INTERNATIONAL JOURNAL OF AGRICULTURE & BIOLOGY
ISSN Print: 1560–8530; ISSN Online: 1814–9596
10–206/MFA/2010/12–4–581–585
http://www.fspublishers.org

Full Length Article

Evaluating the Potential of Allelopathic Plant Water Extracts in Suppressing Horse Purslane Growth

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ABSTRACT

This study was conducted to investigate the potential of sorghum (*Sorghum bicolor*), sunflower (*Helianthus annuus*), brassica (*Brassica napus*), maize (*Zea mays*), rice (*Oryza sativa*) and mulberry (*Morus alba*) water extract applied in combination in suppressing germination and growth of horse purslane. In the laboratory bioassay, sorghum+sunflower water extract combination at higher concentration (100%) completely inhibited germination of horse purslane. In pot experiment, the foliar application of sorghum + sunflower water extract combination at higher concentration (100%) greatly suppressed growth traits (shoot & root length) of horse purslane seedling and this combination reduced shoot dry weight by 66% over control. Inhibitory effect was proportional to the concentrations of the extracts and higher concentration had the stronger inhibitory effect. In crux, combination of sorghum + sunflower water extracts may be used as natural herbicide to control horse purslane.

Key Words: Allelopathy; Plant water extracts; Horse purslane; Growth

INTRODUCTION

Horse purslane (*Trianthema portulacastrum*) is one of the serious weeds of maize, sugarcane, cotton and summer vegetables in Pakistan (Nayyar *et al*., 2001). Seeds have mainly no dormancy and can germinate soon after they mature (Balyan & Bhan, 1986). Its physiological characteristics made it well known competitive weed for crops. A mature horse purslane plant can produce as many as 3330 fruits per plant and 6-10 seeds/fruit (Prakongvongs, 1999). It could reduce crop yields by 32% (Balyan & Bhan, 1989), losses may be even more if not properly managed.

Horse purslane is currently controlled mechanically and hoeing in most of the developing countries around the globe, but this method is quite expensive and time consuming (Brar *et al*., 1995). The use of herbicides is the most effective and immediate solution to control this weed. Grichar (2007 & 2008) reported that application of herbicides used as early post emergence reduced horse purslane population by 70-80% in peanut (*Arachis hypogea*). The indiscriminate use of synthetic chemicals for pest and weed control cause environmental pollution, pollute agricultural products and affects human health (Kohli *et al*., 1998; Xuan *et al*., 2004). This suggests the need to search for new approaches of weed control, which may be inexpensive, easy-to-use, effective and friendly to environment.

Allelopathy is a novel approach for environment safety and development of sustainable agriculture (Yongqing, 2005). Active allelopathic compounds are found in different plants parts viz. leaves, roots, stem, pollens, flowers, stem, seeds and fruits (Turk & Tawaha, 2003), these allelopathic compounds could be used as lead for herbicide production. Use of allelochemicals as plant water extracts offers a promising substitute for sustainable and eco-friendly weed management.

Sorghum is potent allelopathic crop and its inhibitory effects against weeds are well documented (Weston, 1996; Cheema *et al*., 2003a; Weston & Duke, 2003), its water extracts have suppressive effect on horse purslane. Concentrated sorghum water extract (100%) reduced the germination of *Trianthema portulacastrum* by 15 to 20% (Randhawa *et al.,* 2002). Cheema *et al*. (2002) reported that sorghum water extracts reduced weed growth by 28%, but this inhibition level still not effective for profitable crop production. For better and eco-friendly control of horse purslane, the effectiveness of sorghum water extracts needs to be improved. Duke *et al*. (2000) stated that mixture of two or more allelopathic aqueous extracts caused more inhibition of weeds due to synergistic mode of action. Likewise in another field study Cheema *et al*. (2003b) found that application of sorghum + eucalyptus + sunflower water extracts combination furnished >70% weed reduction than sorghum water extract alone in wheat, probably due to the presence of and synergistic effects of different allelochemicals in these species. It indicates that the efficacy of sorghum water extract can be enhanced by mixing it with

To cite this paper: Mahmood, A., Z.A. Cheema, A. Khaliq and A.U. Hassan, 2010. Evaluating the potential of allelopathic plant water extracts in suppressing horse purslane growth. *Int. J. Agric. Biol.*, 12: 581–585

other allelopathic plant water extracts. Suppressive effects of allelopathic rice, sorghum, sunflower, brassica, maize and mulberry have been well documented (Anaya *et al*., 1987; Leather, 1987; Olofsdotter *et al*., 1995; Kato-Noguchi, 2000; Mughal, 2000; Seal *et al*., 2004; Batish *et al*., 2002; Hong *et al*., 2003; Turk & Tawaha, 2003; Weston & Duke, 2003). Effect of allelopathic plant water extracts in mixture has not yet been evaluated against the growth of horse purslane. This study was carried out to investigate the effects of different combinations of sorghum, sunflower, brassica, maize, rice and mulberry water extracts on the germination and growth of horse purslane under laboratory conditions.

MATERIALS AND METHODS

To study the allelopathic effects of various plant water extract combinations on seed germination and early seedling growth of horse purslane, an experiment was conducted during, 2007 in Weed Science-Allelopathy Laboratory and net house, Department of Agronomy, University of Agriculture, Faisalabad. Allelopathic plant water extracts were prepared following the method of Cheema and Khaliq (2000). Herbage (stem + leaves) of field grown sorghum, sunflower, brassica, maize, rice were harvested at maturity while leaves of mulberry were collected from the trees growing at the Agronomic Research Area. All plant materials were dried under shade for a few days. The well dried plants were chopped into about 3 cm pieces with electric fodder cutter. The dried plant herbage and dry leaves of mulberry were soaked in water for 24 h at room temperature (21°C ± 2) in the ratio of 1 kg herbage: 10 L water (Cheema & Khaliq, 2000). The water extract was obtained by filtering the mixture (herbage & water) through 40 and 60 mesh sieves to obtain 10% extract (leachate). These water extracts were boiled at 100°C to concentrate and reduce the extract volume by 95% for easy handling and application. Same procedure was adopted to prepare all plant water extracts. Due to higher boiling point of allelochemicals, boiling of extracts has no effect on nature and type of allelochemicals present in water extracts (Parveen, 2000; Jamil *et al*., 2009). The concentrated extracts were called 100% (stock solution), which was further diluted with distilled water to 25% and 50% extract concentrations.

Laboratory bioassay: In germination and early seedling growth bioassay, water extracts of sorghum alone and its mixtures (sorghum+mulberry, sorghum+brassica, sorghum+ sunflower, sorghum+maize & sorghum+rice) were investigated at three concentrations (25, 50 & 100%). Experiment was arranged in CRD (completely randomized design) based factorial design with four replicates. As precautionary measure against pathogens and pollutants, Petri dishes were given a thorough washing with detergent using hot water. Seed of horse purslane was cleaned manually and physical purity was ensured. Ten seeds of horse purslane were placed on Whatman No. 1 filter paper in each Petri dish of a 9 cm diameter and 4 mL of extract of various concentrations was applied per Petri dish as per treatments. Distilled water was used as control. The seeds were covered with second layer of filter paper and also covered with lid. Petri dishes were kept at 30±2°C temperature and were kept moist by applying distilled water as required. The outer filter paper was removed just before the initiation of germination. On redicle emergence, the seed was considered as germinated. Germination was recorded daily for 10 days, while root and shoot length data of seedlings were recorded with a measuring tape on 10 DAS (days after sowing).

Pot experiment: On the basis of results of germination bioassay, pot experiment was designed. During experiment, the average temperature was 2 ± 33, relative humidity 52-78%, sunshine 7-10 h. In pot culture, the plastic pots (height & diameter each of 9 cm) were filled with 350 g of soil. Seedlings of horse purslane at 3-4 leaf stage were collected from field and transplanted in plastic pot three in each pot. The plants were saturated with distilled water. When plants properly established, the same treatments as used in germination bioassay were applied after calibration of mini sprayer (hand automizer) as foliar spray to horse purslane seedlings in pots. Volume of spray was 18 L ha^{-1}. Control treatment having distilled water in pots was included for comparison. The experiment was laid out in completely randomized design (CRD) with factorial arrangements in four replicates. All the pots were kept in net house and water was applied as and when required to avoid water stress. Experiment was terminated on 20th day after spray and data on shoot length and root length of horse purslane seedling was measured with measuring tape. Dry weight of root and shoot of horse purslane seedling was measured with the help of electric balance after drying (70^{o}C oven dry until constant weight), then average dry weights were determined in grams.

Data were analysed by using "MSTATC" statistical package on a computer (Anonymous, 1986). The mean differences were adjudged using Duncan Multiple Range Test (Steel *et al*., 1997).

RESULTS

Germination bioassay: In germination bioassay, the interaction of plant water extracts and extract concentration was significant (Table I). The germination was completely inhibited in petri dishes wherein sorghum + sunflower water extracts combination was used. Likewise, all other plant water extracts combinations applied at 100% concentrations were also very effective in inhibiting germination of horse purslane.

The interaction of plant water extract and extract concentration for shoot length of horse purslane was significant (Table I). As germination was completely inhibited in petri dishes wherein sorghum + sunflower water extracts was used so there is no shoot length data. The highest suppression of shoot length of horse purslane was recorded with the application of water extract combination

Table I: Allelopathic effect of different plant water extracts on germination, shoot and root length of horse purslane

Treatments	Germination (%)	Shoot length (cm)	Root length (cm)
Plant water extracts			
W_0= Control (Distilled water)	92.08 a †	1.70 a	2.52 a
W_1=Sorghum water extract	35.00 b	0.56 b	0.88 b
W_2= Sorghum+mulberry (WEs)	20.83 d	0.30 e	0.50 e
W_3= Sorghum+brassica (WEs)	21.67 d	0.44 c	0.66 d
W_4=Sorghum+sunflower (WEs)	13.33 e	0.24 f	0.37 f
W_5= Sorghum+maize (WEs)	24.17 cd	0.37 d	0.64 d
W_6= Sorghum+rice (WEs)	27.92 c	0.45 c	0.70 c
Sx ±	1.397	0.009	0.013
Extract concentrations			
C_1=25%	45.89 a	0.89 a	1.309 a
C_2=50%	36.96 b	0.55 b	0.86 b
C_3= 100%	17.86 c	0.31 c	0.52 c
Sx ±	0.914	0.006	0.008
Interaction			
W_0C_1	93.75 a	1.80 a	2.69 a
W_0C_2	91.25 a	1.58 c	2.40 c
W_0C_3	91.25 a	1.73 b	2.46 b
W_1C_1	52.50 b	0.97 d	1.39 d
W_1C_2	40.00 cd	0.52 h	0.85 g
W_1C_3	12.50 gh	0.19 l	0.40 l
W_2C_1	32.50 de	0.56 h	0.88 g
W_2C_2	25.00 f	0.32 k	0.53 k
W_2C_3	5.000 i	0.03 no	0.09 o
W_3C_1	36.25 cd	0.88 e	1.20 e
W_3C_2	25.00 f	0.41 ij	0.61 j
W_3C_3	3.75 i	0.02 o	0.18 n
W_4C_1	25.00 f	0.56 h	0.78 h
W_4C_2	15.00 g	0.19 l	0.34 l
W_4C_3	0.00 i	0.00 o	0.00 p
W_5C_1	38.75 cd	0.66 g	1.07 f
W_5C_2	28.75 ef	0.39 j	0.61 j
W_5C_3	5.00 i	0.07 mn	0.23 mn
W_6C_1	42.50 c	0.82 f	1.17 e
W_6C_2	33.75 de	0.45 i	0.69 i
W_6C_3	7.50 hi	0.09 m	0.25 m
Sx ±	2.419	0.016	0.022

†=Means not sharing a letter in common differ significantly at p 0.05; WEs= Water extracts; Sx ± =Standard error mean

Table II: Allelopathic effect of different plant water extracts on shoot length, root length, shoot dry weight and root dry weight of horse purslane

Treatments	Shoot length (cm)	Root length (cm)	Shoot dry weight (g)	Root dry weight (g)
Plant water extracts				
W_0= Control (Distilled water)	17.27 a †	7.87 a	0.380 a	0.267 a
W_1=Sorghum water extract	11.28 b	5.35 b	0.195 b	0.152 b
W_2= Sorghum+mulberry (WEs)	9.37 de	4.64 d	0.141 cd	0.083 c
W_3= Sorghum+brassica (WEs)	9.83 cd	4.72 d	0.157 c	0.096 c
W_4=Sorghum+sunflower (WEs)	8.921 e	4.56 d	0.129 d	0.084 c
W_5= Sorghum+maize (WEs)	10.18 c	4.97 c	0.162 c	0.11 c
W_6= Sorghum+rice (WEs)	10.18 c	4.96 c	0.165 c	0.11c
Sx ±	0.201	0.067	0.009	0.008
Extract concentrations				
C_1=25%	12.69 a	5.92 a	0.233 a	0.161 a
C_2=50%	11.19 b	5.33 b	0.186 b	0.126 b
C_3= 100%	9.146 c	4.65 c	0.149 c	0.099 c
Sx ±	0.132	0.044	0.005	0.006
Interaction			NS	NS
W_0C_1	17.42 a	7.88 ab	-	-
W_0C_2	17.66 a	8.10 a	-	-
W_0C_3	16.72 a	7.63 b	-	-
W_1C_1	13.13 b	6.15 c	-	-
W_1C_2	11.05 cde	5.33 d	-	-
W_1C_3	9.67 f	4.57 ef	-	-
W_2C_1	11.66 c	5.40 d	-	-
W_2C_2	10.05 ef	4.74 ef	-	-
W_2C_3	6.41 i	3.77 g	-	-
W_3C_1	11.70 c	5.48 d	-	-
W_3C_2	9.77 f	4.75 ef	-	-
W_3C_3	8.04 h	3.94 g	-	-
W_4C_1	11.18 cd	5.30 d	-	-
W_4C_2	9.40 fg	4.64 ef	-	-
W_4C_3	6.19 i	3.75 g	-	-
W_5C_1	11.88 c	5.60 d	-	-
W_5C_2	10.19 def	4.87 e	-	-
W_5C_3	8.48 gh	4.44 f	-	-
W_6C_1	11.86 c	5.60 d	-	-
W_6C_2	10.19 def	4.85 e	-	-
W_6C_3	8.50 gh	4.42 f	-	-
Sx ±	0.349	0.117		

†=Means not sharing a letter in common differ significantly at p 0.05; WEs= Water extracts; NS= Non-significant at 0.05 P; Sx ± = Standard error mean

of sorghum + mulberry at 100% concentration. Inhibition in root length of horse purslane seedling depicted the same trend as observed in case of shoot length (Table I).

Pot experiment: In pot experiment, all treatments significantly decreased shoot length, root length and seedling dry weight as compared with control (Table II). The highest suppression of shoot length of horse purslane was recorded with foliar application of sorghum+sunflower water extracts combination at 100% concentration and it was followed by mixture of sorghum + mulberry water extracts at same concentration. The same trend was found for root length suppression as was recorded for shoot length of horse purslane. The suppression of horse purslane growth traits was more at higher concentration than lower one. Interaction of plant water extracts and concentration for shoot and root dry weights of horse purslane was non significant; however, main effects were significant (Table II). The highest reduction in shoot dry weight was observed in pots treated with foliar application of sorghum+sunflower water extracts combination, while root dry weight reduction was maximum for mixture of sorghum+mulberry water extracts and it was followed by sorghum+sunflower water extracts combination and both these were equal.

DISCUSSION

Germination and seedling growth of horse purslane in laboratory bioassays was significantly inhibited by all the combinations of sorghum extract with either of the extracts as sunflower, mulberry, brassica, maize and rice. Sorghum+sunflower extract combination appeared the most effective one with complete inhibition of the germination in Petri dishes (Table I), while sorghum + mulberry extract

combination inhibited germination of horspurslane by 95% at higher concentration (100%). However, sorghum water extract alone inhibited germination of the weed by 86% at 100% concentration. In pot culture, higher concentration (100%) of sorghum + sunflower foliar spray inhibited the shoot length (seedlings of horse purslane) by 64% (Table II). While, sorghum + mulberry extract combination suppressed the shoot length of the weed by 63%. Whereas sorghum extract alone (100% conc.) reduced shoot length by 44%. Shoot dry weight inhibition for sorghum + sunflower and sorghum + mulberry water extracts was 66 and 63%, respectively. However, sorghum extract alone suppressed shoot length by 46%. The enhanced inhibition of shoot dry weight of horse purslane in combined application of sorghum + sunflower and sorghum + mulberry extracts is very valuable finding showing complementary effects of various extracts. Similar trend in other extract combinations was also observed though little less inhibition than sorghum + sunflower and sorghum + mulberry extracts combinations. The inhibition of this weed germination and growth may be due to the presence of several phytotoxins in sorghum as gallic acid, protocateuic acid, syringic acid, vanillic acid, p-hydroxybenzoic acid, p-coumaric acid, benzoic acid, ferulic acid, m-coumaric acid, caffeic acids, dhurrin, p-hydroxybenzaldehyde and sorgoleone has been reported by several researchers (Haskins & Gorz, 1985; Netzly & Butler, 1986; Nimbal *et al*., 1996). Sunflower plant has allelochemicals viz. chlorogenic acid, isochlorogenic acid, α-naphthol, scopolin and annuionones (Wilson & Rice, 1968; Macias *et al*., 1998 & 2002; Anjum & Bajwa, 2005). More suppression of horse purslane from the combined use of sorghum + sunflower water extracts indicates the synergistic mode of action of allelochemicals in these extracts. It has been reported that in a mixture compounds can replace each other due to their biological exchange rate and may add to the potency of each other (Gerig & Blum, 1999). Similarly, it has been reported that combination of sorghum + sunflower water extracts controlled wild oat and canary grass weeds in wheat more effectively than sorghum water extract used alone (Jamil *et al*., 2009). Water extracts of all allelopathic plants inhibited horse purslane germination and growth; however, inhibition of germination and growth was concentration dependent (Table I). More inhibition was obtained at higher concentration and less at low concentration, which was in the order of 100%>50%>25%. These findings are also supported by earlier work of (Kim *et al*., 1993; Malik *et al.,* 1994; Ahn & Chung, 2000; Turk & Tawaha, 2003; Javaid *et al*., 2005), who explained concentration effects. Higher concentration contains more quantity of allelochemicals, which enhance ability of an extract to show better inhibition due to synergistic effect (Einhellig, 1995; Chon & Kim, 2004).

CONCLUSION

Findings of present study indicate that mixture of allelopathic plant water extracts have great potential to inhibit the germination and growth of horse purslane. Combination of sorghum + sunflower water extract is useful in inhibiting germination and growth of this noxious weed. This allelopathic mixture may be used as eco-friendly natural herbicide for management of horse purslane.

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(Received 09 May 2010; Accepted 20 May 2010)