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*Full Length Research Paper*

# Management of parthenium weed by extracts and residue of wheat

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**This study was carried out to investigate the prospects of using methanolic extracts and residue of wheat (*Triticum aestivum* L.) for the management of parthenium (*Parthenium hysterophorus* L.), one of the world's worst weeds. In a laboratory bioassay, the effect of methanol extracts of 1, 2, 3, 4 and 5% (w/v) concentrations of four wheat varieties namely: AS 2002, Inqalab 91, Ufaq and Uqab was studied against the germination and seedling growth of parthenium. Extracts of all the four wheat varieties suppressed germination as well as root and shoot growth of the seedlings. In soil amendment bioassay, dried and chopped wheat straw of the four test wheat varieties was thoroughly mixed in pot soil at 0.5, 1.0 and 1.5% (w/w). Pots were irrigated with tap water and left for one week followed by sowing of seeds in these pots. The effect of residue incorporation of all the wheat cultivars was insignificant on germination of parthenium seeds. However, all the residue incorporation treatments significantly reduced the survival percentage of the parthenium seedlings. Root and shoot growth in terms of length, and fresh and dry biomass were also significantly suppressed by residues of all the four test wheat cultivars. This study concludes that parthenium weed can effectively be managed by amending the soil with wheat residue.**

**Key words:** Non-chemical weed control, parthenium, wheat residue.

## INTRODUCTION

Parthenium (*Parthenium hysterophorus* L.) is an annual invasive weed of the family Asteraceae. It is native to the subtropics of North and South America, and is now widely distributed in a number of tropical and subtropical countries of the world (Navie, 1996). It is notorious for its strong competitiveness for soil moisture and nutrients, allelopathic effects and the hazards it poses to humans and animals (Evans, 1997). In Pakistan, this weed is rapidly spreading in parts of Province Punjab, North Western Frontier Province and Kashmir, and replacing the local flora (Javaid and Anjum, 2005; Javaid et al., 2009). Some synthetic chemical herbicides are known to be very effective in controlling this weed (Javaid, 2007).

However, increasing public concern on environmental issues requires alternative weed management systems which are based on naturally occurring compounds (Javaid and Adrees, 2009).Wheat (*Triticum aestivum* L.) is one of the most important grain crops in the world. Wheat exhibit allelopathy and can chemically affect the growth of other plants by exuding secondary metabolites like phenolic and hydroxamic acids into the surrounding environment from living plants and the subsequent decomposition of wheat straw (Zhang et al., 2004). The exuded chemicals can inhibit weed growth and prevent infestation by insects and pathogens (Wu et al., 2001; Zuo et al., 2007). Allelopathic wheat has broad application potential in the areas of plant protection, environmental safety and crop resistance breeding (Kruse et al., 2000). There is a tremendous difference of allelopathic effects in various cultivars and genotypes of wheat against weeds (Zhang et al., 2006; Zuo et al., 2005). Studies regarding the role of wheat allelopathy in the management of parthenium weed are entirely lacking. This study was, therefore, designed to manage the parthenium weed by exploiting allelopathic potential of different varieties of wheat.

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**Table 1.** Analysis of variance for the effect of different concentrations of methanolic straw extracts of four wheat varieties on germination and growth of parthenium in laboratory bioassays.

| Trait | df | Mean squares | | |
|---|---|---|---|---|
| | | Germination | Shoot length | Root length |
| Treatments | 23 | 1303*** | 13.6*** | 42*** |
| Wheat var. (V) | 3 | 1754*** | 4.8 ns | 45* |
| Concentration (C) | 5 | 3815*** | 51.6*** | 122*** |
| V × C | 15 | 377* | 2.7 ns | 15 ns |
| Error | 72 | 189 | 2.8 | 14 |
| Total | 96 | | | |

*, ***, Significant at P ≤ 0.05 and 0.001, respectively; ns, not significant.

## MATERIALS AND METHODS

### Preparation of methanol extracts

Seeds of four wheat cultivars viz. AS 2002, Inqalab 91, Ufaq and Uqab were sown in field plots of 1.5 × 1.5 $m^2$ in Punjab University**,** Lahore. All the agronomic practices were carried out as recommended by Agriculture Department of Punjab, Pakistan. Plants were harvested at maturity and dried straw of each wheat cultivar was collected. Straw was chopped into small pieces of less than 1 cm in length. **20 g** dried and chopped straw of each wheat cultivar were soaked in 200 m**l** of methanol for two weeks. After two weeks**,** materials were passed through muslin cloth to separate the methanol from plant materials. Methanol was evaporated under vacuum in rotary evaporator at 45**°**C to yield 1.64, 1.73, 1.61 and 2.06 g residues of AS 2002, Inqalab 91, Ufaq and Uqab, respectively.

### Laboratory bioassays

To the earlier mentioned residue of each of the four wheat cultivars, distilled water was added to prepare 32.8, 34.6, 32.2 and 41.2 m**l** of 5% **(**w/v**)** solutions of AS 2002, Inqalab 91, Ufaq and Uqab, respectively. Lower concentrations of 4, 3, 2 and 1% **(**w/v**)** were prepared by adding appropriate quantities of distilled water to 5% stock solutions. In a laboratory bioassay, the effect of different concentrations of methanol extracts of different wheat varieties was studied on germination and early seedling growth of parthenium. **20** seeds of parthenium were placed in 9 cm diameter Petri plates lined with Whatman No. 1 filter papers moistened with 3 m**l** of different concentrations of each extract. Control treatment received the same amount of distilled water. Each treatment was replicated four times. Plates were incubated at 25°C in a growth room. After 10 days, seed germination, seedling root/shoot length and plant fresh biomass were determined.

### Soil amendment bioassay

Copped materials were mixed in sandy loam soil in plastic pots of 8 cm diameter and 4 cm deep, at 0.5, 1.0 and 1.5 g per 100 g of soil. Pots were irrigated with tap water and left for 10 days to release allelochemicals and begin decomposition. Ten seeds of parthenium were sown in each pot. Each treatment was replicated thrice. Data regarding germination was recorded one week after sowing. Plants were harvested 30 days after sowing and data regarding survival of plants, and root and shoot growth was recorded.

### Statistical analysis

All the data were analyzed by applying analysis of variance followed by Duncan's **multiple range test** to separate the treatment means (Steel and Torrie, 1980).

## RESULTS AND DISCUSSION

### Laboratory bioassays

Analysis of variance showed that the effect of wheat varieties and extract concentration was significant for germination and root length. The effect of concentration was also significant for shoot length. The interactive effect of varieties and concentration was, however, significant only for germination (Table 1).

In general, germination was reduced by increasing the extract concentration. Generally, the effect of lower concentrations of 1 and 2% was insignificant on germination, while extracts of 3% and higher concentrations significantly suppressed this parameter. Highest adverse effect on germination was recorded due to extracts of wheat var. Inqalab 91 where extracts of different concentrations reduced germination by 25 to 86%. Extracts of the other wheat varieties viz. AS 2002, Ufaq and Uqab reduced the germination by 15 to 38%, 8 to 45% and 18 to 66%, respectively (Table 2). All the concentrations of methanol extracts of the four wheat varieties significantly reduced shoot length. There was 39 to 59%, 33 to 42%, 26 to 48% and 30 to 47% reduction in shoot length due to various extract concentrations of AS 2002, Inqalab 91, Ufaq and Uqab, respectively (Table 2). Root length was also adversely affected by methanol extracts of various wheat varieties. The effect of extracts of Ufaq and Uqab was more pronounced as compared to the other two wheat varieties. All the extract concentrations of these two varieties significantly sup-pressed root length as compared to the control (Table 2). In earlier studies, generally, aqueous extracts of different wheat varieties were used, which significantly reduced the germination and seedling growth of different weed species (Liebl and

**Table 2.** Effect of different concentrations of methanol straw extracts of four wheat varieties on germination and seedling growth of parthenium in laboratory bioassays.

| Wheat variety | Extract concentration (% w/v) | Germination (%) | Shoot length (mm) | Root length (mm) |
|---|---|---|---|---|
| Control | 0 | 100$^{a}$ | 10.6$^{a}$ | 16.2$^{ab}$ |
| AS 2002 | 1 | 85$^{a-c}$ | 4.3$^{e}$ | 17.2$^{a}$ |
| | 2 | 69$^{a-e}$ | 4.8$^{de}$ | 10.2$^{bc}$ |
| | 3 | 62$^{b-g}$ | 5.8$^{c-e}$ | 10.8$^{bc}$ |
| | 4 | 69$^{b-f}$ | 6.1$^{c-e}$ | 11.0$^{bc}$ |
| | 5 | 70$^{b-f}$ | 6.5$^{c-e}$ | 9.5$^{c}$ |
| Inqalab 91 | 1 | 75$^{a-d}$ | 6.2$^{c-e}$ | 7.8$^{c}$ |
| | 2 | 69$^{a-e}$ | 7.0$^{b-d}$ | 10.9$^{bc}$ |
| | 3 | 37$^{f-i}$ | 7.0$^{b-d}$ | 9.7$^{c}$ |
| | 4 | 29$^{hi}$ | 6.5$^{c-e}$ | 9.9$^{c}$ |
| | 5 | 14$^{i}$ | 7.1$^{b-d}$ | 10.6$^{bc}$ |
| Ufaq | 1 | 83$^{a-c}$ | 5.6$^{c-e}$ | 8.0$^{c}$ |
| | 2 | 92$^{ab}$ | 5.8$^{c-e}$ | 7.0$^{c}$ |
| | 3 | 55$^{c-h}$ | 7.8$^{bc}$ | 9.5$^{c}$ |
| | 4 | 65$^{b-g}$ | 7.1$^{b-d}$ | 8.5$^{c}$ |
| | 5 | 66$^{b-g}$ | 5.5$^{c-e}$ | 6.8$^{c}$ |
| Uqab | 1 | 82$^{a-d}$ | 7.4$^{bc}$ | 8.5$^{c}$ |
| | 2 | 78$^{a-d}$ | 6.7$^{c-e}$ | 9.8$^{c}$ |
| | 3 | 40$^{e-i}$ | 5.8$^{c-e}$ | 6.7$^{c}$ |
| | 4 | 34$^{g-i}$ | 5.6$^{c-e}$ | 9.5$^{c}$ |
| | 5 | 49$^{d-h}$ | 5.7$^{c-e}$ | 9.0$^{c}$ |

In a column, values with different letters show significant difference ($P \leq 0.05$) as determined by Duncan's multiple range test.

Worsham, 1983; Rambakudzibga, 1991; Bertholdsson, 2005). A number of phytotoxic substances suspected to have allelopathic effects have been identified from wheat. Three main categories of allelochemicals, namely: phenolic acids (*p*-hydro-xybenzoic, vanillic, *p*coumaric, syringic and ferulic acids being most frequently reported and *trans*-ferulic and *trans*-*p*coumaric acids being the dominant acids), cyclic hydroxamic acids (a class of alkaloids) and short-chain fatty acids have been identified from wheat (Blum et al., 1992; Wu et al., 2000).

## Soil amendment bioassay

Analysis of variance revealed that the effect of wheat varieties was significant for germination, shoot and root length, and root fresh biomass. However, the effect of residue dose was significant for all the studied parameters of germination, and shoot and root growth. The interactive effect of wheat varieties and residue dose was significant for germination, survival of seedlings, root length and root fresh biomass (Table 3).

In general, the effect of residue incorporation was insignificant on germination as compared to the control. However, germination was markedly suppressed by residues of wheat var. AS 2002 (Table 4). The insignificant effect on germination could be attributed to the slow decomposition of wheat straw and release of allelochemicals in the beginning. In contrast to germination, survival of the seedlings was severely affected due to various wheat residue incorporation treatments. All the wheat varieties significantly reduced the survival percentage of parthenium seedlings to variable extent. The effect of wheat var. Uqab was most severe where seedlings survival was 0 to 12% followed by AS 2002, Inqalab 91 and Ufaq where survival was 0 to 36%, 0 to 50% and 0 to 58%, respectively, as compared to 100% in control. Residues of all the wheat varieties significantly suppressed root and shoot growth in terms of length and biomass of plants (Table 4). The reduced survival percentage and growth of parthenium seedlings in wheat straw amended treatments may be attributed to the release of allelochemicals viz. phenolic acids, cyclic hydroxamic acids and short-chain fatty acids in the

**Table 3.** Analysis of variance for the effect of different doses of residue incorporation of four wheat varieties on germination, survival and growth of parthenium in soil incorporation bioassay.

| Trait | df | Mean squares | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Germination | Survival | Shoot length | Shoot fresh weight | Shoot dry weight | Root length | Root fresh weight | Root dry weight |
| Treatments | 15 | 469*** | 2639*** | 2.9*** | 0.095*** | 0.004*** | 98*** | 30*** | 0.0003 $^{ns}$ |
| Wheat var. (V) | 3 | 1200*** | 147 $^{ns}$ | 0.67*** | 0.003 $^{ns}$ | 0.0005 $^{ns}$ | 34$^{***}$ | 29$^{***}$ | 0.0007 $^{ns}$ |
| Dose (D) | 3 | 300* | 12225*** | 12.7*** | 0.464*** | 0.02*** | 378*** | 34*** | 0.002*** |
| V × D | 9 | 281** | 275** | 0.4** | 0.003 $^{ns}$ | 0.0005 $^{ns}$ | 25*** | 30*** | 0.0006 $^{ns}$ |
| Error | 32 | 79 | 98 | 0.1 | 0.002 | 0.0003 | 5 | 0.83 | 0.0002 |
| Total | 48 | | | | | | | | |

*, **, ***, Significant at P ≤ 0.05, 0.01 and 0.001, respectively. ns, not significant.

**Table 4.** Effect of residue incorporation of four wheat varieties on germination, survival and growth of parthenium.

| Wheat variety | Residue dose (% /w) | Germination (%) | Survival (%) | Shoot length (cm) | Shoot fresh weight (g) | Shoot dry weight (g) | Root length (cm) | Root fresh weight (g) | Root dry weight (g) |
|---|---|---|---|---|---|---|---|---|---|
| Control | 0 | 70$^{a-c}$ | 100$^{a}$ | 2.3$^{a}$ | 0.66$^{a}$ | 0.079$^{a}$ | 12.8$^{a}$ | 0.65$^{a}$ | 0.027$^{a}$ |
| AS 2002 | 0.5 | 47$^{c}$ | 36$^{bc}$ | 0.8$^{c}$ | 0.10$^{bc}$ | 0.003$^{b}$ | 7.4$^{bc}$ | 0.11$^{b}$ | 0.010$^{b}$ |
| | 1.0 | 47$^{c}$ | 0$^{d}$ | 0.0$^{d}$ | 0.00$^{c}$ | 0.000$^{b}$ | 0.0$^{d}$ | 0.00$^{b}$ | 0.000$^{b}$ |
| | 1.5 | 60$^{a-c}$ | 0$^{d}$ | 0.0$^{d}$ | 0.00$^{c}$ | 0.000$^{b}$ | 0.0$^{d}$ | 0.00$^{b}$ | 0.000$^{b}$ |
| Inqalab 91 | 0.5 | 80$^{a}$ | 50$^{b}$ | 1.1$^{c}$ | 0.10$^{bc}$ | 0.050$^{ab}$ | 9.8$^{ab}$ | 0.10$^{b}$ | 0.010$^{b}$ |
| | 1.0 | 63$^{a-c}$ | 0$^{d}$ | 0.0$^{d}$ | 0.00$^{c}$ | 0.000$^{b}$ | 0.0$^{d}$ | 0.00$^{b}$ | 0.000$^{b}$ |
| | 1.5 | 63$^{a-c}$ | 0$^{d}$ | 0.0$^{d}$ | 0.00$^{c}$ | 0.000$^{b}$ | 0.0$^{d}$ | 0.00$^{b}$ | 0.000$^{b}$ |
| Ufaq | 0.5 | 40$^{c}$ | 58$^{b}$ | 1.7$^{d}$ | 0.16$^{b}$ | 0.050$^{ab}$ | 10.5$^{ab}$ | 0.12$^{b}$ | 0.005$^{b}$ |
| | 1.0 | 53$^{bc}$ | 18$^{cd}$ | 1.0$^{d}$ | 0.02$^{c}$ | 0.001$^{b}$ | 7.5$^{bc}$ | 0.03$^{b}$ | 0.001$^{b}$ |
| | 1.5 | 60$^{a-c}$ | 0$^{d}$ | 0.0$^{d}$ | 0.00$^{c}$ | 0.000$^{b}$ | 0.0$^{d}$ | 0.00$^{b}$ | 0.000$^{b}$ |
| Uqab | 0.5 | 73$^{ab}$ | 0$^{d}$ | 0.0$^{d}$ | 0.00$^{c}$ | 0.000$^{b}$ | 0.0$^{d}$ | 0.00$^{b}$ | 0.000$^{b}$ |
| | 1.0 | 77$^{a}$ | 0$^{d}$ | 0.0$^{d}$ | 0.00$^{c}$ | 0.000$^{b}$ | 0.0$^{d}$ | 0.00$^{b}$ | 0.000$^{b}$ |
| | 1.5 | 83$^{a}$ | 12$^{d}$ | 0.2$^{d}$ | 0.02$^{c}$ | 0.010$^{b}$ | 5.0$^{c}$ | 0.09$^{b}$ | 0.003$^{b}$ |

In a column, values with different letters show significant difference (P ≤ 0.05) as determined by Duncan's multiple range test.

rhizospheric soil (Blum et al., 1992; Wu et al., 2000). The most important hydroxamic acids reported in wheat are 2,4-dihydroxy-(2*H*)-1,4-benzoxazin-3(4*H*)-one (DIBOA) and 2,4-dihydroxy-7-methoxy-(2*H*)-1,4-benzoxazin-3(4*H*)-one (DIMBOA) (Macias et al., 2004, 2005). These compounds are present as glycosides in plant, and are being released as aglycones by the activity of the enzyme β-glucosidase. These aglycones are unstable in solution and soil, and are being transformed to 2-benzoxazolinone (BOA), 7-methoxy-2-benzoxazolinone (MBOA), and other degradation products. These transformations depend on the chemical and biological conditions. Some of these transformation products are more biologically active than the original ones (Friebe et al., 1998; Villagrasa et al., 2009).

Generally, the adverse effect of residue of wheat var. Uqab was more pronounced on parthenium growth as compared to the residues of the rest of the test wheat varieties (Table 4). The variable effects of residues of different wheat varieties on survival and growth of parthenium seedlings may be attributed to variation in allelopathic potential of different wheat varieties (Wu et al., 2003; Zuo et al., 2007). The varietal differences in allelopathy in wheat may be attributed to the difference in DIMBOA production in different wheat varieties. The concentration of DIMBOA ranged from 1.4 to 10.9 mmol $kg^{-1}$ fresh weight in 52 Chilean wheat varieties (Copaja et al., 1991), and from 0.99 to 8.07 mmol $kg^{-1}$ fresh weight in a worldwide collection of 47 wheat varieties (Nicol et al., 1992). The study concludes that wheat exhibit allelopathic potential against parthenium weed. However, the allelopathic potential was variable in different wheat varieties. Wheat var. Uqab was found to be the most allelopathic against parthenium. Further studies should be undertaken to evaluate the allelopathic potential of more wheat varieties against parthenium weed.

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