COMPARATIVE ALLELOPATHIC POTENTIAL OF TWO AIZOACEAE WEEDS AGAINST GERMINATION OF DIFFERENT CROPS

Muhammad Asghar[1], Asif Tanveer*, Muhammad Ather Nadeem and Hafiz Haider Ali

ABSTRACT

Comparative allelopathic potential of two Aizoaceae weeds namely *Trianthema portulacastrum* L. and *Sesuvium portulacastrum* L. was studied against the germination and seedling growth of *Pennisetum glaucum* L. (millet), *Sorghum bicolor* L. (sorghum), *Zea mays* L. (maize), *Triticum aestivum* L. (wheat), *Vigna mungo* L. (mash), *Vigna radiata* L. (mungbean), *Cyamopsis tetragonoloba* L. (guar) and *Helianthus annuus* L. (sunflower) under controlled conditions. Five percent aqueous extracts of different plant parts of both weed species were prepared by soaking dried plant parts in distilled water in the ratio of 1:20 (w/v). The aqueous extracts of different plant parts (stem, leaf, root, seed and whole plant) of *Trianthema portulacastrum* and *S. portulacastrum* produced a significant effect on germination percentage, mean germination time, root/shoot lengths and seedling vigor index of all tested crops as compared to control. Further, the delay in germination and reduction in germination percentage of all test crops was more pronounced with *T. portulacastrum* than *S. portulacastrum*. The whole plant extract of *T. portulacastrum* proved most harmful to germination and seedlings growth of all tested crops than *S. portulacastrum*. Total water soluble phenolic acids analysis revealed that *T. portulacastrum* and *S. portulacastrum* contain compounds (caffeic acid, ferulic acid, M-coumeric acid, P- coumeric acid, syringic acid, venillic acid; and caffeic acid, gallic acid, 4-Hydroxy-3- Methoxybenzoic acid, P-coumeric acid, syringic acid, respectively) in their tissues which may cause allelopathic effects under field conditions.

Key words: Allelopathy, *Pennisetum glaucum*, *Sorghum bicolor*, *Zea mays*, *Triticum aestivum*, *Vigna mungo*, *Vigna radiata*, *Cyamopsis tetragonoloba*, *Helianthus annuus*, germination, seedling growth.

[1]Department of Agronomy, University of Agriculture, Faisalabad, 38040, Pakistan.
*Corresponding author's email: drasiftanveeruaf@hotmail.com

Citation: Asghar, M., A. Tanveer, M.A. Nadeem and H.H. Ali. 2013. Comparative allelopathic potential of two aizoaceae weeds against germination of different crops. Pak. J. Weed Sci. Res. 19(4): 377-391.

INTRODUCTION

Trianthema portulacastrum L. is a serious weed worldwide and is indigenous to South Africa and has been reported to be widely distributed in India, Srilanka, West Asia, Africa and Tropical America (Balyan and Bhan, 1986, Javed *et al.,* 2011). It has become a noxious weed due to competition for yields in many crops like *Pennisetum glaucum* L. (millet), *Sorghum bicolor* L. (sorghum), *Zea mays* L. (maize), *Triticum aestivum* L. (wheat), *Vigna mungo* L. (mash), *Vigna radiata* L. (mungbean), *Cyamopsis tetragonoloba* L. (guar) and *Helianthus annuus* L. (sunflower) and causing significant reduction in the yield (Nayyar *et al.,* 2001). *Sesuvium portulacastrum* L. is succulent weed with pink to purple flowers. It is a littoral plant usually grown in sand and a pioneer species of beaches and coastal zones where sand movements are influenced by prevailing winds (Judd *et al.,* 1977; Johnson, 1977). It is capable to grow both in dry and wet conditions. Its flowering occurs throughout the year and ripe seed is readily available (Anaya *et al.,* 1987). However, many aspects of the biology of *S. portulacastrum* remain unknown (Lonard and Judd, 1997).

Weeds limit growth and yield of crops through becoming their partner with available moisture, nutrients, light, space and air; and escaping phytotoxic compounds in their environment (Zimdahl, 2007). The weeds influence the crop plants by releasing phytotoxin from their seeds, decomposing residues, leachates, exudates and volatiles (Narwal, 2004). The presence of different allelochemicals like caffeic, chlorogenic, and ferulic acids which inhibits the seed germination of other plants (Hussain *et al.,* 1987; Marwat *et al.,* 2008). Based on the work of Weidenhamer (1996), the range of these compounds, biochemical sites and their obvious effects need to be given consideration. These compounds may be water soluble that are released through leaching, root exudation as well as through decomposition of plant residues. Allelopathic effect of a weed on crop can be ascertained by its reduced germination and growth, a technique known as plant bioassay. Extent of allelopathic inhibition on germination and seedling growth of crops varies from weed species (Hamayun *et al.*, 2005) and its plant parts (Economou *et al.*, 2002; Aziz *et al.*, 2008). Mechanism of allelopathic suppression by weeds is complex involving interactions of different classes of chemicals like flavonoids, alkaloids, steroids, terpenoids, phenolic compounds and amino acids. Since majority of these compounds have phytotoxic

properties, their overall effect is inhibitory on germination and growth of crop plants (Prasad and Subhashini, 1994).

There is no information available on the allelopathic effects of both these weeds on crops. Therefore the present study was carried out with the objective to explore the comparative allelopathic effects of whole plant and different plant parts i.e. seeds, leaves, stem and roots of *T. portulacastrum* and *S. portulacastrum* on the germination and seedling growth of field crops namely millet (*Pennisetum glaucum* L.), sorghum (*Sorghum bicolor* L.), maize (*Zea mays* L.), moong (*Vigna radiata* L.), mash (*Vigna mungo* L.), guar (*Cyamopsis tetragonoloba* L.), sunflower (*Helianthus annuus* L.) and wheat (*Triticum aestivum* L.).

MATERIALS AND METHODS

Collection of plants and Preparation of water extracts

The plants of *T. portulacastrum* and *S. portulacastrum* were uprooted at the time of maturity and dried at room temperature (25°C). Plant material was further dried in an oven at 70°C for 48 h. After getting dried, the whole plants and the parts of plants i.e. seeds, leaves, stem and roots were separated. The whole dried plants and the parts of these plants were cut into small pieces (1cm) with the help of scissor. These pieces of whole dried plants and their parts were immersed in distilled water separately at 1:20 (w/v) ratio at room temperature for 24 hours (Hussain and Gadoon, 1981). After 24 hour, the solutions were filtrated and centrifuged at 12000 rpm, after which extracts were collected. These extracts were individually bottled and tagged. The aqueous extracts (5%) of whole plants and different parts of the weed plants were obtained by filtering water through sieve and then through Minisart (C) non-pyrogenic, 4.45 µm filters. The extracts were collected in separate bottles and tagged.

Twenty seeds of each millet, sorghum, moong, mash, guar, wheat, 15 seeds of sunflower and 10 seeds of maize were placed on Wattman No.10 filter paper of 9 cm diameter in Petri dishes evenly. Before sowing, seeds were surface-sterilized with 1.5% (v/v) sodium hypochlorite solution for 1 min and washed (three times; 3 min/wash) in sterile distilled water. Then aqueous extracts of whole plant, stem leaves, fruits and roots or distilled water was added to the seeds according to the nature of treatments. To avoid the drying out of seeds throughout the incubation period, the petri dishes were sealed with parafilm. All Petri dishes were placed at room temperature. During this period, the petri dishes were observed daily and water or plant extracts were added to each petri dish as needed.

Determination of total soluble phenolics in *T. portulacastrum* and *S. portulacastrum*

Total soluble phenolics were determined as described by Randhir & Shetty (2005) and were expressed as gallic acid equivalents.

Detection of Phytotoxins in aqueous *T. portulacastrum and S. portulacastrum* extracts.

Due to their greater suppression potential, aqueous *T. portulacastrum* and *S. portulacastrum* extracts were chemically analyzed on Shimadzu HPLC system (Model SCL-10A, Tokyo, Japan) for identification and quantification of their suspected phytotoxins. The conditions of separation are listed in Table-7.

The peaks were detected by UV detector. Standards of suspected phytotoxins (Aldrich, St Louis, USA) were run similarly for identification and quantification. Standards of phenolics were prepared in different concentrations. Vanillic acid and 4-(hydroxymethyl) benzoic acid were identified by their retention time with authentic standards. Concentration of each isolated compound was determined by the following equation:

$$Concentration\,(ppm) = \frac{Area\ of\ the\ sample}{Area\ of\ the\ standard} \times Concentration\ of\ the\ standard \times Dilution\ \ factor$$

Statistical analysis

The experiment was laid out in CRD (Factorial) with four replications. All experiments were repeated once?. The data from the repeated experiments were combined because there was no time-by-treatment interaction. The germination percentage was taken with the help of a formula:

$$\text{Germination \%age} = \frac{\text{No. of seeds germinate x 100}}{\text{Total seeds}}$$

Mean germination time (MGT) was calculated as per equation of Ellis and Roberts (1981),

$$MGT = £\,(Dn) / €n$$

Where, n is the number of seeds or emerged seedlings on day D, and D is the total number of days counted from the beginning of germination. Shoot and root lengths of field crops were measured after 10 days of emergence with a meter rod and average lengths were determined in cm.

Seedling vigour index was calculated according to the equation of Abdul-baki and Anderson (1973):

SVI = Germination %age x Radical length (cm)

The data collected was analyzed statistically using Fisher's Analysis of Variances technique and treatment means showing F-

values significant were compared using least significant difference (LSD) at 0.05 probability level (Steel *et al.,* 1997).

RESULTS AND DISCUSSION

The data reveal that weed species and weed extracts interaction significantly affected the germination of *Pennisetum glaucum* L. (millet), *Sorghum bicolor* L. (sorghum), *Zea mays* L. (maize), *Triticum aestivum* L. (wheat), *Vigna mungo* L. (mash), *Vigna radiata* L. (moong), *Cyamopsis tetragonoloba* L. (guar) and *Helianthus annuus* L. (sunflower). All the extracts of both weeds species significantly decreased germination of field crops as compared to control (Table-2). The minimum germination percentage of *P. glaucum* (5.25), *S. bicolor* (4.20), *Z. mays* (10.25), *T. aestivum* (4.75), *V. mungo* (11.00), *V. radiate* (3.9), *C. tetragonoloba* (10.25), and *H. annuus* (10.27) was recorded in the whole plant extract of *T. portulacastrum*. It was followed by the germination percentage of all tested crops in the whole plant extract of *S. portulacastrum*. However, maximum germination percentage was recorded in control treatment of all experiments.

The results of our studies showed that whole plant of extract *T. portulacastrum and S. portulacastrum* had significantly greater allelopathic effect as compared to other parts of the plant. The greater number of growth inhibitors detected in the whole plant explains the stronger inhibitory activity. These results were supported by the findings of Kadioglue *et al.* (2005). They reported inhibition in the germination rate and final germination of lentil (*Lens culinaris*), chickpea (*Cicer arietinum*), and wheat (*Triticum aestivum*) with different plant part extracts of several broad and narrow leaf weeds. This finding agrees with that of Hussain *et al*. (1987) who also found suppression of maize seed germination with higher concentration of *Trianthema* water extract. Our findings were also in line with that of Kadioglue *et al.* (2005) and Tanveer *et al.* (2008 and 2010). They reported inhibition in the germination rate of different crops with different plant part extracts.

All the extracts of both weed species increased mean germination time of all tested crops significantly as compared to the control (Table-3). The maximum value of mean germination time of *P. glaucum* (5.00 days), *S. bicolor* (5.00 days), *Z. mays* (5.00 days), *T. aestivum* (5.00 days), *V. mungo* (5.00 days), *V. radiata* (4.75 days), *C. tetragonoloba* (5.00 days), and *H. annuus* (5.00 days) was recorded in the whole plant extract of *T. portulacastrum*. It was followed by the mean germination time of these tested crops in the whole plant extract of *S. portulacastrum*. The seeds of all tested crops took minimum time to germinate in control treatment of all experiments.

These results suggest that the phytotoxicity of *T. portulacastrum and S. portulacastrum* leaf, stem, fruit, whole plant and root extracts may be due to restriction of water uptake and, hence, inhibition of seed germination. Maximum total water soluble phenolics were detected in whole plant extract as compared to leaf extracts (Table-1) which showed that inhibition of germination is due to the presence of more phenolics in whole plant extract. Interruption in water uptake caused decrease in seed protease activity, which played a key role in protein hydrolysis during germination and, to a large extent, was related to imbibition and water uptake of seeds (Rice, 1984). The results are supported by the findings of Babar *et al.* (2009) who stated that chickpea seeds soaked in root extract of *Asphodelus tenuifolius* Cav. took more time for germination. Similarly, Tawaha and Turk (2003) also observed an inhibitory effect of allelochemicals on water imbibition by wild barley (*Hordeum leporinum*) in a study on the allelopathic effects of black mustard (*Brassica nigra*).

Data presented in Table-4 reveal that the minimum root length of *P. glaucum* (0.53 cm), *S. bicolor* (1.30 cm), *Z. mays* (1.49 cm), *T. aestivum* (0.62 cm), *V. mungo* (1.44 cm), *V. radiata* (0.51 cm), *C. tetragonoloba* (0.49 cm), and *H. annuus* (0.55 cm) was recorded in the whole plant extract of *T. portulacastrum*. It was followed by the root length of all the tested crops in the whole plant extract of *S. portulacastrum*. The minimum value of shoot length of *P. glaucum* (0.80 cm), *S. bicolor* (1.20 cm), *Z. mays* (2.50 cm), *V. mungo* (1.75 cm), *V. radiata* (0.49 cm), *C. tetragonoloba* (3.15 cm), and *H. annuus* (0.65 cm) was recorded in the whole plant extract of *T. portulacastrum* (Table-5). It was followed by the root length of all these crops in the whole plant extract of *S. portulacastrum*. The minimum seed vigor of *P. glaucum* (2.8), *S. Bicolor* (5.9), *Z. mays* (15.35), *T. aestivum* (19.8), *V. mungo* (15.00), *V. radiata* (10.50), *C. tetragonoloba* (5.08), and *H. annuus* (5.75) was recorded in the whole plant extract of *T. portulacastrum* (Table-6). It was followed by the seedling vigor of tested crops in the whole plant extract of *S. portulacastrum*.

Trianthema portulacastrum L. and *Sesuvium portulacastrum* L. extracts significantly inhibited the root length, shoot length and seedling vigour index of all crops (Table-4, 5, 6). In all cases, the largest seedlings in terms of root and shoot length were found in the control treatment that had no *T. portulacastrum and S. portulacastrum* extracts. Suppression of maize root in response to *Trianthema* water extract was also reported by Hussain *et al.* (1987). The results are supported by the findings of Rashid *et al.* (2010), who reported impaired growth of lettuce (*Lactuca sativa*) and radish (*Raphanus sativus*) seeds (root and shoot length and fresh biomass) by

allelopathic potential of leaf and root leachates of kudzu (*Pueraria lobata*). Tanveer *et al.* (2008) also reported that minimum GI and germination percentage of rice seeds was observed when treated with leaf leachates of common Cocklebur (*Xanthium strumarium)*. Similarly, Stavrianakou *et al.* (2004) also documented the inhibition of germination, germination index and increase in germination time of chickpea and lentil with the extract of different weeds. Khan *et al*. (2012) tested the inhibition of wheat growth with parthenium extracts. Yousaf *et al*. (2013) examined the allelopathy of *Psidium guajava* against wheat and canary grass.

Many phenolic acids (caffeic acid, ferulic acid, M- coumeric acid, P- coumeric acid, syringic acid, venillic acid; and caffeic acid, gallic acid, 4-Hydroxy-3- Methoxybenzoic acid, P- coumeric acid, syringic acid) were found in the *T. portulacastrum and S. portulacastrum* extracts (Table-1). Phenolic acids have been found in a wide range of plants and soils and are often mentioned as putative allelochemicals (Inderjirt, 1996; Inderjit and Nishimura, 1999). It has been shown that the contribution of phenolic acids to allelopathy might not be due to a single phenolic acid because of the weak inhibitory activity (Inderjit, 1996). It has also been demonstrated that mixtures of phenolic acids have additive inhibitory action and/or synergistic inhibitory action (Einhellig, 1999).

CONCLUSION

The results show that the aqueous extracts of *T. portulacastrum* and *S. portulacastrum* possess allelochemicals that suppressed the germination and seedling growth of many crops. The presence of considerable amount of phenolic acids suggests that it is essential to keep these weeds under check at the emergence stage so that its inhibitory effects on the crop may be avoided. These results were obtained under laboratory conditions. The evaluation of the allelochemicals and their isolation, identification, release, and movement under field conditions are important future research guidelines.

Table-1. Water soluble Phenolics identified in *T. portulacastrum* and *S. portulacastrum*

	Whole plant		Leaves	
	T. portulacastrum	*S. portulacastrum*	*T. portulacastrum*	*S. portulacastrum*
Caffeic acid	-	-	18.75	14.06
Ferulic acid	12.00	-	-	-
Gallic acid	-	-	-	17.13
4-Hydroxy-3-Methoxybenzoic acid	-	51.6	-	28.61
M-Coumeric acid	-	-	4.14	-
P-Coumeric acid	-	2.94	2.78	-
Syringic acid	5.85	-	5.63	8.80
Venillic acid	15.46	-	-	-

Table-2. Effect of *T. portulacastrum* and *S. portulacastrum* on germination (%) of field crops

Weed	Extract	*Pennisetum glaucum*	*Sorghum bicolor*	*Zea mays*	*Triticum aestivum*	*Vigna mungo*	*Vigna radiata*	*Cyamopsis tetragonoloba*	*Helianthus annuus*
Trianthema portulacastrum	Control	90.0 a	90.0 a	80.75 a	89.25 a	90.75 a	90.0 a	81.25 a	86.75 a
	Whole plant	5.25 k	4.20 k	10.25 k	4.75 k	11.0 k	3.90 k	10.25 k	10.27 k
	Seed	38.25 e	30.5 e	40.75 e	34.75 e	40.75 e	30.0 e	40.5 e	39.87 e
	Leaves	15.25 i	15.5 i	20.0 i	14.95 i	20.75 i	12.4 i	24.75 i	19.75 i
	Stem	24.5 g	24.0 g	30.50 g	24.5 g	30.0 g	18.3 g	33.0 g	29.87 g
	Root	50.0 c	40.0 c	49.75 c	44.25c	44.5 c	40.0 c	50.5 c	49.75 c
Sesuvium portulcastrum	Control	90.25 a	89.80 a	80.75 a	90.0 a	91.75 a	91.25 a	81.5 a	86.5 a
	Whole plant	10.25 j	10.5 j	15.5 j	9.50 j	14.75 j	7.97 j	15.85 j	14.97 j
	Seed	44.5 d	39.7 d	45.50 d	39.5 d	44.5 d	35.15 d	44.75 d	44.5 d
	Leaves	20.5 h	20.0 h	24.50 h	19.95 h	24.75 h	16.0 h	30.25 h	24.87 h
	Stem	30.0 f	28.0 f	37.50 f	28.75 f	35.0 f	24.97 f	37.25 f	44.75 f
	Root	60.25 b	50.0 b	59.25 b	50.75 b	49.75 b	45.27 b	55.5 b	54.54 b
LSD at 5%		0.765	0.639	1.055	0.910	1.227	1.625	1.058	0.405

Means followed by same letter in a column did not differ significantly according to LSD test ($p<0.05$)

Table-3. Allelopathic Effect of *T. portulacastrum* and *S. portulacastrum* on the mean germination time of field crops

Weed	Extract	*Pennisetum glaucum*	*Sorghum bicolor*	*Zea mays*	*Triticum aestivum*	*Vigna mungo*	*Vigna radiata*	*Cyamopsis tetragonoloba*	*Helianthus annuus*
Trianthema portulacastrum	Control	1.60 k	2.17 k	2.08 k	1.55 k	1.45 k	1.89 k	1.95 k	1.90 k
	Whole plant	5.00 a	5.00 a	5.00 a	5.00 a	5.00 a	4.75 a	5.00 a	5.00 a
	Seed	2.85 g	3.04 g	3.00 g	2.31 g	2.36 g	2.65 g	2.86 g	2.83 g
	Leaves	3.71 c	3.69 c	4.00 c	3.31 c	3.23 c	3.50 c	3.60 c	3.67 c
	Stem	3.23 e	3.36 e	3.35 e	2.79 e	2.83 e	3.00 e	3.20 e	3.20 e
	Root	2.21 i	2.57 i	2.55 i	1.89 i	1.88 i	2.40 i	2.36 i	2.36 i
Sesuvium portulcastrum	Control	1.59 k	2.16 k	2.08 k	1.54 k	1.44 k	1.88 k	1.94 k	1.90 k
	Whole plant	4.46 b	4.63 b	4.4 b	4.0 b	4.29 b	3.92 b	4.33 b	4.54 b
	Seed	2.57 h	2.87 h	2.8 h	2.13 h	2.19 h	2.57 h	2.63 h	2.54 h
	Leaves	3.45 d	3.54 d	3.65 d	3.0 d	3.00 d	3.25 d	3.42 d	3.48 d
	Stem	3.13 f	3.20 f	3.3 f	2.48 f	2.59 f	2.79 f	3.03 f	3.0 f
	Root	2.00 j	2.39 j	2.3 j	1.71 j	1.66 j	2.22 j	2.2 j	2.1 j
LSD at 5%		0.033	0.032	0.026	0.034	0.057	0.22	0.023	0.01

Means followed by same letter in a column did not differ significantly according to LSD test ($p<0.05$)

Table-4. Effect of *T. portulacastrum* and *S. portulacastrum* on root length of field crops

Weed	Extract	*Pennisetum glaucum*	*Sorghum bicolor*	*Zea mays*	*Triticum aestivum*	*Vigna mungo*	*Vigna radiata*	*Cyamopsis tetragonoloba*	*Helianthus annuus*
Trianthema portulacastrum	Control	14.97 a	11.46 a	10.11 a	11.97 a	9.03 a	8.69 a	8.10 a	9.38 a
	Whole plant	0.53 k	1.30 k	1.49 k	0.62 k	1.44 k	0.51 k	0.49 k	0.55 k
	Seed	5.05 e	4.77 e	4.57 e	4.89 e	4.29 e	3.05 e	4.00 e	4.5 e
	Leaves	2.31 i	2.4 i	2.6 i	1.98 i	2.54 i	1.59 i	2.00 i	2.4 i
	Stem	3.0 g	3.15 g	3.79 g	2.93 g	3.34 g	2.39 g	3.00 g	3.5 g
	Root	77.4 c	5.6 c	5.39 c	5.68 c	5.98 c	3.97 c	6.02 c	5.5 c
Sesuvium portulacastrum	Control	14.97 a	11.46 a	10.11 a	11.97 a	9.03 a	8.69 a	8.10 a	9.39 a
	Whole plant	1.21 j	1.97 j	2.09 j	1.65 j	1.84 j	1.3 j	1..49 j	1.5 j
	Seed	6.09 d	5.27 d	5.29 d	5.39 d	4.74 d	3.4 d	4.99 d	4.99 d
	Leaves	2.9 h	3.05 h	3.2 h	2.79 h	2.9 h	2.19 h	2.39 h	2.98 h
	Stem	3.5 f	3.95 f	4.29 f	4.19 f	3.66 f	2.89 f	3.49 f	4.05 f
	Root	8.19 b	6.64 b	6.59 b	6.96 b	6.24 b	4.99 b	6.99 b	6.19 b
LSD at 5%		0.015	0.010	0.026	0.02	0.013	0.032	0.04	0.026

Means followed by same letter in a column did not differ significantly according to LSD test ($p<0.05$)

Table-5. Allelepathic effect of *T. portulacastrum* and *S. portulacastrum* on shoot length of field crops

Weed	Extract	*Pennisetum glaucum*	*Sorghum bicolor*	*Zea mays*	*Triticum aestivum*	*Vigna mungo*	*Vigna radiata*	*Cyamopsis tetragonoloba*	*Helianthus annuus*
Trianthema portulacastrum	Control	10.99 a	11.62 a	7.92 a	17.49 a	11.46 a	14.37 a	12.92 a	10.33 a
	Whole plant	0.8 k	1.2 k	2.5 k	1.25 k	1.75 k	0.49 k	3.15 k	0.65 k
	Seed	3.71e	3.5 e	4.05 e	5.5 e	5.4 e	4.97 e	5.72 e	4.09 e
	Leaves	1.6 i	2.01 i	3.05 i	3.19 i	3.4 i	1.9 i	4.02 i	2.0 i
	Stem	2.39 g	2.98 g	3.49 g	4.5 g	4.74 g	3.49 g	4.99 g	3.0 g
	Root	6.47 c	4.82 c	5.05 c	6.24 c	6.15 c	6.95 c	6.5 c	5.74 c
Sesuvium portulacastrum	Control	11.01 a	11.62 a	7.93 a	17.51 a	11.46 a	14.39 a	12.92 a	10.33 a
	Whole plant	1.35 j	1.97 j	2.8 j	1.84 j	2.21 j	1.1 j	3.51 j	1.74 j
	Seed	4.75 d	4.05 d	4.2 d	5.98 d	6.04 d	5.97 d	5.95 d	4.5 d
	Leaves	2.0 h	2.74 h	3.31 h	3.79 h	4.1 h	2.5 h	4.49 h	2.4 h
	Stem	3.1 f	3.3 f	3.7 f	5.09 f	5.25 f	2.99 f	5.49 f	3.5 f
	Root	7.1 b	5.49 b	5.22 b	7.87 b	6.54 b	8.07 b	7.22 b	6.49 b
LSD at 5%		0.209	0.01	0.042	0.212	0.01	0.054	0.098	0.027

Means followed by same letter in a column did not differ significantly according to LSD test ($p<0.05$)

Table-6. Allelepathic effect of *T. portulacastrum* and *S. portulacastrum* seedling vigor of field crops

Weed	Extract	*Pennisetum glaucum*	*Sorghum bicolor*	*Zea mays*	*Triticum aestivum*	*Vigna mungo*	*Vigna radiata*	*Cyamopsis tetragonoloba*	*Helianthus annuus*
Trianthema portulacastrum	Control	1347.8 a	1031.8 a	810.0 a	1126.5 a	860.75 a	606.5 a	632.89 a	765.83 a
	Whole plant	2.8 k	5.9 k	15.35 k	19.8 k	15 k	10.5 k	5.08 k	5.75 k
	Seed	193.2 e	145.6 e	186.5 e	321 e	300 e	210 e	162.1 e	59.5 e
	Leaves	35.2 i	37.2 i	52.05 i	115.5 i	99.5 i	39.5 i	49.69 i	20 i
	Stem	73.7 g	75.7 g	113.9 g	209.5 g	199.5 g	104.5 g	99.00 g	39.75 g

	Root	370 c	224.3 c	265.0 c	454.3 c	400.7 c	324.5 c	304.27 c	110 c
Sesuvium portulacastrum	Control	1348.2 a	1031.2 a	809.0 a	1126.3 a	861.7 a	606.5 a	632.63 a	765.3 a
	Whole plant	12.4 j	20.8 j	32.51 j	79.5 j	35.5 j	22.75 j	23.21 j	15.5 j
	Seed	271.2 d	209.2 d	238.7 d	410.5 d	350 d	290 d	223.41 d	90.5 d
	Leaves	59.5 h	61.1 h	78.59 h	189.5 h	141.2 h	79.5 h	72.45 h	30.5 h
	Stem	105 f	110.7 f	161.1 f	290.5 f	249.5 f	190.5 f	130.19 f	50.5 f
	Root	493.6 b	332.1 b	383.3 b	560 b	535.5 b	405.5 b	388.36 b	139.63b
LSD at 5%		1.280	0.895	1.003	1.094	1.183	0.976	1.734	0.937

Means followed by same letter in a column did not differ significantly according to LSD test ($p<0.05$)

Table-7. HPLC conditions for determination of phytotoxins in aqueous *T. portulacastrum and S. portulacastrum* extracts

Parameter	**Characteristic**
Column dimensions	25 cm length ×4.6 mm diameter, particle size of 5 µm
Diatomite	Supleco wax 10
Attenuation	0.01ppm
Rate of recorder	10 mm min^{-1}
Detector	SPD-10A vp-detector
Detection	UV,280 nm
Flow rate	0.25 ml min^{-1}
Volume injection sample	50 µl
Type of Column	Shim-pack CLC-Octadecyl Silicate (ODS) (C-18)
Mobile phase	Isocrartic;100% methanol
Temperature	25 °C

REFERENCES CITED

Abdul-Baki, A.A. and J.D. Anderson. 1973. Vigour determination in soybean by multiple criteria. Crop Sci. 13: 630-637.

Alam, S.M., A.R. Azami S.S.M. Naqvi, M.A. Khan and B. Khanzada. 1997. Effect of leaf aqueous extracts of common lambsquarter and NaCl on germination and seedling growth of rice. Acta Physiologia Plantarum, 19: 91-94.

Anaya, L., L. Ramos R.H. Cruz, J.G. Fernandez and V. Nava. 1987. Perspectives on Allelopathy in Mexican traditional agroecosystems: A case study in Taxcala. J. Chem. Ecol. 13: 2083-2101.

Aziz, A., A. Tanveer, A. Ali, M. Yasin, B.H. Babar and M.A. Nadeem. 2008. Allelopathic effect of cleavers (*Galium aparine*) on germination and early growth of wheat (*Triticum aestivum*). Allelopathy J. 22: 25-34.

Babar, B.H., A. Tanveer, M. Tahir, A. Aziz, A.U.H. Ahmad, M.A. Nadeem and M.M. Javaid. 2009. Allelopathic potential of wild onion (*Asphodelus tenuifolius*) on the germination and seedling growth of chickpea (*Cicer arietinum*). Weed Biol. Manag. 9: 146-151.

Balyan, R.S. and V.M. Bhan. 1986. Emergence, growth and reproduction of horse purslane (*Trianthema portulacastrum*) as influenced by environmental conditions. Weed Sci. 34:516-519.

Economou, G., O. Tzakou, A. Gani, A. Yannitsaro and D. Bilalis. 2002. Allelopathic effect of *Conyza albida*. Ecolog. 17: 2021-2034.

Einhellig, F.A. 1999. An integrated view of allelochemicals amid multiple stresses. In: Principles and Practices in Plant Ecology:Allelochemical Interactions (ed. by Inderjit, Dakshini K.M.M. and FoyC.L.). CRC Press, Boca Raton, FL, p. 479–494.

Ellis, R.A. and E.H. Roberts. 1981. The quantification of ageing and survival in orthodox seeds. Seed Sci. Tech. 9: 373-409.

Hamayun, M., F. Hussain. S. Afzal and N. Ahmad. 2005. Allelopathic effects of *Cyperus rotundus* and *Echinochloa crusgalli* on seed germination, plumule and radical growth in maize (*Zea mays* L.). Pak J. Weed Sci. Res. 11: 81-84.

Hussain, F., Yasmin and F. Rehman. 1987. *Trianthema portulacastrum* Linn. Exhibits allelopathy: advances in weed Sci. Proc. Pak-Indo Weed Control Workshop. Pp 325-334, Islamabad.

Hussain, F. and M. A. Gadoon. 1981. Allelopathic effects of *Sorghum vulgare* Pers. Oecologia (Berl), v. 51, p. 284-288.

Inderjirt, I. 1996. Plant phenolies in Allelopathy. Botanical Review, 62: 186 – 202.

Inderjit and H. Nishimura. 1999. Plant phenolics and terpenoid:transformation, degradation, and potential of

allelopathic interactions.In: Principles and Practices in Plant Ecology:Allelochemical Interactions (ed.by Inderjit, Dakshini K.M.M. and Foy C.L.). CRC Press, Boca Raton, FL, p. 255–266,.

Javed, A., A.H. Farooqi and S. Ahmad. 2011. *Trianthema portulacastrum* L., a herbal drug for the cure of Edema. J. Herbs. Spices and Medicinal Plants, 7: 65-70.

Johnson, A.R. 1977. A survey of the strand and dune vegetation along the Pacific and southern gulf coasts of Baja California. Mexico J. Biogeogr. 7: 83-99.

Judd, F.W., R.I. Lonard and S.I. Sides. 1977. The vegetation of South Padre Island. Texas in relation to topography. Southwest Nat. 23: 31-48.

Kadioglue, I., Y. Yanar and U. Asav. 2005. Allelopathic effects of weed leachates against seed germinatio n of some plants. J. Environ. Biol. 26:169-173.

Khan, N., Hashmatullah, K. Naveed, Z. Hussain and S.A. Khan. 2012. Assessment of allelopathic effects of parthenium (*Parthenium hysterophorus* L.) plant parts on seed germination and seedling growth of wheat (*Triticum aestivum* L.) cultivars. Pak. J. Weed Sci. Res. 18(1): 39-50.

Lonard, R.I. and F.S. Judd. 1997. The biological flora of coastal dunes and wetlands. *Sesuvium portulacastrum* L. J. Coastal Res. 13: 96-104.

Marwat, K.B., M. A. Khan, A. Nawaz and A. Amin. 2008. *Parthenium hysterophorus* L.: A potential source of bioherbicide. Pak. J. Bot. 40 (5): 1933-1942.

Narwal, S. S. 2004. Allelopathy in crop Production, Scientific Publishers, Jodhapur, India.

Nayyar, M.N., M. Ashiq and I. Ahmad. 2001. Manual on Punjab Weeds 1:52 Directorate of Agronomy. Ayub Agricultural Institute, Faisalabad, Pakistan.

Prasad, M.N.V. and P. Subhashini. 1994. Mimosine inhibited seed germination. Seedling growth and enzymes of *Oryza sativa* L. J. Chem. Ecol. 20:1689-1696.

Randhir, R. and K. Shetty. 2005. Developmental stimulation of total phenolics and related antioxidant activity in light and dark germinated maize by natural elicitors. Process Biochem. 40:1721-1732.

Rashid, M. H., T. Asaeda and M.N. Uddin. 2010. The Allelopathic Potential of Kudzu (Pueraria montana). Weed Sci. 58:47–55.

Stavrianakou, S., V. Liakoura, E. Levizou, P. Karageorgou, C. Delis, G. Liakopoulos, G. Karabourniotis, G. Manetas and Y. Manetas. 2004. Allelopathic effect of water-soluble leaf epicuticular

material from *Dittrichia viscosa* on seed germination of crops and weed. Allelopathy J. 14:35-41.

Steel, R. G. D., J. H. Torrie and D. A. Dickey. 1997. Principles and Procedures of Statistics. A Biometrical Approach 3rd ed. McGraw Hill Book Co., Inc., Singapore, p. 172-177.

Tanveer, A., M. Tahir, M.A. Nadeem, M. Younis, A. Aziz and M. Yaseen. 2008. Allelopathic effects of *Xanthium strumarium* L. on seed germination and seedling growth of crops. Allelopathy J. 21:18-328.

Tanveer, A., A. Rehman, M. M. Javaid, R. N. Abbass, M. Sibtain, A.U.H. Ahmad, M.S. Ibin-I-Zamir, K.M. Chaudhary and A. Aziz. 2010. Allelopathic potential of *Euphorbia helioscopia* L. against wheat (*Triticum aestivum* L.), chickpea (*Cicer arietinum* L.) and lentil (*Lens culinaris Medic*.). Turk. J. Agric. For., 34:75-81.

Tawaha, A. M. and M. A. Turk. 2003. Allelopathic Effects of Black Mustard (*Brassica nigra*) on Germination and Growth of Wild Barley (*Hordeum spontaneum*). J. Agron. Crop Sci. 189:298–303.

Weidenhamer, J.D. 1996. Distinguishing resource competition and chemical interference: Overcoming the methodological impasse. Agron. J. 88: 866-875.

Yousaf, M., A.F. Zahoor, K.G. Ali, A. Anjum, H. Shahzadi, Z. Mubeen, M. Awais and S. Purveen. 2013. Qualitative determination of allelochemicals in *Psidium guajava* L. leaves for their effect against wheat and canary grass. Pak. J. Weed Sci. Res. 19(3): 239-256.

Zimdahl, R.L. 2007. Fundamentals of Weed Science. Third Edition. Academic Press, an imprint of Elsevier. p 228.