ISOLATED AND COMBINED EFFECT OF ALLELOPATHIC PLANTS WATER EXTRACTS FOR WEED MANAGEMENT IN MAIZE

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Annotation: Current study was designed under laboratory condition (Pots trials). The specific objective of the study was to evaluate the most effective, ecofriendly and an economical treatment for weed management in maize through various allelopathic plant aqueous extracts. Selected allelopathic plant species were collected from farmer fields. All the plants were cleaned, dried in oven and grinned. The grinned powders were soaked in distilled water according to treatments in the ratio of 1:10 (w/v) or 100 g/L and kept at room temperature. Atrazine 38 SC (atrazine) @ 100 g/L was used as recommended herbicide. Distilled water treatment was also included for comparison. All the treatments were applied on maize, T. *portulicastrum* and L. *regidum* seeds. Data on Germination (%), Shoot Length (cm) and Dry Biomass (g) was recorded.

Results showed that S.*bicolor*, H.*annuus* and P.*hysterophorus* (WE) @ 33.33+33.33+33.33 (g/L) reduced dry biomass of T.*portulacastrum* and L.*regidum* by 35-41 %, whereas the commercial herbicide ranged from 45-47 %. Maize seeds were found more tolerant as compared to weed species. Furthermore allelopathic plant water extracts applied in combination had more inhibitory effect than their sole application, however the efficacy of commercial herbicide was more pronounced in suppressing the germination and seedling growth of test species. Hence it is concluded from the current study that allelopathy could be a potential source for designing an alternative to synthetic herbicide. Results showed that S.bicolor, H.annuus and P.hysterophorus WE @ 33.33+33.33+33.33 (g/L) reduced the dry biomass of T.portulacastrum and L.regidum by 54-68 % and 35-41 %, whereas the commercial herbicide

Key words: Allelopathy, Maize, Weeds, Sorghum, Sunflower, Parthenium

JEL Classification: A29 others

1. Introduction

Weed infestation is becoming a major constraint in maize production systems and is reported to reduce its yield by 24-83 % (Dogan et al., 2004 and Usman et al., 2001). Weeds are the most omnipresent class of pests and interfere with crop plants through allelopathy and competition, resulting of direct loss to quantity and quality of the produce (Gupta, 2004). The yield of maize could be reduced up to 32% due to trianthema infestation (Balyan and Bhan, 1989) and up to 80 % due to the competition from lolium regidum depending on the season and infestation level (Izquierdo et al., 2003).

Weeds can be controlled effectively using herbicides with a resultant increase in crop yield but non-judicious use of herbicides can create many environmental and health related problems everywhere (Jabran et al., 2008). Hand weeding is labor intensive, time consuming and getting expensive. This is not practical for large areas. Cultural methods are environmental friendly but very slow. Therefore, the scientist realized the need of an alternative to herbicide should be design for sustainable weed management.

Research efforts have made it possible to use these allelopathic plants and weeds for quality production of crops and to reduce the use of synthetic herbicides to contribute for maintaining sustainable agriculture (An et al., 2005).

Sorghum (Sorghum bicolor L.) plant contains allelochemicals that possess phytotoxic effect against weeds (Cheema et al., 2004), and against other crops (Correia et al., 2005). This toxicity is mainly due to the production and release of phenolic compounds, including phenolic acids (Ben- Hammouda et al., 1995) and sorgoleone (Einhellig and Souza, 1992). The germination and growth of weed seedlings is inhibited by sorghum seeds and seedlings (Kim et al., 1993).

Sunflower allelopathic effect on crops and weeds are well documented in literature Mahmood (2013) reported that sunflower actively influence the growth of its surrounding plants, and known to have a strong allelopathic effect against other plants. Macias and his team have isolated and identified the natural compounds from various cultivars of sunflower which includes simple phenolics, steroids, triterpenses, sesquiterpenses, flavonides, heliespirones and helikauranoside (Macias et al., 2002, 2004).

Parthenium is an aggressive and troublesome weed with strong allelopathic potential (Javaid et al., 2011; Amin et al., 2007). Infesting both cultivated and wasteland in Pakistan (Riaz et al., 2010, 2011, 2012). Parthenium weed is known to be allelopathic Adkin and Sowerby (1996). It has allelopathic effect and drastically retards the growth of many species (Tefera, 2002). Phenolic acids identified from Parthenium plant parts with reference to allelochemical interactions include caffeic acid, vanilic acid, ferulic acid, chlorogenic acid, pcoumaric acid and p-hydroxybenzoic acid and among the organic acids, fumaric acid (Kanchan and Jayachandra 1980b; Das and Das 1995)

Several laboratory experiments indicated that mixture solution of allelochemicals have greater effect than the same concentration of the compound applied separately (Blum et al., 1999; Einhellig 1995b), similarly combined use of root exudate of sorghum and fagopyrum tataricum were recorded for higher inhibition of weeds as compare to extracts applied as in isolated. (Uddin et al., 2013).

Keeping in view the importance of these allelopathic plants/weed inhibitory effects on weeds, the present study was designed with the objective to find the allelopathic effects of water extracts applied alone and in mixture for weed control in maize under laboratory (Pot condition).

2. Materials and Methods

Two runs of laboratory based experiments (Pots) were conducted at Weed Research Laboratory, The University of Agriculture Peshawar, Pakistan during June-July (2013) and were repeated in September-October 2013. Sorghum (Sorghum bicolor L.), and Sunflower (Helianthus annuus L.) were collected from the farmer fields in district Swabi, while Parthenium (Parthenium hesterophorus L.) plants were collected from the road sides and waste areas. Sorghum and sunflower plants were collected after harvesting crops in the field while Parthenium was collected freshly at maturity stage. All the plants samples were cleaned to remove dust and other particles and then were dried in oven (Kenton; KH-120AS) for 72 hours at 65 ^{0} C and were ground with the help of electrical grinder. The final grinded samples of all three species were kept in bags and labeled properly for further use in both runs of experiments. All plants powders were soaked in distilled water as per the treatment combination @ 1:10 (w/v). The extracts were kept at room temp 20 + 22 ^{0} C for 48 hours and filtered through muslin cloth and finally through Whatman No.1 filter paper to collect the respective water extract. Synthetic herbicide (atrazine) and distilled water was included for comparison. Fungicide Topsin-M 70 % @ 2 g kg $^{-1}$ was used in all treatment to avoid fungal attack. Water extracts were bottle individually and tagged for further utilization. Total 81 plastic pots (12 cm Height and 15 cm diameter) filled with 1 kg soil. These pots were replicated thrice. All the seeds of test species were soaked in their respective treatments for 48 hours, and were sown in in the pots. All pots were irrigated through mini sprayer when needed. All pots were discarded after 45 days of experiment.

Factor A. Treatments (plant water extract types)

Treatment	Water extracts (WEs) Species	WEs Conc. @ (w/v)
T1	Sorghum	100 g/L
T2	Sunflower	100 g/L
T3	Parthenium	100 g/L
T4	Sorghum + Sunflower	50+50 g/L
T5	Sorghum + parthenium	50+50 g/L
T6	Sunflower + Parthenium	50+50 g/L
T7	Sorghum+Sunflower + Parthenium	33.3+33.3+33.3 g/L
T8	Atrazine (herbicide)	100 g/L
T9	Control (distilled water)	1L

Factor B. Test Species

Maize (*Zea mays L).*

Trianthema *partulacastrum* (horse purslane)

Lolium regidum. (Regid Rye grass)

Data Recording:

Germination (%) was recorded by counting the number of germinated seeds in each pot and percentage were computed and recorded for each treatment. Seeds having 2mm radicle were consider as germinated. On daily basis germination % were observed. After germination shoot length (cm) was measured with measuring scale for all germinated seeds in each treatment. Dry biomass (g) was taken on an electrical balance after drying the fresh biomass in oven at 65 ^{0}C for 48 hours. The data presented for experiment is the mean of two runs conducted during June-July (2013) and September-October (2013).

Statistical Analysis

The data recorded for all the individual parameters were statistically analyzed using the appropriate ANNOVA suitable for Completely Randomized Design (CRD). Means were separated by using LSD test at 0.05 probability, where P-values were less than 0.05 (Steel et al., 1984).

3. Results and Discussion

Germination (%)

The statistical analysis of the data revealed that various plant extract treatments had significant effect on germination (%) of test species (Table-1). Data recorded showed the maximum germination (100 %) of *Z. mays* in control (distilled water) treatment. minimum germination (85 %) was recorded in *H. annuus* + *P. hysterophorus* (WE), similarly for *T. portulacastrum* seeds maximum germination (75 %) was recorded in control (distilled water) treatment while the minimum germination (36.67 %) was recorded in herbicide (atrazine) treatment. Furthermore, data recorded for *L. regidum* showed maximum germination (98.33 %) in control (distilled water) treatment while the minimum (40 %) was equally recorded in herbicide (atrazine) and *H. annuus* +*S. bicolor* + *P. hysterophorus* (WE) treatments. Among the species means highest germination (90.55 %) was recorded in *Z.mays* followed by *L. regidum* (57.59 %) whereas the lowest value (49.81 %) was recorded for *T. portulacastrum*. Among the treatment mean highest value of germination (83.89 %) was recorded in control (distilled water) treatment while the lowest value (55.56 %) was recorded in herbicide (atrazine) treatment followed by *H. annuus* + *S. bicolor* + *P. hysterophorus* (WE) with (56.11 %).

Allelopathic plants/weed water extracts and herbicide (atrazine) treatments had significantly influenced the germination (%), shoot length (cm), dry biomass (g) of test species viz. *Z. mays*, *T. portulacastrum* and *L. regidum.* Water extracts in mutual combination had more inhibitory effect than their sole effect on weed germination (%), shoot length (cm), and dry biomass (g) of test species, however efficacy of water extracts in mutual combination was slightly less than synthetic herbicide (atrazine). Higher inhibitory effects of water extracts in mutual combination could be due to synergistic actions off allelopathins present in these allelopathic plants/weed species which enhance the ability of extracts to show better inhibition for recorded parameters. Furthermore, strong inhibitory effect of these extracts on germination (%) of the test species indicating the presence of seed inhibitors in the allelochemicals released by these plants/weed species. Among the test species *Z. mays* seeds showed tolerance against herbicides and other allelopathic plants/weed water extracts. The tolerance of *Z. mays* seeds against allelopathins is a good indicator that could be further explored for selective weed management whereas, *T. portulacastrum* followed by *L. regidum* seeds were found more sensitive to water extracts and herbicide (atrazine) treatments.

Minimum germination (%) of *T. portulacastrum* seeds recorded in herbicide (atrazine) treatment was followed by *H. annuus* + *S. bicolor* + *P. hysterophorus* (WE) treatment. *H. annuus* + *S. bicolor* + *P. hysterophorus* (WE) inhibited the seed germination of *T. portulacastrum* by 41 % whereas the synthetic herbicide (atrazine) by 46 %. Allelopathic extracts is ecofriendly and economical, yet the inhibition on seed germination of test species is slightly less than synthetic herbicides. Our results are in close similarity with the findings of (Cheema et al., 2000; Cheema et al. 2000b) who observed that the inhibitory effect of allelopathic plant extracts on weeds is less than synthetic herbicides. However minimum germination of *L. regidum* was recorded in *H. annuus* + *S. bicolor* + *P. hysterophorus* (WE) followed by herbicide (atrazine). *H. annuus* + *S. bicolor* + *P. hysterophorus* (WE) inhibited the seed germination of *L. regidum* by 54 % whereas the synthetic herbicide (atrazine) by 50 %. Higher inhibitory effects of aforesaid extract in mutual combination may be due to synergistic actions of various allelopathins present in these allelopathic plants/weed species which enhanced the efficacy of extracts. Furthermore strong inhibitory effect of *H. annuus* + *S. bicolor* + *P. hysterophorus* (WE) on germination (%) of the tested species indicating the presence of seed inhibitors in the allelochemicals released by these plants. Leather (1983) reported that chlorogenic acid and Isochlorogenic acids could reduce the seed germination of many weed species.

Shoot length (cm)

The statistical analysis of the data showed that all extracts had significant effect on shoot length (cm) of test species (Table 2). Data recorded for *Z. mays* showed that maximum shoot length (38.46 cm) was recorded in control (distilled water), while minimum (29.99 cm) was recorded in *H. annuus* + *S. bicolor* + *P. hysterophorus* (WE) treatment which was statistically at par with herbicide (atrazine) treatment. Furthermore, maximum shoot length of *T. portulacastrum* (6.20 cm) was recorded in control (distilled water) treatment, while the minimum (3.55 cm) was recorded in herbicide (atrazine) treatment. Data recorded for the *L. regidum* showed the maximum shoot length (16.96 cm) was recorded in control (distilled water) treatment while the minimum (9.45 cm) was recorded in herbicide (atrazine) treatment which was statistically at par with *H. annuus* + *S. bicolor* + *P. hysterophorus* (WE) treatment. Among the species means maximum shoot length (32.36 cm) was recorded for *Z. mays* followed by *L. regidum* with (11.76 cm) whereas lowest shoot length (4.5 cm) was recorded for *T. portulacastrum* Among the treatment means maximum shoot length (20.54 cm) was recorded in control (distilled water) treatment while minimum (14.46 cm) was recorded in herbicide (atrazine) treatment which was statistically at par with *H. annuus* + *S. bicolor* + *P. hysterophorus* (WE) treatment. Minimum shoot length (cm) of *T. portulacastrum* and *L. regidum* species in herbicide (atrazine) treatment by (42-44 %), indicated that allelopathic plant water extracts had less inhibitory effect on shoot length (cm) of test species. furthermore, *H. annuus* + *S. bicolor* + *P. hysterophorus* (WE) was the next best treatment in reducing the shoot length (cm) of *T. portulacastrum* and *L. regidum* species by (37-43 %). The presence of p-coumaric, vanillic, syringic, and ferulic acids in allelopathic plants may inhibit the shoot growth of the tested species. Our results are like that of Turk and Tawaha (2002) who stated that allelopathic plants water extracts were more promising on radicle growth inhibition, as radicle emerges earlier and comes in contact with phytochemicals. Based on result of current study it is suggested to developed additional strategies and techniques to increase the efficacy of allelochemicals to reduce our reliance on synthetic herbicide.

Dry biomass (g)

The statistical analysis of the data showed that all extracts had significant effect on dry biomass (g) of test species (Table 3). Data recorded for *Z. mays* showed maximum dry biomass (0.2585 g) in control (distilled water) treatment, whereas the minimum (0.1895 g) was recorded in herbicide (atrazine) treatment. Furthermore, data recorded for *T. portulacastrum* showed maximum dry biomass (0.0707 g) in control (distilled water), while the minimum (0.0163 g) was recorded in herbicide (atrazine) treatment. Similarly, Data recorded for the *L. regidum* dry biomass, the maximum value (3.04 g) was recorded in control (distilled water) treatment, while the minimum (1.66 g) was recorded in herbicide (atrazine) treatment. Among the species means maximum dry biomass (2.14 g) was recorded for *L. regidum* followed by *Z. mays* with (0.2126 g) whereas minimum value (0.038 g) was recorded for *T. portulacastrum*. Among the treatment means maximum dry biomass (1.12 g) was recorded in control (distilled water) treatment, whereas the minimum (1.62 g) was recorded in herbicide (atrazine) treatment.

All allelopathic plant water extracts had significant effect on dry biomass (g) of the tested species. Among the tested species maize showed maximum tolerance to various allelopathic water extracts and herbicide (atrazine) treatment, whereas *T. portulacastrum* and *L. regidum* species were more sensitive to herbicide treatment (atrazine) followed by *H. annuus* + *S. bicolor* + *P. hysterophorus* (WE) treatment. Furthermore, herbicide (atrazine) treatment reduced the dry biomass (g) of *T. portulacastrum* and *L. regidum* by (77 and 53 %) whereas the *H. annuus* + *S. bicolor* + *P. hysterophorus* (WE) by (68 and 41 %) respectively. The inhibitory effect of allelopathic plant extracts on weeds is less than synthetic herbicides (Cheema et al., 2000; Cheema et al. 2000b). Though, the utilization of allelopathic water extracts for weed management was economical and ecofriendly yet the reduction in dry biomass of test species was less than synthetic herbicide (Einhellig, 1996). The presence of sorgoleone, phenolics, p-coumaric, vanillic, syringic, and ferulic acids in allelopathic plants may inhibit dry biomass (g) of the tested species by inhibiting the electron transport in both photosynthesis and respiration, reduction in chlorophyll content, and reduction in chlorophyll accumulation.

Table 1. Allelopathic effect of different plants water extracts applied alone and mixed on germination (%) of Z. *mays*, and its associated weeds under laboratory condition (pots study).

	Species tested			
Treatment types	*Z. mays*	*T.partulacastrum*	*L.rigidum*	*Means*
Sor W.E @ 1:10 (w/v)	90.00 bc	56.66 b	78.33 b	74.1000
Sun W.E @ 1:10 (w/v)	86.67 bc	56.66 b	73.33 bc	72.2200
Par W.E @ 1:10 (w/v)	91.67 b	58.33 b	71.67 c	73.8900
Sor+ Sun W.E @ 1:10 (w/v)	86.67 bc	45.00 cd	51.67 d	61.1100
Sor+ Par W.E @ 1:10 (w/v)	86.67 bc	48.33 c	51.67 d	62.3300
Sun+ Par W.E @ 1:10 (w/v)	85.00 c	50.00 c	53.33 d	62.7800
Sun + Sor + Par W.E @ 1:10 (w/v)	88.33 bc	40.00 de	40.00 e	56.1100
Atrazine (commercial herbicide)	86.67 bc	36.67 e	40.00 e	54.4500
Control (distilled water)	100.00 a	75.00 a	98.33 a	91.1100
Means	89.07	51.85	62.03	
LSD 5 %	6.37	6.57	6.57	

For each effect, values with same letter (s) in a column do not differ from one another at P≤0.05 according to LSD test.

Whereas Sorg= Sorghum bicolor L. Sun= Helianthus annuus L. Par= Parthenium hysterophorus L.

Table 2. Allelopathic effect of different plants water extracts applied alone and mixed on shoot length (cm) of Z. *mays*, and its associated weeds under laboratory condition (pots study).

	Species tested			
Treatment types	*Z.mays*	*T.partulacastrum*	*L.rigidum*	*Means*
Sor W.E @ 1:10 (w/v)	35.51 b	5.04 b	12.16 c	17.5700
Sun W.E @ 1:10 (w/v)	31.85 cd	4.95 b	12.94 b	16.5800
Par W.E @ 1:10 (w/v)	32.48 c	4.95 b	12.10 c	16.5100
Sor+ Sun W.E @ 1:10 (w/v)	31.39 de	4.16 c	10.28 e	15.2800
Sor+ Par W.E @ 1:10 (w/v)	30.58 ef	3.99 cd	11.20 d	15.2600
Sun+ Par W.E @ 1:10 (w/v)	30.68 ef	4.00 cd	11.11 d	15.2600
Sun + Sor + Par W.E @ 1:10 (w/v)	29.99 f	3.71 de	9.70 f	14.4700
Atrazine (commercial herbicide)	30.37 f	3.55 e	9.45 f	14.4600
Control (distilled water)	38.46 a	6.20 a	16.96 a	20.5400
Means	32.36	4.5	11.76	
LSD 5 %	0.85	0.37	0.339	

For each effect, values with same letter (s) in a column do not differ from one another at P≤0.05 according to LSD test.

Whereas Sorg= Sorghum bicolor L. Sun= Helianthus .annuus L Par= Parthenium .hysterophorus L.

Table 3. Allelopathic effect of different plants water extracts applied alone and mixed on dry biomass (g) of Z. *mays*, and its associated weeds under laboratory condition (pots study).

	Species tested			
Treatment types	*Z.mays*	*T.partulacastrum*	*L.rigidum*	*Means*
Sor W.E @ 1:10 (w/v)	0.2175 b	0.0508 b	2.32 b	0.8600
Sun W.E @ 1:10 (w/v)	0.2157 b	0.0482 bc	2.33 b	0.8700
Par W.E @ 1:10 (w/v)	0.2148 b	0.0440 c	2.30 b	0.8500
Sor+ Sun W.E @ 1:10 (w/v)	0.2048 bd	0.0295 d	1.99 c	0.7400
Sor+ Par W.E @ 1:10 (w/v)	0.2063 bc	0.0315 d	1.94 c	0.7300
Sun+ Par W.E @ 1:10 (w/v)	0.2092 bc	0.0283 de	1.94 c	0.7300
Sun + Sor + Par W.E @ 1:10 (w/v)	0.1968 cd	0.0227 e	1.80 d	0.6700
Atrazine (commercial herbicide)	0.1895 d	0.0163 f	1.66 e	0.6200
Control (distilled water)	0.2585 a	0.0707 a	3.04 a	1.1200
Means	0.2126	0.038	2.146	
LSD 5 %	0.016	0.006	0.065	

For each effect, values with same letter (s) in a column do not differ from one another at $P \leq 0.05$ according to LSD test.

Whereas Sorg= Sorghum bicolor L. Sun= Helianthus .annuus L. Par= Parthenium .hysterophorus L.

4. Conclusion:

It is concluded from the current study that all tested allelopathic plants species plants viz sorghum, sunflower, and parthenium have allelpathic effect against the weeds of maize. They have water soluble allelochemicals which could inhibit the germination % and growth parameters of weeds. Among all the various treatments Sorghum + Sunflower + Parthenium (WEs) showed significant results which were almost nearby to the effect of synthetic herbicide. A positive indicator during the study has been observed that maize seeds shown more tolerance against these extracts. Furthermore, the combination of these extracts had more inhibitory effect as compared to their sole application; hence the combination extracts of these plants could be utilized for sustainable weed management in maize.

It is recommended that water extract of sorghum + sunflower + parthenium @ 33.3+33.3+33.3 g/L in mutual combination may be recommended for sustainable weed management in maize.

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