Pak. J. Weed Sci. Res. 19(1): 31-43, 2013

ALLELOPATHIC SUPPRESSION OF *Avena fatua* AND *Rumex dentatus* IN ASSOCIATED CROPS

Tauseef Anwar[1*], Shahida Khalid[1], Yasir Arafat[1], Sehrish Sadia[2] and Sana Riaz[1]

ABSTRACT

The study was conducted to investigate the allelopathic effects of leaf powder of *Rumex dentatus* L., *Euphorbia helioscopia* L., *Parthenium hysterophorus* L. and *Carica papaya* L. on seed germination and seedling growth of *Avena fatua* L., *R. dentatus, Helianthus annuus* L., *Triticum aestivum* L. and *Zea mays* L. using a laboratory bioassay. Seed germination, radical and plumule length of *T. aestivum* were significantly suppressed by *R. dentatus* and *P. hysterophorus* leaf powder whereas these parameters were not suppressed by *E. helioscopia* and *C. papaya* leaf powder when compared to their control treatments. *Euphorbia helioscopia* and *P. hysterophorus* leaf powder application decreased the seed germination and subsequent seedling growth of *A. fatua* and *R. dentatus.* There was no effect on growth of *Z. mays* and *H. annuus* when the leaf powder of *E. helioscopia* was applied on their seedlings. *Rumex dentatus* exhibited auto-toxicity.

Key words: Allelopathy, *A. fatua*, crops, *Rumex dentatus*, *P. hysterophorus*, suppression.

INTRODUCTION

In Pakistan the average annual growth rate of agriculture had decreased during 2004 to 2008 due to low production of major crops (Jabeen and Ahmad, 2009). The main reasons for this decline in the production of the major crops are the expensive inputs, shortage of irrigation water, low quality crop seed, use of conventional farming methods, non-availability of fertilizers and improper weed control (Nasir and Sultan, 2004). Weeds shares nutrients, moisture and sunlight with the crop plants and hence reducing the growth of the crop plants. Therefore, suppression of weeds is important to minimize production losses to the major crops (Norris, 1982). The is estimated losses to the major crops by weeds are *ca*. 20 to 30% in Pakistan (Anonymous, 2005). Herbicides generally affect environment by creating pollution, due to incessant use of herbicides and the remnant toxic elements of these chemicals remain in soil for a long time (Chung *et al*., 2003). Increasing concern against pesticides and herbicides has

[1]National Agricultural Research Centre, Islamabad, Pakistan
[2]Department of Botany, PMAS University of Arid Agriculture, Rawalpindi
*Corresponding author's email: tauseefsko@yahoo.com

compelled the scientists to explore environment friendly methods for controlling weeds, diseases and pests (Hussain *et al.,* 2007). Allelopathy, an eco-friendly technique, has proved useful in weed control and raised crop productivity (Ridenour and Callaway 2001). Molish was the first scientist who introduced the science of allelopathy by conducting study about the effect of one plant on another by releasing chemicals into the environment (Molish, 1937). Allelochemicals are a sub-group of secondary metabolites not needed for metabolism such as growth, development and reproduction of the allelopathic plant. Growth-inhibiting allelochemicals are an important part of crop defense against weeds. Plant-based chemicals or allelochemicals have proved more eco-friendly (Sharma *et al*., 2000). Trees like *Prosopis juliflora*, *Eucalyptus camaldulensis* and *Acacia nilotica* have also been observed in reducing seed germination of *Ipomoea* sp., *Asphodelus tenuifolius, Brassica campestris* and *Triticum aestivum* and can prove very useful for pesticide industry (Khan *et al.,* 2005).

The focus of present research was to investigate the effect of selected plants leaf powder on seed and seedling of *A. fatua*, *R. dentatus* and associated crops like *H. annuus* (KSE-7777), *T. aestivum* (Wafaq-2001), *Z. mays* (Islamabad Gold-2010) on filter paper, agar and soil in laboratory conditions. This work encompasses the possible use of allelochemicals to regulate growth and control weeds for sustainable agriculture. *E. helioscopia* (Euphorbiaceae) contains a series of diterpenes, the jatrophanes euphoscopin, euphoscopin, euphornin and the lathyrane euphohelioscopin (Barile *et al*., 2008). *P. hysterophorus* (Asteraceae) has secondary metabolites like alkaloids, parthenin, coronopilin, kaempferol, p-coumaric acid, caffeic acid (Patil and Hegde, 1988). The sesquiterpene lactones, coronopilin and parthenin have phytotoxicity for other plants including aquatic species (Batish *et al*., 2002a). *R. dentatus* (Polygonaceae) contains significant phytochemicals including emodin, aloe-emodin, chrysophanol, physocin, chrysophanol, parietin, nepodine and anthraquinones (Choi *et al.,* 2004; Liu *et al.,* 1997).

MATERIALS AND METHODS

Fresh leaves of *R. dentatus*, *E. helioscopia*, *P. hysterophorus* and *C. papaya* were collected, dried for 4 weeks in shade at room temperature. All samples were separately ground to fine powder (20 mm mesh size) and stored in glass reagent bottles till further use (Jafariehyazdi and Javidfar, 2011). *Avena fatua, R. dentatus, H. annuus, Z. mays* and *T. aestivum* were used as test species. Seeds of the test species were sterilized with sodium hypochlorite for one minute and then rinsed thoroughly with distilled water several times using the protocols of Jabeen *et al*. (2011).

Seed and seedlings were used separately. Ten sterilized test species seeds/seedlings placed in sterilized petri dishes having filter paper or soil (Rejila and Vijayakumar, 2011). 0.25g of plants powder was added on filter paper along with 5ml distilled water per petri dish while 0.25g of plants powder was also added to 25g soil along with 15ml distilled water per petri dish Each treatment was replicated five times in completely randomized design (Zahedi and Ansari, 2011). The dishes were incubated in the growth chamber (Salam *et al.,* 2011). After 15 days, the data was recorded on seed germination, radical and plumule length.

Statistical analysis performed by using the STATISTIX 9 computer software and the means were separated by using Fisher's protected LSD test (Steel and Torrie, 1997).

RESULTS AND DISCUSSION

Seed germination (%)

Wheat seed germination was significantly reduced by the leaf powder of *R. dentatus*, and *P. hysterophorus.* Leaf powder of all of the *R. dentatus, E. helioscopia, P. hysterophorus* and *C. papaya* L. inhibited the seed germination of *A. fatua* and *R. dentatus.* Seed germination of *Z. mays* was not decreased when treated with *E. helioscopia* leaf powder. *Rumex dentatus* however exhibited auto-toxicity (Fig. 1). Wheat germination was significantly suppressed by *R. dentatus* followed by *P. hysterophorus* correlating with the work of Umer *et al.,* 2010 and Hussain *et al.,* (1997) where wheat germination was reduced by *R. dentatus* and *P. hysterophorus.* The above study was also supported by work of Maharjan *et al.,* (2007), Dhole *et al.,* (2011) and Tanveer *et al.*, (2007) that parthenin is highly toxic to wheat as compared to maize, *E. helioscopia* treatments showed no effect on wheat germination. In this study, *P. hysterophorus* decreased the germination of *A. fatua* and *R. dentatus.* Batish *et al.,* (2002b) and Marwat *et al.,* (2008) have also shown that *P. hysterophorus* decreased germination of *A. fatua.*

Seed emergence (%) in soil

Emergence of *Z. mays* and *H. annuus* was not suppressed by *E. helioscopia* and *P. hysterophorus* leaf powders, respectively. *P. hysterophorus* and *C. papaya* decreased the emergence of *A. fatua* and *R. dentatus.* Wheat germination was significantly suppressed by *R. dentatus* and *P. hysterophorus* while remained unaffected in *E. helioscopia* and *C. papaya* leaf powders (Fig. 2).

Radical length (cm) on filter paper (direct seeding)

Radical growth of *T. aestivum* was significantly suppressed by *R. dentatus* and *P. hysterophorus* while remained unaffected in *E. helioscopia* and *C. papaya* leaf powders as compared to control (Table-1). In direct seeding, radical length of wheat was suppressed by *R. dentatus* and *P. hysterophorus.* Mishra *et al.,* (2011) studied that *P. hysterophorus* suppressed wheat radical length. *Rumex dentatus* was significantly suppressed by *P. hysterophorus*. *Euphorbia helioscopia* decreased the radical length of *A. fatua* and *R. dentatus.* Radical length of *T. aestivum* was significantly suppressed by *R. dentatus* and *P. hysterophorus* while remained unaffected by *E. helioscopia* and *C. papaya* treatments (Fig. 3. a. b). Tanveer *et al.,* (2007), Oudhi (2001) and Maharjan *et al*., (2007) studied that *E. helioscopia* was non-toxic for wheat (Fig. 3. c, d). The work of Batish *et al.,* (2002) and Hussain *et al.,* (1997) supported that wheat seedling growth was reduced by *P. hysterophorus* (Fig. 4).

Table-1. Radical length (cm) as suppressed by the leaf powder when germinated in filter papers in direct seeding.

Treatments	Test species				
	T. aestivum	***A. fatua***	***Z. mays***	***H. annuus***	***R. dentatus***
R. dentatus	8.05b	5.04c	5.03c	1.49d	4.22c
E. helioscopia	12.9a	2.03d	7.26b	6.48b	3.06c
C. papaya	13.1a	1.01e	3.23d	4.25c	5.49b
P. hysterophorus	4.26c	7.02b	2.14e	2.02d	0.49d
Control	14.3a	9.34a	9.01a	8.49a	7.07a
[1]LSD	3.2679	0.5692	0.6136	1.4388	1.203
F-value	22.22*	485.76*	279.70*	56.00*	56.71*

[1]Means followed by different letters within one column differ significantly at α = 0.05
* = Significant at α = 0.01

Radical length (cm) in soil (direct seeding)

R. dentatus and *P. hysterophorus* leaf powders suppressed radical length of all test species as compared to control. *R. dentatus* exhibits auto-toxicity and significantly suppressed by *P. hysterophorus* leaf powder. *E. helioscopia* decreased the radical length of *A. fatua* and *R. dentatus.* Radical length of *T. aestivum* was significantly suppressed by *R. dentatus* and *P. hysterophorus* while remained unaffected in *E. helioscopia* and *C. papaya* leaf powders as compared to control (Table-2).

Radical length (cm) on filter paper (seedlings)

P. hysterophorus significantly suppressed all the test species. There was no effect of *C. papaya* and *E. helioscopia* on wheat while these inhibited *A. fatua.* Radical length of both *Z. mays* and *H. annuus* was unaffected by *E. helioscopia* leaf powder (Table-3).

Table-2. Radical length (cm) in leaf powder in soil in direct seeding.

Treatments	Test species				
	T. aestivum	***A. fatua***	***Z. mays***	***H. annuus***	***R. dentatus***
R. dentatus	6.36b	6.02b	7.28c	3.10d	5.01c
E. helioscopia	9.45a	3.22c	9.28b	7.31b	3.19d
C. papaya	10.3a	2.47c	4.31d	6.06c	6.45b
P. hysterophorus	3.47c	5.32b	3.45d	2.48d	1.45e
Control	9.49a	8.05a	11.1a	9.30a	8.46a
[1]LSD	1.540	0.999	1.1125	1.0662	1.320
F-value	45.47*	66.33*	111.84*	95.32*	56.72*

[1]Means followed by different letters within one column differ significantly at α = 0.05
* = Significant at α = 0.01

Table-3. Radical length (cm) in leaf powder of seedlings on filter paper.

Treatments	Test species				
	T. aestivum	***A. fatua***	***Z. mays***	***H. annuus***	***R. dentatus***
R. dentatus	9.13b	9.48b	5.12b	6.25b	4.05b
E. helioscopia	12.1a	5.17d	7.41a	9.03a	2.44a
C. papaya	1.9a	2.07e	3.30c	2.08c	2.10cd
P. hysterophorus	6.18c	7.12c	2.23c	3.45c	1.38d
Control	13.4a	12.3a	8.07a	9.45a	6.07a
[1]LSD	2.4770	0.9870	1.4150	1.1352	0.9713
F-value	18.01*	209.06*	41.84*	110.25*	49.22*

[1]Means followed by different letters within one column differ significantly at α = 0.05
* = Significant at α = 0.01

Table-4. Radical length (cm) in leaf powder of seedlings in soil.

Treatments	Test species				
	T. aestivum	***A. fatua***	***Z. mays***	***H. annuus***	***R. dentatus***
R. dentatus	7.17b	8.14b	5.25b	4.14b	3.45b
E. helioscopia	11.3a	4.24d	7.00ab	7.49a	1.10d
C. papaya	11.8a	3.38d	1.49c	1.17c	2.17c
P. hysterophorus	3.28c	6.25c	2.39c	3.28b	1.12d
Control	13.4a	10.05a	8.14a	8.00a	5.21a
[1]LSD	3.1490	0.8763	1.7841	1.2929	0.8953
F-value	22.59*	129.81*	34.17*	66.06*	50.17*

[1]Means followed by different letters within one column differ significantly at α = 0.05
* = Significant at α = 0.01

Radical length (cm) in soil (seedlings)

P. hysterophorus leaf powder significantly suppressed all the test species. There was no effect of *C. papaya* and *E. helioscopia* on wheat seedlings. Radical length of *A. fatua* and *R. dentatus* was decreased by *E. helioscopia* (Table-4).

Plumule length (cm) on filter paper (direct seeding)

Plumule growth of *T. aestivum* was significantly suppressed by *R. dentatus* and *P. hysterophorus* while there was no effect in *E. helioscopia* and *C. papaya* treatments as compared to control. Plumule length of *A. fatua* was suppressed in *E. helioscopia* treatments. *C. papayas* treatment decreased plumule growth of *Z. mays, H. annuus* and *R. dentatus* (Table-5). With the application of leaf powders on seedlings, plumule growth of *T. aestivum* was significantly suppressed by *R. dentatus* and *P. hysterophorus.* Mishra *et al.* (2011), Dhole *et al.* (2011), Sajjan and Pawa (2005) and Singh and Sangeeta (1991) studied that maize was suppressed by *P. hysterophorus. Carica papaya* treatments equally suppressed the plumule growth of *A. fatua* and *R. dentatus* seedling on filter paper and soil. *Carica papaya* and *E. helioscopia* had no effect on wheat. *Rumex dentatus* and *P. hysterophorus* treatments were most toxic for wheat so these weeds need to be eradicated from the wheat crop. *Euphorbia helioscopia* treatment was found toxic for the growth of *Z. mays* and *H. annus* in direct seeding while non-toxic to the seedlings. *Rumex dentatus* exhibited auto-toxicity and *P. hysterophorus* has the ability to replace *R. dentatus.*

Plumule length in soil (direct seeding)

In this study, leaf powders in soil decreased the plumule growth of *A. fatua*, *R. dentatus, Z. mays* and *H. annuus.* Plumule growth of *T. aestivum* was significantly suppressed by *R. dentatus* and *P. hysterophorus* (Table-6).

Plumule length on filter paper (seedlings)

Wheat was not affected by *C. papaya* and *E. helioscopia* treatments while these acts as inhibitor for *A. fatua.* Plumule growth of seedlings of both *Z. mays* and *H. annuus* remained unaffected by *E. helioscopia* treatments showings that it did not suppress plumule growth of seedlings (Table-7).

Plumule length in soil (seedlings)

C. papaya and *E. helioscopia* treatments had no effect on wheat. The growth of the crops in this study was not reduced by *E. helioscopia* while *P. hysterophorus* treatment was most inhibitory to crops. *C. papaya* treatment inhibited the plumule growth of *A. fatua* and *R. dentatus* seedlings (Table-8).

Table-5. Plumule length (cm) in leaf powder in direct seeding on filter paper.

Treatments	Test species				
	T. aestivum	***A. fatua***	***Z. mays***	***H. annuus***	***R. dentatus***
R. dentatus	6.31bc	6.12b	3.32c	1.22c	2.20c
E. helioscopia	8.48ab	3.09cd	5.02b	3.08b	4.60b
C. papaya	7.65ab	2.47d	4.09bc	2.23b	0.02e
P. hysterophorus	4.49c	4.39c	2.14d	0.98c	0.70d
Control	9.48a	8.49a	7.46a	5.42a	7.96a
[1]LSD	2.7846	1.2971	0.9640	0.8718	0.0182
F-value	6.44**	46.74*	57.31*	55.81*	14.11*

[1]Means followed by different letters within one column differ significantly at α = 0.05
* = Significant at α = 0.01

Table-6. Plumule length (cm) in leaf powder in direct seeding in soil.

Treatments	Test species				
	T. aestivum	***A. fatua***	***Z. mays***	***H. annuus***	***R. dentatus***
R. dentatus	7.39b	5.49b	2.07d	3.44bc	6.39b
E. helioscopia	10.9a	4.32bc	6.35b	4.05b	2.09d
C. papaya	11.25a	3.00cd	5.45b	2.12d	2.12d
P. hysterophorus	4.37c	2.45d	3.12c	2.34cd	4.14c
Control	12.15a	7.44a	8.07a	6.40a	9.07a
[1]LSD	2.2332	1.4091	0.9679	1.1428	0.7297
F-value	28.95*	26.83*	83.03*	29.95*	221.41*

[1]Means followed by different letters within one column differ significantly at α = 0.05
* = Significant at α = 0.01

Table-7. Plumule length (cm) in leaf powder of seedlings on filter paper.

Treatments	Test species				
	T. aestivum	***A. fatua***	***Z. mays***	***H. annuus***	***R. dentatus***
R. dentatus	6.10b	7.31b	7.26b	6.35b	3.13d
E. helioscopia	8.19a	3.11d	10.2a	8.32a	6.32b
C. papaya	9.35a	2.13d	5.30b	4.09c	2.00e
P. hysterophorus	4.39c	6.18c	2.27c	3.39c	4.05c
Control	9.35a	9.45a	11.4a	9.45a	8.12a
[1]LSD	1.8694	0.9834	2.1870	1.2510	0.6111
F-value	17.04*	124.10*	37.65*	57.71*	216.40*

[1]Means followed by different letters within one column differ significantly at α = 0.05
* = Significant at α = 0.01

Table-8. Plumule length (cm) in leaf powder of seedlings in soil

Treatments	Test species				
	T. aestivum	***A. fatua***	***Z. mays***	***H. annuus***	***R. dentatus***
R. dentatus	4.13b	7.34ab	7.14b	5.48b	2.05d
E. helioscopia	7.48a	4.33c	9.30a	7.00a	5.48b
C. papaya	7.01a	3.31c	2.14c	3.25c	2.13d
P. hysterophorus	2.00b	6.30b	2.34c	1.49d	3.32c
Control	8.45a	8.07a	10.05a	8.06a	7.10a
[1]LSD	2.1252	1.0523	0.8164	1.1964	0.9823
F-value	70.87*	48.12*	280.93*	66.81*	66.95*

[1]Means followed by different letters within one column differ significantly at α = 0.05
* = Significant at α = 0.01

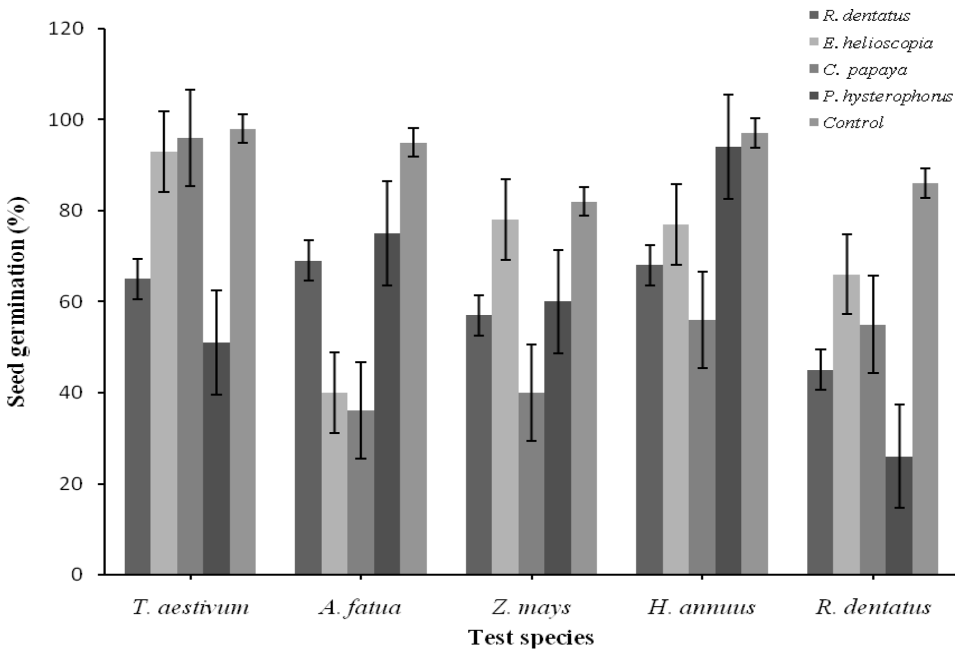

Figure 1. Seed germination (%) when treated with the leaf powder and grown in filter papers under room temperature.

CONCLUSIONS

Carica papaya and *E. helioscopia* treatments had shown no effect on wheat seed germination and seedlings growth while significantly inhibited seed germination and suppressed the radical and plumue growth of *A. fatua. R. dentatus* and *P. hysterophorus* treatments were most toxic for wheat so these weeds need to be eradicated from the wheat crop. *E. helioscopia* treatment was found toxic for the growth of *Z. mays* and *H. annuus* in direct seeding while non-toxic to the seedlings. *R. dentatus* exhibited auto-toxicity and *P. hysterophorus* has the ability to replace *R. dentatus.*

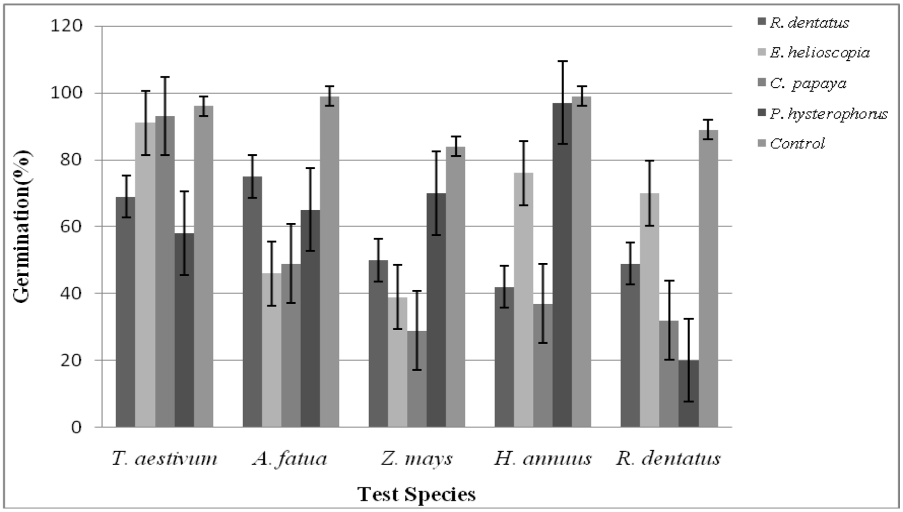

Figure 2. Seed emergence (%) in leaf powder in soil.

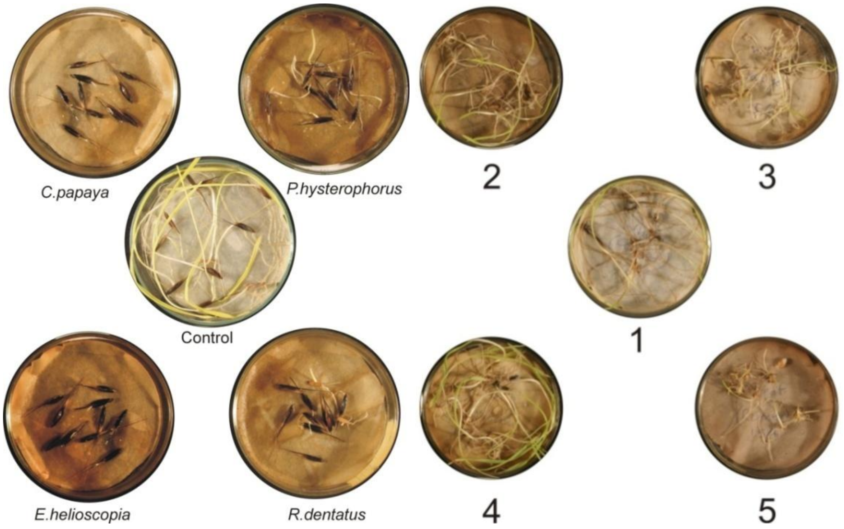

Figure 3a. *Triticum aestivum* in leaf powder on filter paper Fig. 3b. *A. fatua* in leaf powder on filter paper (1-Control, 2-*C. papaya,* 3-*R. dentatus,* 4-*E. helioscopia,* 5-*P. hysterophorus*)

Figure 3c. ***Zea mays*** **in leaf powder on filter paper Fig. 3d.** ***Helianthus annuus*** **in leaf powder on filter paper (A-Control, 1-*C. papaya,* 2-*R. dentatus,* 3-*P. hysterophorus* 4-*E. helioscopia.***

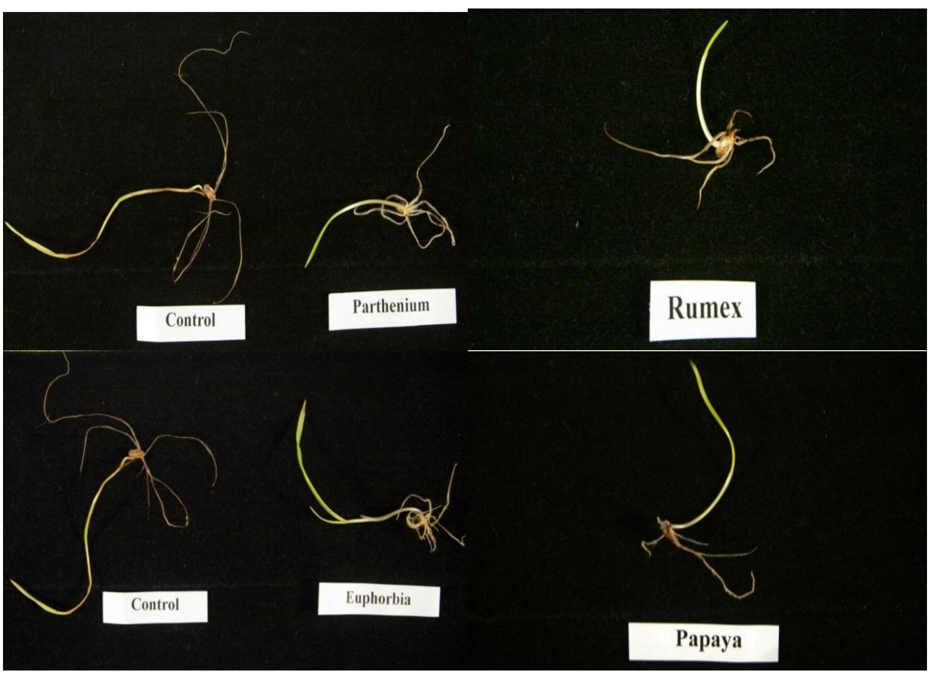

Figure 4. ***Triticum aestivum*** **seedling in leaf powders in soil.**

REFERENCES CITED

Anonymous. 2005. Agricultural Statistics of Pakistan. Government of Pakistan, Ministry of Food, Agriculture and Livestock (Economics Wing), Islamabad, Pakistan.

Barile, E., M. Borriello, A. T. Pietro, A. Doreau, C. Fattorusso, E. Fattorusso and V. Lanzotti. 2008. Discovery of a new series of jatrophane and lathyrane diterpenes as potent and specific P-glycoprotein modulators. Org. Biomol. Chem. 6:1756-1762.

Batish, D.R., H.P. Singh, R.K. Kohli, D.B. Saxena and S. Kaur. 2002a. Allelopathic effect of parthenin against two weedy species *Avena fatua* and *Bidens pilosa*. Environ. Exp. Bot. 47: 149-155.

Batish, D. R., H. P. Singh, D. B. Saxena and R. K. KohliI. 2002b. Weed suppressing ability of parthenin - a sesquiterpene lactone from *Parthenium hysterophorus*. New Zealand J. Plant Prot. 55: 218-221.

Choi, G.J., S.W. Lee, K.S. Jang, J.S. Kim, K.Y. Cho and J.C. Kim. 2004. Effect of chrysophanol, parietin and nepodin of *Rumex crispus* on barley and cucumber powdery mildews. Crop Prot. 23(12): 1215-1221.

Chung, I. M., K.H. Kim, J.K. Ahn, S.B. Lee, S.H. Kim and S.J. Hahn. 2003. Comparison of allelopathic potential of rice leaves, straw, and hull extracts on barnyardgrass. Agron. J. 95: 1063-1070.

Dhole, J. A., S. S. Bodke and N. A. Dhole. 2011. Allelopathic effect of aqueous leaf extract of *Parthenium hysterophorus* L. on seed germination and seedling emergence of some cultivated crops. J. Res. Bio. 1: 15-18.

Hussain, F., F. Mobeen, B. S. Kill and S. O. Yoo. 1997. Allelopathic suppression of wheat and mustard by *Rumex dentatus* ssp. klotzschianus. J. Plant Biol. 40(2):120-124.

Hussain, S., S.U. Siddique, S. Khalid, A. Jamal, A. Qayyum and Z. Ahmad. 2007. Allelopathic potential of senna (*Cassia angustifolia* Vahl.) on germination and seedling characters of some major cereal crops and their associated grassy weeds. Pak. J. Bot. 39(4): 1145-1153.

*Jabeen, N. and M. Ahmad. 2009. Possible allelopathic effect of three different weeds on germination and growth of maize (*Zea mays*) cultivars. Pak. J. Bot. 41(4): 1677-1683.

Jabeen, N., M. Ahmad and S. S. Shaukat. 2011. Interactive activity of *Asphodelus tenuifolius* on germination and growth of wheat (*Triticum aestivum*) and sorghum (*Sorghum bicolor*). Pak. J. Bot. 43(1): 325-331.

Jafariehyazdi, E. and F. Javidfar. 2011. Comparison of allelopathic effects of some brassica species in two growth stages on germination and growth of sunflower. Plant Soil Environ. 57 (2): 52-56.

Khan, M. A., K. B. Marwat, G. Hassan and Z. Hussain. 2005. Bioherbicidal effects of tree extracts on seed germination and growth of crops and weeds. Pak. J. Weed Sci. Res. 11: 179-84.

Liu, S. Y., F. Sporer, M. Wink, J. Jourdane, R. Henning, Y. L. Li and A. Ruppel. 1997. Anthraquinones in *Rheum palmatum* and *Rumex dentatus* (Polygonaceae) and phorhol esters in *Jatropha curcas* (Euphorbiaceae) with molluscicidal activity against the schistosome vector snails *Oncomelania*, *Biomphalaria* and *Bulinus*. Trop. Med. Int. Health. 2(2): 179-188.

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.

Maharjan, S., B. B. Shrestha and P. K. Jha. 2007. Allelopathic effects of aqueous extract of leaves of *Parthenium hysterophorus* L. on seed germination and seedling growth of some cultivated and wild herbaceous species. Sci. World, 5:33-39.

Mishra, S., C. Nautiyal, S. Mishra, S. Chandra. 2011. Reducing the allelopathic effect of *Parthenium hysterophorus* L., on wheat (*Triticum aestivum* L.) by *Pseudomonas putida*. Plant Growth Regul. Pp. 1-11.

Molish, H. 1937. Der Einflus einer Pflanze auf die andere, Allelopathie. Verlag von Gustav Fisher, Jena, Germany.

*Nasir, Z. A. and S. Sultan. 2004. Survey of weeds in mustard fields of district Chakwal. J. Biol. Sci. 7(2): 279-286.

*Norris, R.F. 1982. Interaction between weeds and other pests in the agroecosystem 406. *In: Proc. Conf. on Biometeorology in integrated pest management, (Eds.):* J.L. Hatfield and I.J.Thomson. Uni. of California, Davis, Academic press. New York.

Oudhi, P. A. 2001. Germination and seedling vigour of wheat as affected by allelopathy of some obnoxious weeds. Agric. Sci. Digest. 21 (4): 275-276.

Patil, T. M. and B. A. Hegde. 1988. Isolation and purification of a sesquiterpene lactone from the leaves of *Parthenium hysterophorus* L., its allelopathic and phytotoxic effects. Curr. Sci. 57: 1178-1181.

Rejila, S. and N. Vijayakumar. 2011. Allelopathic effect of *Jatropha curcas* on selected intercropping plants (green chilli and sesame). J. Phytol. 3(5): 01-03.

Ridenour, W.M. and R.M. Callaway. 2001. The relative importance of allelopathy in interference: the effects of invasive weed of native bunchgrass. Oecologica, 126: 444-450.

Salam, I., M. Ahmad and S. T. Ali. 2011. Allelopathic effect of scarlet pimpernel (*Anagallis arvensis*) on seed germination and radical elongation of mung bean and peral millet. Pak. J. Bot. 43(1): 351-355.

Sajjan, A.S. and K.N. Pawa. 2005a. Allelopathic effect of parthenium (*Parthenium hysterophorus* L.) extract and residue on some agronomic crops and weeds. J. Chem. Ecol. 7(13) 1739-1747.

Singh, S. P., and Sangeeta. 1991. Allelopathic Potential of *Parthenium hysterophorus* L. *J. Agron. Crop Sci.,* 167: 201–206.

Sharma, N. K., J. S. Samra and H. P. Singh. 2000. Effect of aqueus extracts of *Populus deltoids* M. on germination and seedling growth of wheat. Allelopath. J. 7: 56-68.

Steel, R.G.D. and J.H. Torrie. 1997. *Principles and procedures of statistic.* 3rd Edition, MC Graw Hill book co, Inc., Singapore. Pp. 172-177.

Tanveer, A., A. Rehman, M.M. Javaid, R.N. Abbas, M. Sibtain, A.H. Ahmad, M.S. Ibin-i-Zamir, K.M. Chaudhary and A. Aziz. 2007. Allelopathic potential of *Euphorbia helioscopia* L. against wheat (*Triticum aestivum* L.), chickpea (*Cicer arietinum* L.) and lentil (*Lens culinaris* Medic.). Turk. J. Agric. 34: 75-81.

Zahedi, S.M. and N.A. Ansari. 2011. Allelopathic potential of common mallow (*Malva sylvestris*) on the germination and the initial growth of tomato, cucumber and cress. Asian J. Agric. Sci. 3(3): 235-241.