.23 ab	17.48	14.18 ab	3.54 a-c	3.00 a-d	5.90 f
E4C3	48 f	31.16 ab	5.64	13.82 ab	14.61	12.63 a-d	3.15 c-f	2.69 b-f	3.68 g
E4C4	15 i-k	20.64 f-h	4.75	10.17 bc	13.03	9.57 d-g	2.52 f-h	2.18 f-h	2.27 g-i
E4C5	8 kl	17.56 h	4.57	8.97 c	11.35	7.55 f-h	2.09 h	1.89 g-j	1.18 ij
E5C1	90 ab	32.68 a	9.72	17.03 a	35.51	15.23 a	3.96 a	3.41 a	13.82 ab
E5C2	70 c	31.33 ab	7.43	16.43 a	16.98	13.88 a-c	3.44 a-c	2.91 a-e	9.15 d
E5C3	45 f	30.15 a-c	6.48	15.72 a	15.35	12.45 a-d	3.19 c-e	2.51 c-g	8.04 de
E5C4	35 g	28.64 a-c	5.62	14.92 a	14.18	10.70 c-f	2.75 d-g	2.08 f-j	5.66 f
E5C5	23 h-j	27.33 b-d	5.42	13.59 ab	12.18	9.88 d-g	2.21 gh	1.86 h-j	3.26 gh
LSD (P)		4.06	NS	4.10	NS	3.31	0.64	0.64	1.73

E1; *Citrullus colocynthis* (fruit extract), E2; *Citrullus colocynthis* (wine extract), E3; Rhazya stricta, E4; Crotalaria burhia, E5; Calligonum polygonoides; C1; Control (Distilled water), C2;25% concentrated extract, C3; 50% concentrated extract, C4; 75% concentrated extract, C5;100% concentrated extract. NS: non-significant; LSD: Least significance difference. Means sharing a letter in common are statistically similar at 1% probability.

with all other plant extracts except *C. polygonides* in case of shoot fresh weight was recorded in *C. colocynthis* (fruit). The interactive effect of extract and their concentrations was significantly different for shoot dry weight (Table 2). The highest inhibition of shoot dry weight was observed in *R. stricta* at 100% concentration and was statistically similar with its 75% and *C. colocynthis* (vine) at 100% concentration. In individual treatment comparison, *R. stricta* was found the highest suppressant and was at par with *C. burhia* (Table 1). Gradual decrease in shoot length, shoot fresh weight, and shoot dry weight was observed with gradual increase in concentration (Table 1).

The interactive effect of plant extracts and their different concentrations was found significant for root length, root fresh weight, and root dry weight (Table 2). Application of *R. stricta* at 100% concentration resulted in maximum inhibition of root growth parameters (root length and root dry weight) and was statistically at par with its 75% concentration of *R. stricta* and 100% concentration *C. colocynthis* (vine). *R. stricta* showed highest inhibitory potential against *L. aphaca* and was statistically similar with other plant extracts except *C. polygonides* in case of root length, and *C. colocynthis* (fruit) in case of root dry weight (Table 1). Inhibitory influence of plant extracts on root parameters increased with increasing concentration and was concentration dependent.

L. aphaca is a leguminous weed. Its nodule numbers were also inhibited by the application of different dry land plant water extracts. A significant interactive effect of extract against concentration was recorded (Table 2).The highest suppression was observed at 100%extract of *R. stricta* which was statistically similar to its 75% and 100% concentration of *C. colocynthis* (vine) and *C.burhia*. The highest suppression was observed in *C. burhia* for nodule numbers as compared with other parameters (Table 1). The increasing concentrations of plant extracts resulted in gradual decrease in number of nodules in *L. aphaca*.

All of the dry land plants were found to have inhibition potential with varying level of suppression against *L. aphaca*. *R. stricta* showed the most allelopathic effect in suppression as compared to other dry land plants. Its herbicidal potential has already been reported in many studies (Assaeed and Al-Doss, 1996; Khan and Khan, 2007; Khan et al., 2011). The presences of alkaloids, glycosides, triterpenes, tannins, and volatile bases in the leaves of this plant have been reported (Ahmad et al., 1983). *C. colocynthis* was found second as suppressant after *R. stricta*. It has also been reported as allelopathic plant in some studies (Najafi et al., 2010; Gurudeeban et al., 2011), but less reported as compared to *R. stricta.* Suppression of the growth of *L. aphaca* by gradual increase in the concentration of the extract is supposed to have higher amount of phytotoxin. Similar findings were also reported earlier (Mallik et al., 1994; Prati and Bossdorf, 2004). Mallik et al. (1994) observed the reduction in germination of radish by 40% and 95%, at 2 and 4 mg g^{-1} sand amended with unextracted lambsquarter (*Chenopodium album* L.) shoots, respectively. They further reported the significant reduction in shoot dry weight and plant height at 4 mg/g but not at 2 mg/g concentration. Due to these promising results, further *in vivo* studies over *R. stricta* are suggested.

Extracts of all dry land plants used in this study showed inhibitory allelopathic effects against *L. aphaca*. However, *R. stricta* was found the most effective in suppressing the weeds. The allelopathic effect of these plants was concentration dependent. Suppression of weed increased gradually with increasing concentration of plant extract.

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