# ALLELOPATHIC MANAGEMENT OF NOXIOUS WEEDS IN Helianthus annuus, Zea mays AND Triticum aestivum BY SELECTED PLANTS

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ABSTRACT

Bioassays were performed to study the allelopathic effect of dried leaf powder of Carica papaya, Parthenium hysterophorus, Euphorbia helioscopia and Rumex dentatus on intact and pre-germinated seeds of R. dentatus, Avena fatua, Helianthus annuus (K.S.E 7777), Zea mays (Islamabad Gold 2010) and Triticum aestivum (Wafaq 2001). Experiments were designed in CRD with five replications accounting parameters of germination percentage, radicle length (cm) and plumule length (cm). C. papaya and P. hysterophorus decreased the emergence of R. dentatus and A. fatua on agar similarly; all treatments inhibited the germination of R. dentatus and A. fatua. In direct seeding, radicle growth of R. dentatus and A. fatua was decreased by all treatments. In same experiments, plumule of A. fatua was significantly repressed by E. helioscopia treatments. In direct seeding, E. Helioscopia reduced the radicle length of R. dentatus and A. fatua. R. dentatus radicle growth was also significantly inhibited by P. hysterophorus. All treatments inhibited the plumule length of R. dentatus and A. fatua. P. hysterophorus significantly inhibited radicle as well as the plumule of all test species. P. hysterophorus and E. helioscopia treatments were evaluated as good weed suppressants. Weed suppressive effects of these treatments are attributed to their secondary metabolites needed to be explored. It is recommended to conduct experiments for weedicidal potential of the species in field to assess the efficacy of leaf dried powder along dose requirements in natural agriculture systems.

Keywords: Allelopathy, Weeds, leaf powder, secondary metabolites, weedicidal potential, weed suppression.

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## INTRODUCTION

In crop defense against weeds, allelopathy is an important component. Previous studies reported decrease in growth of Avena fatua, Coronopus didymus, Chenopodium album and Phalaris minor by sunflower leaf dried powder with no effect on wheat (Naseem et al., 2009). Fungal growth was suppressed by hexane treatments Rumex dentatus (Fatima et al., 2009). Rye was inhibited by Roshan cultivar of wheat due to its allelochemical nature than Tabasi, Niknejad and Shiraz (Labbafy et al., 2009). Seed germination and seedling growth of Lactuca sativa was moderately affected by Lactuca dissecta, highly affected by Inula koelzii and Inula falconeri, while showed stimulatory effect by Anthemis nobilis (Khan et al., 2009). Weeds are non-economic plants that reduce crop yield (Mukhtar et al., 2012). Weeds along resource competition with crops exhibit allelopathy (Hussain et al., 1997; Batish et al., 2007). Allelopathy is a natural tool for weed control, increase crop yield, reduce utilization of synthetic herbicides and improve ecological environment (Alagesaboopathi, 2010). Many studies suggested allelochemicals as an alternative to synthetic herbicides for weed control (Khan et al., 2006; Jamil et al., 2009). Moreover, weeds can inhibit seed germination of themselves a phenomenon discussed under term of 'autotoxicity'. Autotoxicity is intraspecific allelopathy which occurs when a plant releases chemical substance that inhibit germination. Allelopathic compounds are released by plants through residue decomposition, root exudation, leaching and volatilization that affect growth and development of neighboring plants (Cheema et al., 2013). Allelochemical compounds belong to diverse range of chemical groups and have different modes of action. Phenolic compounds are most diverse allelochemicals interfering neighboring plant growth and development (Weir et al., 2004).

Allelochemicals may be distributed among leaves, flowers, seeds, roots, pollen and stems (Zeng et al., 2008). C. papaya belongs to family Caricaceae. Previously papaya seeds and fruits are reported to contain a powerful inhibitory agent benzyl isothiocyanate (BITC). This compound has strong fungicidal, bactericidal and insecticidal activity. Closely related compounds (allyl isothiocyanate, phenethyl isothiocyanate) are known to be germination inhibitors (Wolf et al., 1984). Euphorbia helioscopia is common weed in Pakistan. It appears in November-December and has a strong invasive potential in winter crops, such as potato, wheat, chickpea, lentil and pea. Allelopathic inhibitory effect of weeds on chickpea and wheat has been reported (Mishra et al., 2006; Kadioglue et al., 2005) but no research has yet been carried out on allelopathic effects of E. helioscopia specifically on maize, wheat and sunflower. Parthenium hysterophorus is a hostile weed drastically retarding growth of neighboring species (Picman and Picman, 1984; Tefera, 2002). The ability of P. hysterophorus to displace other species is due to allelopathy (Narwal, 1994). However, its phytotoxic nature has not been exploited for pest management (Datta and Saxena, 2001; Batish et al., 1997). Tefera (2002) reported concentration dependent inhibitory effects of Parthenium weed treatments to seed germination and growth of Eragrostis. Under laboratory conditions, 'parthenin' release by aqueous extraction of fresh leaf material of P. hysterophorus proved to have 16–100% relative role (Regina et al., 2007). Polygonaceous plants including Rumex have been defined as allelopathic (Choi et al., 2004). R. dentatus is wide spread weed in many countries including Pakistan. It is distributed in many habitats including cultivated fields, wastelands, canal bank and orchards. R. dentatus contains bioactive phytochemicals including emodin, chrysophanol, aloe-emodin, physocin, nepodine, parietin, gallic, isovanillic, vanillic, cinnamic, syringic, phydroxycinnamic, benzoic, succinic, ferulic acids, flavonoids and anthraquinones (Choi et al., 2004; Zhang et al., 2012). Keeping in mind R. dentatus allelopathy, experiments were designed to check if R. dentatus manifests allelopathy against selected troublesome weeds in major crops of Pakistan.

## MATERIALS AND METHODS

Allelopathic activity of C. papaya, E. helioscopia, P. hysterophorus and R. dentatus. was tested against the growth and germination of selected test species on agar. Fresh leaves of C. papaya, E. helioscopia, P. hysterophorus and R. dentatus were collected from different locations of District Rawalpindi (73° 02′ E longitude and 33° 36′ N latitude 508 m above sea level), the Punjab, Pakistan and thoroughly splashed under tap water to remove dust and dried under shade at room temperature 25°C until no decrease in weight of sample (6 days in our case) because shade-drying can prevent loss of heat-labile and readily oxidized nutrients (Ramsumair et al., 2014; Anwar et al., 2103). The dried plant material was crushed, ground to fine powder and preserved in air tight plastic bags at 4°C.

Seeds of A. fatua, R. dentatus, H. annuus (K.S.E 7777), Z. mays (Islamabad Gold 2010) and T. aestivum (Wafaq 2001) were procured from Department of Crop Science, National Agriculture and Research Centre, Islamabad. Seeds of test species were sterilized with 1 % sodium hypochlorite (NaOCl) for 2 min, washed with distilled water thrice and used for further bioassay studies. Water Agar 0.5% (w/v) was autoclaved at 121ºC for 15 minutes and then cooled down to 45ºC. After cooling 15 ml of 0.5% water agar solution was poured in each petri dish and 0.25g powder was spread per petri dish on agar, after complete setting used for both on seedling and direct seeding of test species. Following three parameters were used in allelopathic screening methodologies:

a) Germination percentage
b) Radicle length (cm)
c) Plumule length (cm)

STATISTIX 9 software was used for analysis of results. Means were separated by Fisher ‘s protected LSD test (Nekonam et al., 2014; Anwar et al., 2016).

## RESULTS AND DISCUSSION

### Germination percentage

Wheat germination percentage was reduced significantly (44 & 38 % respectively) by P. hysterophorus and R. dentatus. Germination percentage of R. dentatus was suppressed in P. hysterophorus powder. Z. mays and H. annuus was not suppressed by E. helioscopia and P. hysterophorus treatments, respectively (Table 1). The Results were correlated with previous analysis. Sajjan and Pawa (2005) and Dhole et al. (2011) stated that P. hysterophorus leaf dried powder significantly affected germination and growth of Triticum aestivum. R. dentatus, P. hysterophorus, Sisymbrium irio and Oxalis corniculata are most growth inhibitor to wheat (Umeret al., 2010). Germination and seedling growth of T. aestivum was significantly affected by R. dentatus leaf dried powder (Hussain et al., 1997). All treatments inhibited the germination percentage of R. dentatus and A. fatua. Germination percentage of Z. mays was not affected by E. helioscopia leaf dried powder. However, auto-toxicity was exhibited by R. dentatus. Emergence of H. annuus and Z. mays was not affected by P. hysterophorus and E. helioscopia treatments, respectively. P. hysterophorus and C. papaya reduced the emergence of R. dentatus and A. fatua. Germination percentage in T. aestivum was significantly decreased by P. hysterophorus and R. dentatus (44 & 38% respectively) while others remained unaffected by C. papaya and E. helioscopia treatment. Suppressive effect of P. hysterophorus on germination of A. fatua is reported earlier (Batish et al., 2002; Marwat et al., 2008).

### Radicle length

Radicle length of T. aestivum was significantly inhibited by R. dentatus and P. hysterophorus (42.76 & 59.26 % in direct seeding; 39.25 & 54.55% in seedling in plant powder mixed with agar) while it was not affected by C. papaya and E. helioscopia treatments. Radicle growth of Zea mays, R. dentatus, A. fatua and H.

annuus was suppressed by all the treatments. R. dentatus exhibited auto-toxicity and was significantly inhibited by all treatments (Table 2). In seedling experiments, P. hysterophorus leaf dried powder significantly inhibited all the test species. There was no effect of E. helioscopia and C. papaya on seedlings of wheat. Radical length of R. dentatus and A. fatua was suppressed by E. helioscopia leaf dried powder. Radical length of H. annuus and Z. mays was not affected by E. helioscopia leaf dried powder (Table 3). Suppressive effect of P. hysterophorus on wheat radical length was reported earlier by Mishra et al. (2011). P. hysterophorus suppressed R. dentatus significantly. The radical length of A. fatua and R. dentatus were suppressed by E. helioscopia leaf dried powder. Radical length of wheat was significantly repressed by P. hysterophorus and R. dentatus while remained unaffected by C. papaya and E. helioscopia treatments compared to control. Non-toxic effects of E. helioscopia on T. aestivum are reported previously (Tanveer et al., 2007). The work of Maharjan et al. (2007) and Oudhi (2001) also support the above-mentioned results. In seedlings, when E. helioscopia leaf dried powder was applied, the radicle length of both H. annuus and Z. mays remained unaffected. Hussain et al. (1997) and Batish et al. (2002) reported growth reduction in wheat seedling by P. hysterophorus.

Plumule length (cm)

Plumule growth of T. aestivum was significantly suppressed by R. dentatus and P. hysterophorus (40.74 & 64.46% in direct seeding; 36.06 & 55.31% in seedling in powder mixed with agar) while remained unaffected by C. papaya treatments. These results confirmed the negative effect of P. hysterophorus powder on maize and sunflower plumule growth (Table 4). P. hysterophorus leaf dried powder significantly inhibited plumule length (cm) of all the test species. T. aestivum growth was unaffected by E. helioscopia and C. papaya treatments while these acted as suppressors for A. fatua. Plumule length of seedlings of both H. annuus and Z. mays was not affected by the leaf dried powder of E. helioscopia, indicating that it was not inhibitory towards plumule length of seedlings (Table 5). The plumule growth of T. aestivum seeds was significantly inhibited by P. hysterophorus and R. dentatus when treated with their leaf dry powder treatments as compared to control while remained unaffected by C. papaya and E. helioscopia treatments. P. hysterophorus and R. dentatus inhibited plumule growth of all the test species. Dhole et al. (2011) and Mishra et al. (2011) reported suppressive effect of P. hysterophorus on maize growth. The work of Singh and Sangeeta (1991) and Sajjan and Pawa (2005) correlated to the above results. C. papaya leaf dried powder likewise inhibited plumule length of R. dentatus and A. fatua seedling in soil and on filter paper. P. hysterophorus significantly inhibited the plumule length of all the test species. E. helioscopia and C. papaya did not suppress wheat growth. The radicle and plumule length (cm) of the crops in this experiment was not reduced by Euphorbia helioscopia. Weed suppressive activity of plants is generally attributed to the diverse nature of allelochemicals. E. helioscopia contains a series of jatrophanes, euphoscopin, euphornins, diterpenes, lathyrane euphohelioscopin and euphoscopin (Barile et al., 2008). P. hysterophorus has secondary metabolites like kaempferol, parthenin, coronopilin, caffeic acid, p-coumaric acid (Patil and Hegde, 1988).

The sesquiterpene lactones, coronopilin and parthenin have phytotoxicity for other plants including aquatic species (Anwar et al., 2018; Batish et al., 2002). R. dentatus contains significant phytochemicals e.g., emodin, aloeemodin, chrysophanol, physocin, chrysophanol, parietin, nepodine and anthraquinones (Choi et al.,2004; Liu et al.,1997). Compounds such as carotenoids, papain, pectin, dehydrocarpines, chymopapain, carpaine, carposide, pseudocarpaine, cis-violaxanthin, cryptoglavine and antheraxanthin (Ortega and Pino, 1997) have been isolated from C. papaya.

## CONCLUSIONS AND RECOMMENDATIONS

Application of all treatments of allelopathic plants showed a pronounced inhibitory impact for controlling weeds. This suggests the studied plants as potential candidates for detailed experimentation in field conditions to authenticate the hypothesis of their weedicide activity against selected weeds in crops. Moreover, P. hysterophorus and E. helioscopia are more efficient in weed growth suppression. Active compounds from these allelopathic plants are needed to be explored to support organic agriculture.

Table-1. Germination percentage in powder mixed with agar.

| Treatments | Test species | | | | |
|---|---|---|---|---|---|
| | T. aestivum | A. fatua | Z. mays | H. annuus | R. dentatus |
| R. dentatus | 72b | 67bc | 72b | 78b | 55bc |
| E. helioscopia | 95a | 50cd | 96a | 49c | 66b |
| C. papaya | 94a | 42d | 26c | 38c | 40cd |
| P. hysterophorus | 56c | 70b | 59b | 96a | 29d |
| Control | 98a | 92a | 98a | 99a | 92a |
| [1]LSD | 17.66 | 18.32 | 19.23 | 17.957 | 21.13 |
| [2]F-value | 14.19* | 14.85* | 31.44* | 31.00* | 17.61* |

Note. [1]. Means followed by different letters within one column differ significantly (P < 5%)
[2]. *=Significant at (P < 1%)

Table-2. Radical length (cm)in plant powder mixed with agar in direct seeding.

| Treatments | Test species | | | | |
|---|---|---|---|---|---|
| | T. aestivum | A. fatua | Z. mays | H. annuus | R. dentatus |
| R. dentatus | 7.04b | 5.49c | 5.35c | 7.12c | 4.14c |
| E. helioscopia | 11.45a | 2.12e | 7.13b | 9.39b | 2.49d |
| C. papaya | 11.5a | 3.49d | 2.05d | 4.08d | 6.03b |
| P. hysterophorus | 5.01b | 8.07b | 1.32d | 3.31d | 1.12e |
| Control | 12.3a | 11.2a | 9.01a | 11.3a | 8.07a |
| [1]LSD | 1.7087 | 1.2058 | 0.8098 | 0.9741 | 0.8677 |
| [2]F-value | 47.38* | 98.75* | 216.04* | 161.39* | 134.19* |

Note. [1]. Means followed by different letters within one column differ significantly (P < 5%)
[2]. *=Significant at (P < 1%)

Table-3. Radical length (cm)of seedling in plant powder mixed with agar.

| Treatments | Test species | | | | |
|---|---|---|---|---|---|
| | T. aestivum | A. fatua | Z. mays | H. annuus | R. dentatus |
| R. dentatus | 8.14b | 4.37c | 7.43c | 10.23c | 4.34c |
| E. helioscopia | 12.65a | 1.65e | 9.53b | 12.47b | 4.65d |
| C. papaya | 12.1a | 2.75d | 4.25d | 6.28d | 8.33b |
| P. hysterophorus | 6.09b | 7.02b | 3.72d | 6.32d | 3.78e |
| Control | 13.4a | 10.1a | 11.11a | 13.43a | 10.37a |
| [1]LSD | 1.7178 | 1.2124 | 1.8188 | 1.9831 | 1.8778 |
| [2]F-value | 48.47* | 88.65* | 226.04* | 171.45* | 144.19* |

Note. [1]. Means followed by different letters within one column differ significantly (P < 5%)
[2]. *=Significant at (P < 1%)

Table-4. Plumule length (cm) in powder mixed with agar in direct seeding.

| Treatments | Test species | | | | |
|---|---|---|---|---|---|
| | T. aestivum | A. fatua | Z. mays | H. annuus | R. dentatus |
| R. dentatus | 7.17bc | 6.45b | 4.07c | 5.02c | 7.22b |
| E. helioscopia | 9.99ab | 5.28bc | 6.12b | 7.09b | 1.12e |
| C. papaya | 10.2a | 4.14c | 3.32d | 308d | 2.34d |
| P. hysterophorus | 4.34c | 1.49d | 2.19e | 1.09e | 4.27c |
| Control | 12.1a | 9.07a | 7.09a | 8.39a | 9.07a |
| [1]LSD | 2.9953 | 1.2127 | 0.6756 | 0.6841 | 0.8319 |
| [2]F-value | 13.53* | 70.45* | 117.35* | 245.78* | 209.87* |

Note. [1]. Means followed by different letters within one column differ significantly ($P < 5\%$)
[2]. *=Significant at ($P < 1\%$)

Table-5. Plumule length (cm) of seedling in powder mixed with agar.

| Treatments | Test species | | | | |
|---|---|---|---|---|---|
| | T. aestivum | A. fatua | Z. mays | H. annuus | R. dentatus |
| R. dentatus | 9.27bc | 9.65b | 9.04c | 10.12c | 8.12b |
| E. helioscopia | 11.23ab | 8.23bc | 11.13b | 12.39b | 2.43e |
| C. papaya | 12.4a | 7.15c | 8.52d | 8.28d | 3.23d |
| P. hysterophorus | 6.48c | 3.42d | 7.39e | 6.02e | 5.23c |
| Control | 14.5a | 12.06a | 12.49a | 13.29a | 10.17a |
| [1]LSD | 2.9783 | 1.2347 | 1.6456 | 1.6231 | 1.8239 |
| [2]F-value | 14.53* | 69.45* | 121.45* | 233.78* | 211.87* |

Note. [1]. Means followed by different letters within one column differ significantly ($P < 5\%$)
[2]. *=Significant at ($P < 1\%$)

## REFERENCES CITED


Alagesaboopathi, C. 2010. Allelopathic effects of Centella asiatica aqueous treatments on pearl millet (Pennisetum typhoides L.) and cowpea (Vigna unguiculata WALP.). Pak. J. Weed Sci. Res., 16(1): 67-71.

Anwar, T., S. Khalid, Y. Arafat, S. Sadia and S. Riaz. 2013. Allelopathic suppression of Avena fatua and Rumex dentatus in associated crops. Pak. J. Weed Sci. Res., 19: 31-43.

Anwar, T., S. Khalid, M. Saeed, R. Mazhar, H. Qureshi and M. Rashid.2016. Allelopathic interference of leaf powder and aqueous treatments of hostile weed: Parthenium hysterophorus (Asteraceae). Sci. Int., 4: 86-93.

Anwar, T., S. Khalid, R. Mazhar, H. Qureshi and M. Rashid. 2017a. Herbicidal potential of selected species to overcome weed infestation in Triticum aestivum, Zea mays and Helianthus annuus. Pak. J. Weed Sci. Res., 23: 49-63.

Anwar, T., S. Khalid, M.K. Panni, H. Qureshi and M. Rashid. 2017b. Allelopathic effect of Euphorbia helioscopia on Avena fatua, Rumex dentatus, Helianthus annuus, Zea mays and Triticum aestivum. Pak. J. Weed Sci. Res., 23: 165-177.

Anwar, T., N. Ilyas, R. Qureshi, M. Munazir, A. M. Khan, L. Ansari, B. Z. Rahim, K. A. Ansari, M. K. Panni. 2018. Allelopathic activity of solvent extracts of Rhazya stricta Decne. against selected weeds of wheat crop. Appl. Ecol. Environ. Res. 16(5):5405-5421.

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. 2002. Allelopathic effect of parthenin against two weedy species Avena fatua and Bidens pilosa. Environ. Exp. Bot., 47: 149-155.

Batish, D. R., Singh, H. P., Kaur, S. and Kohli, R. K. 2007. Root-mediated allelopathic interference of nettle-leaved goosefoot (Chenopodium murale) on wheat (Triticum aestivum). J. Agron. Crop Sci., 193: 37-44.

Cheema, Z. A. M. Farooq, and A. Wahid. 2013. Allelopathy: current trends and future applications. Springer, Verlag.

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

Datta, S. and D. B. Saxena. 2001. Pesticidal properties of parthenin (from Parthenium hysterophorus) and related compounds. Pest manag. sci., 57(1): 95-101.

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.

Fatima, N., M. Zia, R. Rsehman, Z. F. Rizvi, S. Ahmad, B. Mirza and M. F. Chaudhary. 2009. Biological activities of Rumex dentatus, extraction of methanol and hexane treatments. Afr. J. Biotechnol., 8 (24): 6945-6951.

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.

Jamil, M., Z. A. Cheema, M. N. Mushtaq, M. Farooq and M. A. Cheema. 2009. Alternative control of wild oat and canary grass in wheat fields by allelopathic plant water treatments. Agron. Sustain. Dev., 475-482.

Kadioglue, I., Y. Yanar and U. Asav. 2005. Allelopathic effects of weeds treatments against seed germination of some plants. J. Environ. Biol., 26(2): 169-173.

Khan, A. L., M. Hamayun, J. Hussain, H. Khan, S. A. Gilani, A. Kikuchi, K. N. Watanabe, E. H. Jung and I. J. Lee. 2009. Assessment of allelopathic potential of selected medicinal plants of Pakistan. Afr. J. Biotechnol., 8(6): 1024-1029.

Khan, T. D., I. M. Chung, S. Tawata and T. D. Xuan. 2006. Weed suppression by Passiflora edulis and its potential allelochemicals. Weed Res., 46: 296-303.

Labbafy, M. R., F. Maighany, A. Hejazy, H. Khalaj, A. M. Baghestany, I. Allahdady, and A. Mehrafarin. 2009. Study of allelopathic interaction of wheat (Triticum aestivum) and rye. (Secale cereal) using equal-compartment-agar method. Asian J. Agri. Sci.,1(2): 25-28.

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.

Mahbarjan, 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.

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.

Mishra, J. S., V. P. Singh and N. T. Yaduraju. 2006. Wild onion (Asphodelus tenuifolius Cav.) interference in lentil and chickpea crops and its management through competitive cropping. Weed Bio. Manag., 6(3): 151-156.

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

Mukhtar, I., S. Mushtaq, M. S. Haider and I. Khokhar. 2012. Comparative analysis of autotoxicity in Chenopodium album L., Parthenium hysterophorus L. and Rumex dentatus L. Pak. J. Phytopathol., 24(2): 85-89.

Narwal, S.S. 1994. Allelopathy in crop production. Scientific Publishers, Jodhpur. pp. 145.

Naseem, M., M. Aslam, M. Ansar and M. Azhar. 2009. Allelopathic effect of sunflower water extract on weed control and wheat productivity. Pak. J. Weed. Sci. Res., 15(1): 107-116.

Nekonam, M. S., H. Kraimmojeni, B. Sharifnabi, J. Razmjoo, H. Amini and F. Bahrami. 2014. Assessment of some medicinal plants for their allelopathic potential against redroot pigweed (Amaranthus retroflexus). J. Plant Prot. Res., 54: 90-95.

Ortega, A. and J. S. Pino. 1997. The volatile constituents of tropical fruits. II. Fruits of Carica species. Alimentaria, 35(286): 27-40.

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.

Picman, J. and A. K. Picman. 1984. Autotoxicity in Parthenium hysterophorus and its possible role in control of germination. Biochem. Syst. Ecol., 12: 287-297.

Ramsumair. A., V. Mlambo and C. H. O. Lallo. 2014. Effect of drying method on the chemical composition of leaves from four tropical tree species. Trop. Agric. (Trinidad). 91(3):178-186.

Regina, G. B., C. F. Reinhardtb, L. C. Foxcroftc and K. Hurlea. 2007. Residue allelopathy in Parthenium hysterophorus L.-Does parthenin play a leading role. Crop Prot., 26: 237-245.

Sajjan, A. S. and K. N. Pawa. 2005. 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.

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.

Tefera, T. 2002. Allelopathic effects of Parthenium hysterophorus treatments on seed germination and seedling growth of Eragrostis tef. J. Agron. Crop Sci., 188: 306-310.

Umer, A., Z. Yousaf, F. Khan, U. Hussain, A. Anjum, Q. Nayyab and A.Younas. 2010. Evaluation of allelopathic potential of some selected medicinal species. Afr. J. Biotechnol., 9(37): 6194-6206.

Weir, T. L., S. W. Park and J. M. Vivanco, 2004. Biochemical and physiological mechanisms mediated by allelochemicals. Curr. Opin. Plant Biol., 7: 472-479.

Wolf, R. B., G. F. Spencer and W. F. Kwolek. 1984. Inhibition of velvetleaf (Abutilon theophrasti) germination and growth by Benzyl isothiocyanate, a natural toxicant. Weed Science, 32: 612-615.

Zeng, R. S., A. A. U. Mallik and S. M. Luo. 2008. Allelopathy in sustainable agriculture and forestry. Springer, New York, USA.

Zhang, H., Z. Guo, N. Wu, W. Xu, L. Han, N. Li, and Y. Han. 2012. Two novel naphthalene glucosides and an anthraquinone isolated from Rumex dentatus and their antiproliferation activities in four cell lines. Molecules, 17: 843-850.