*Indian J. Plant Physiol.*, Vol. 15, No. 4, (N.S.) pp. 310-318 (Oct.-Dec., 2010)

# ALLELOPATHIC EFFECTS OF WEED SPECIES EXTRACTS ON SOME PHYSIOLOGICAL PARAMETERS OF WHEAT VARIETIES

**SARIKA, N. PANDEY[1] AND P.B. RAO**

Department of Biological Sciences, College of Basic Sciences & Humanities, G.B. Pant University of Agriculture & Technology, Pantnagar- 263 145 (U.S. Nagar, Uttarakhand)
[1]Department of Botany, Kumaun University, Nainital- 263 0002 (Uttarakhand)

Received on 1st April, 2010, Revised on 11th Oct., 2010

## SUMMARY

**Effect of aqueous extracts of *Ageratum conyzoides* L., *Chenopodium album* L., *Cynodon dactylon* (L.) Pers., *Melilotus alba* L., *Parthenium hysterophorus* L., *Phalaris minor* L. and *Solanum nigrum* L. were examined on seedling dry weight, chlorophyll (a, b and total), carotenoid and proline content; net photosynthetic rate, net transpiration rate and stomatal resistance in PBW-154, PBW-343, PBW-373, PBW-443, PBW-502, RR-21, UP-262, UP-1109, UP-2382 and UP-2425 varieties of wheat (*Triticum aestivum* L.). The extracts of all weeds except *C. dactylon* and *P. minor* significantly decreased the seedling dry weight in all the varieties. The per cent reduction in chl-a was 100 % of the varieties with *A. conyzoides* and *S. nigrum*; 90 % with both *C. dactylon* and *P. hysterophorus;* 80 % with *M. alba;* 70 % with *P. minor* and 30 % with *C. album.* But the percent reduction in chl-b was 80; 60; 50 and 20 per cent of the varieties with *A. conyzoides*, *M. alba* and *S. nigrum*; both *P. hysterophorus* and *P. minor*, *C. dactylon* and *C. album*, respectively. The proline content in different varieties was significantly increased with all weed extracts, except PBW-154 with *C. dactylon;* RR-21 with both *C. album* and *C. dactylon* and PBW-343, PBW-443 and UP-2382 with *C. dactylon*. The net photosynthetic rate (P) (µmol/$m^2$/s); net transpiration rate (E) (mM/$m^2$/s) and stomatal resistance (R) ($m^2$s/mol) decreased in different varieties with all weed extracts as compared to control. Results revealed that PBW-154, PBW-373, PBW-443 and UP-1109 were resistant and others were susceptible. The inhibitory effects of weed extracts on different varieties followed the order: *P. hysterophorus* > *M. alba* > *A. conyzoides* > *S. nigrum* > *C. album* > *P. minor* and > *C. dactylon*.**

*Key words:* **Allelopathy, physiological parameters, seedling growth, weed extracts, wheat**

## INTRODUCTION

Plants have an ability to accumulate a wide variety of low molecular weight constituents, resulting from long metabolic pathways, *i.e.*, the secondary metabolites (Harborne 1997). Plants produce a diverse nature of secondary metabolites (allelochemicals) that are released to the environment and can have biological effects on other organisms (Rice 1974). Weeds in crop fields not only pose strong competition for natural resources also utilize more efficiently and thus interfere with germination, growth, productivity and yield of crops. Allelochemicals are selective in their action and/or plants may be selective in their responses. Hejl *et al.* (1993) studied the allelopathic effects of *Juglans nigra*, Juglone, the principal allelopathin inhibited growth and net photosynthesis and reduced its chlorophyll content in *Lemna minor*. Yang *et al.* (2002) investigated the

*Corresponding author, E-mail: pasumartip658@gamil.com

effect of o-hydroxy phenylacetic, ferulic and p- coumaric acids on the chlorophyll supply orientation in the rice leaf (*Oriza sativa* CV. TN 67). As the phenolic concentrations increased, accumulation of chlorophyll and porphyrin contents reduced. Yu *et al.* (2003) reported that root exudates and aqueous root extracts of cucumber and its allelochemicals affected photosynthesis and antioxidant enzymes in cucumber. Leaf stomatal conductance, leaf transpiration and net assimilation rate were also reduced. Root peroxidase and super oxide dismutase activities increased significantly in cucumber, after exposure to allelopathic agents. In the present investigation, a laboratory study was carried to examine the effect of extracts of seven dominant weed species of Tarai region of Uttarakhand on certain physiological parameters in different varieties of wheat (*Triticum aestivum* L.).

## MATERIALS AND METHODS

The dominant weed species *i.e.*, *Ageratum conyzoides* L., *Chenopodium album* L., *Cynodon dactylon* (L.) Pers., *Melilotus alba* L., *Parthenium hysterophorus* L., *Phalaris minor* L. and *Solanum nigrum* L. were collected at the time of fruiting during 2006-07 from the crop fields of G.B. Pant Univ. of Agric. & Technology, Pantnagar. The extracts (10%, w/v) were prepared by soaking 10 g of crushed weed mass in 100 ml sterilized distilled water for 24 h at room temperature, filtered through Whatman filter paper and made a final volume of 100 ml by adding distilled water. Seeds of ten different varieties *i.e.,* PBW-154, PBW-343, PBW-373, PBW-443, PBW-502, RR-21, UP-262, UP-1109, UP-2382 and UP-2425 of wheat (*Triticum aestivum* L.) were obtained from Seed Production Centre (SPC), Pantnagar. Healthy and uniform seeds were selected and sterilized with 0.01 % $HgCl_2$ and washed thoroughly with distilled water. The seeds were placed in Petri dishes containing two blotting papers for each variety and moistened either with sterilized distilled water (control) or with aqueous extracts (treatment) of weeds and kept under laboratory conditions. At the end of experiment, three seedlings from each Petri dish (a total of nine seedlings) were randomly selected for measurement of seedling dry weight.

The chlorophyll (a, b and total) content from eight days old seedlings of different varieties of wheat both in control and treatment were estimated by using dimethyl sulphoxide (DMSO) extraction procedure given by Hiscox and Israelsham (1979). The Chl-a Chl-b and total chlorophyll content (mg/g fresh weight) was calculated according to the formula given by Arnon (1949). Carotenoid was estimated by using procedure given by Hiscox and Israelsham (1979). Proline content (μmol proline $g^{-1}$ fresh weight) from eight days old seedlings of different varieties of wheat both in control and treatment was estimated according to the procedure of Bates *et al*. (1973) on fresh weight basis. The photosynthetic rate ($\mu mol/m^2/s$), transpiration rate (mili $mol/m^2/s$) and stomatal resistance ($m^2$ s/mol) were estimated by using an open system, portable Infra Red Gas Analyzer (IRGA CID 301 P.S., U.S.A.) in the fore noon (10.00 AM to 12.00 noon) of 15 days old seedlings in both treatment and control.

Analysis of variance (ANOVA), least significant difference (LSD) and correlation were performed according to Snedecor and Cochran (1969).

## RESULTS AND DISCUSSION

### Seedling growth

The seedling dry weight (mg/seedling) in different varieties of wheat after eight days of growth was significantly decreased in all varieties with all weed extracts except *C. dactylon* (PBW-343, PBW-443, PBW-502, RR-21, UP-262, UP-1109, UP-2382 and UP-2425); *C. album* (RR-21) and *P. minor* (PBW-154, PBW-343, PBW-373, PBW-443, PBW-502 and UP-2382), in which it was increased. The per cent reduction was maximum in UP-2425 with *P. hysterophorus* (73.6) and minimum in PBW-154 with *C. dactylon* (1.3) (Table 1). The study showed conformity with the observation of Agarwal *et al.* (2000) who reported the allelopathic effect of *E. crusgalli, M. indica, P. minor* and straw of PD-4 extracts on 13 different varieties of wheat. The seedling dry weight of different varieties of wheat were significantly reduced when they grew in field soil previously infested with *A. conyzoides*

**Table 1.** Effect of different weed species extracts on total seedling dry weight (mg/seedling) and per cent reduction (percentage of control) in different varieties of *T. aestivum.*

| Varieties | Control | Weed species | | | | | | | LSD P<0.05 |
|---|---|---|---|---|---|---|---|---|---|
| | | ***A. conyzoides*** | ***C. album*** | ***C. dactylon*** | ***M. alba*** | ***P. hysterophorus*** | ***P. minor*** | ***S. nigrum*** | |
| PBW154 | 16.7 | **8.8** (47.1) | **12.6** (24.6) | 16.5(1.3) | **9.1** (45.5) | **5.6** (66.4) | 18.5 (+10.8) | **12.8** (23.4) | 3.64 |
| PBW343 | 15.5 | **5.6** (64.0) | **8.4** (45.9) | 16.9(+9.0) | **8.9** (42.5) | **4.9** (68.1) | **20.2** (+30.3) | 13.3 (13.9) | 3.14 |
| PBW373 | 15.7 | **7.3** (53.7) | **11.1** (29.2) | 14.4(8.77) | **8.4** (46.5) | **5.3** (66.5) | 18.3 (+16.6) | 14.7 (8.1) | 2.59 |
| PBW443 | 14.1 | **5.5** (60.9) | **7.7** (45.1) | 15.1 (+7.1) | **8.3** (40.9) | **5.0** (64.3) | **18.2** (+29.1) | **10.3** (27.0) | 2.99 |
| PBW502 | 14.4 | **9.3** (35.7) | **10.1** (29.6) | **17.5** (+21.5) | **8.5** (40.7) | **5.2** (63.6) | **17.7** (+22.9) | **11.1** (23.1) | 2.33 |
| RR-21 | 17.0 | **8.3** (51.3) | 19.5 (+14.7) | **22.3** (+31.2) | **9.4** (44.7) | **8.3** (51.1) | 16.5 (2.5) | **13.0** (23.5) | 3.98 |
| UP-262 | 18.6 | **8.3** (55.2) | 15.2 (18.5) | **24.0** (+29.0) | **8.9** (52.2) | **5.8** (68.7) | 15.5 (16.8) | **13.1** (29.5) | 3.58 |
| UP-1109 | 14.5 | **7.3** (49.7) | 13.4 (7.8) | **18.7** (+28.9) | **7.6** (47.6) | **5.5** (62.0) | 14.3 (1.7) | 13.5 (7.4) | 2.09 |
| UP-2382 | 12.8 | **6.2** (51.9) | **9.5** (25.4) | **18.5** (+34.5) | **9.5** (25.4) | **6.1** (52.4) | **15.3** (+19.5) | 12.3 (3.6) | 2.43 |
| UP-2425 | 17.5 | **8.1** (53.6) | 13.9 (20.6) | 19.0 (+8.6) | **9.7** (44.4) | **4.6** (73.6) | 15.3 (12.2) | 11.4 (34.9) | 3.62 |

Bold figures in the Table indicate significantly different from control.
+ indicate stimulation.

compared to control soil collected from an area devoid of this weed (Singh *et al.* 2003). Qasem and Hill (2006) recorded that the leachates *of C. album* significantly reduced total seedling dry weight of tomato shoots under laboratory conditions. In present study, the variety UP-2425 was susceptible and PBW-154 was resistant to different weed extracts. The LSD values at P<0.05 indicated that the differences between weed species extracts were significant as compared to control in all (100%) with *A. conyzoides, M. alba* and *P. hysterophorus* and 70%, 60%, 50% and 40% of the varieties with *C. album, S. nigrum, C. dactylon* and *P. minor*, respectively. The ANOVA values indicated that the differences between varieties, weed species, weed species × varieties were significant at P<0.01.

## Chlorophyll content

The Chl-a content (mg/g fresh weight) at the end of experiment was significantly reduced in all the varieties (100%) both with *A. conyzoides* and *S. nigrum* and 90% with both *C. dactylon* and *P. hysterophorus*; 80% with *M. alba*; 70% with *P. minor* and 30% with *C. album*. However, it was increased in rest of the varieties with different weed species extracts (Table 2). The per cent reduction was maximum in UP-2382 with *P. hysterophorus* (97) and minimum in PBW-343 with *C. dactylon* (2). The chl-a was positively correlated with seedling dry weight (P<0.05) only in PBW-373 ($r^2$ = 0.504), PBW-502 ($r^2$ = 0.627), RR-21 ($r^2$ = 0.470) and UP-2425 ($r^2$ = 0.523).

The Chl-b content of varieties was significantly reduced by 80% with *A. conyzoides* , *M. alba* and *S. nigrum*; 70% with *P. hysterophorus*; 60% with *P. minor*; 50% with *C. dactylon* and 20% with *C. album*. However, it was increased in rest of the varieties with different weed species extracts (Table 2). The per cent reduction was maximum in UP-2425 with *M. alba* (97) and minimum in UP-2425 with *P. minor* (1). The chl-b was positively correlated with seedling dry weight only in PBW-502 ($r^2$ = 0.759) and RR-21 ($r^2$ = 0.713) (P<0.01). Inderjit and Dakshini (1992) studied that water soluble compounds synthesized by weed, *Pluchea lanceolata* and released by it into the soil significantly reduced chl- a and b and chl- a : b ratio of bean plants.

**Table 2.** Effect of different weed species extracts on chlorophyll- a, -b and total (a + b) content (mg/g fresh weight) in different varieties of wheat.

| Varieties | Control | Weed species | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | *A. conyzoides* | *C. album* | *C. dactylon* | *M. alba* | *P. hysterophorus* | *P. minor* | *S. nigrum* |
| **Chl- a** | | | | | | | | |
| PBW154 | 0.20 | 0.07 (65) | 0.85 (+323) | 0.02 (92) | 0.31 (+53) | 0.03 (86) | 0.87 (+336) | 0.08 (62) |
| PBW343 | 0.44 | 0.09 (79) | 0.50 (+15) | 0.43 (2) | 0.45 (+3) | 0.99 (+129) | 0.85 (+95) | 0.04 (92) |
| PBW373 | 0.88 | 0.12 (87) | 0.98 (+11) | 0.39 (56) | 0.24 (73) | 0.06 (93) | 0.67 (24) | 0.69 (92) |
| PBW443 | 0.22 | 0.13 (41) | 0.73 (+236) | 0.54 (+148) | 0.16 (27) | 0.10 (56) | 0.64 (+195) | 0.05 (79) |
| PBW502 | 0.88 | 0.17 (81) | 0.52 (41) | 0.61 (31) | 0.13 (86) | 0.08 (91) | 0.73 (17) | 0.07 (93) |
| RR-21 | 1.02 | 0.20 (81) | 0.94 (7) | 0.41 (60) | 0.17 (83) | 0.07 (93) | 0.76 (26) | 0.04 (96) |
| UP-262 | 0.80 | 0.13 (84) | 0.80 (+0.1) | 0.19 (76) | 0.22 (72) | 0.08 (91) | 0.32 (60) | 0.03 (96) |
| UP-1109 | 1.01 | 0.19 (82) | 1.38 (+36) | 0.15 (85) | 0.11 (89) | 0.82 (92) | 0.77 (24) | 0.10 (91) |
| UP-2382 | 1.12 | 0.21 (81) | 0.34 (70) | 0.37 (67) | 0.16 (86) | 0.03 (97) | 0.37 (67) | 0.10 (91) |
| UP-2425 | 0.96 | 0.23 (76) | 1.09 (+13) | 0.64 (33) | 0.05 (95) | 0.15 (84) | 0.70 (28) | 0.07 (92) |
| **Chl- b** | | | | | | | | |
| PBW154 | 0.06 | 0.23(+312) | 1.07 (+399) | 0.28 (+385) | 0.19(+236) | 0.08 (+35) | 0.75 (+120) | 0.28(+384) |
| PBW343 | 0.32 | 0.25 (22) | 0.60 (+88) | 0.81 (+151) | 0.32 (2) | 2.35 (+632) | 0.82 (+157) | 0.20 (36) |
| PBW373 | 0.77 | 0.44 (43) | 1.14 (+49) | 0.80 (+4) | 0.11 (86) | 0.22 (72) | 0.69 (10) | 0.24 (69) |
| PBW443 | 0.12 | 0.15 (+28) | 0.91 (+681) | 0.98 (+741) | 0.10 (+19) | 0.23 (+95) | 0.75 (+540) | 0.14 (+16) |
| PBW502 | 0.77 | 0.25 (68) | 0.70 (9) | 1.00 (+300) | 0.06 (92) | 0.06 (92) | 0.84 (+9) | 0.17 (78) |
| RR-21 | 0.94 | 0.19 (80) | 1.16 (+24) | 0.72 (23) | 0.09 (90) | 0.21 (77) | 0.77 (18) | 0.21 (78) |
| UP-262 | 0.78 | 0.28 (64) | 0.98 (+25) | 0.43 (45) | 0.07 (91) | 0.19 (75) | 0.41 (48) | 0.14 (82) |
| UP-1109 | 1.06 | 0.28 (72) | 1.81 (+80) | 0.25 (75) | 0.04 (97) | 0.23 (77) | 0.96 (4) | 0.32 (69) |
| UP-2382 | 1.20 | 0.27 (75) | 0.51 (54) | 0.92 (16) | 0.07 (94) | 0.14 (87) | 0.59 (47) | 0.18 (83) |
| UP-2425 | 0.89 | 0.31 (65) | 1.37 (+54) | 0.84 (6) | 0.03 (97) | 0.45 (50) | 0.88 (1) | 0.30 (66) |
| **Total Chl- (a + b)** | | | | | | | | |
| PBW154 | 0.26 | 0.31 (+19) | 1.91 (+643) | 0.30 (+15) | 0.50 (+94) | 0.11 (59) | 1.62 (+530) | 0.36 (+38) |
| PBW343 | 0.76 | 0.34 (55) | 1.10 (+46) | 1.23 (+63) | 0.76 (+1) | 3.35 (+342) | 1.67 (+121) | 0.24 (68) |
| PBW373 | 1.65 | 0.56 (66) | 2.24 (+356) | 1.19 (28) | 0.35 (79) | 0.28 (83) | 1.37 (17) | 0.31 (81) |
| PBW443 | 0.33 | 0.28 (17) | 1.64 (+392) | 1.52 (+356) | 0.25 (24) | 0.33 (3) | 1.39 (+316) | 0.18 (46) |
| PBW502 | 1.65 | 0.41 (75) | 1.23 (26) | 1.61 (2) | 0.19 (89) | 0.14 (92) | 1.53 (7) | 0.24 (86) |
| RR-21 | 1.96 | 0.39 (80) | 2.11 (+8) | 1.14 (42) | 0.26 (87) | 0.29 (85) | 1.45 (26) | 0.24 (88) |
| UP-262 | 1.58 | 0.41 (74) | 1.77 (+13) | 0.63 (60) | 0.29 (81) | 0.27 (83) | 0.73 (54) | 0.17 (89) |
| UP-1109 | 2.02 | 0.47 (77) | 3.19 (+58) | 0.40 (80) | 0.18 (91) | 0.31 (84) | 1.74 (14) | 0.41 (80) |
| UP-2382 | 2.22 | 0.48 (78) | 0.85 (62) | 1.28 (42) | 0.23 (90) | 0.17 (92) | 0.96 (57) | 0.28 (87) |
| UP-2425 | 1.86 | 0.54 (71) | 2.46 (+33) | 1.48 (20) | 0.07 (96) | 0.60 (68) | 1.58 (15) | 0.38 (80) |

Values in parentheses indicate per cent reduction or stimulation (+) (percentage of control).

Suseelamma *et al.* (1992) observed that the chl- a and b decreased in first leaves of horse gram at higher concentration of extract of *Digera muricata*. The ANOVA values indicated that the difference between weed species was significant at P< 0.01.

The total chlorophyll (a + b) was significantly reduced in 90% of varieties each with *A. conyzoides, S. nigrum* and *P. hysterophorus*; 80% with *M. alba*; 70% both with *C. dactylon* and *P. minor;* and 20% with *C. album* (Table 2). However, it was increased in

PBW-154 with 86% of the extracts (*A. conyzoides, C. album, C. dactylon*, *M. alba, P. minor* and *S. nigrum*); PBW-343 with 71% (*C. album, C. dactylon, M. alba, P. hysterophorus* and *P. minor*); PBW-443 with 43% (*C. album, C. dactylon* and *P. minor*); PBW-373, UP-262, UP-1109 and UP-2425 with 14% (*C. album*) of extracts. The per cent reduction was maximum in UP-2425 with *M. alba* (96) and minimum in PBW-502 with *C. dactylon* (2). The total chlorophyll (a + b) was positively correlated to seedling dry weight in RR-21 ($r^2$ = 0.602) and UP-2425 ($r^2$ = 0.482) ($P<0.05$) and in PBW-502 ($r^2$ = 0.721) ($P<0.01$). Leaf residue of *Parthenium* reduced the dehydrogenase activity in roots, and chlorophyll a, b and total chlorophyll content in *Salvinia* (Pandey 1994). *Andrographis paniculata* aqueous extracts on cowpea (*Vigna unguiculata*) significantly inhibited seedling growth, chlorophyll a, total chlorophyll, total sugar, protein and soluble amino acid contents, but increased the phenol content (Deena *et al.* 2003). Qian *et al.* (2005) studied the allelopathic actions of *Artemisia annua* L. extract, which inhibited the growth and chlorophyll content in wheat seedlings. In the present study, ANOVA values indicated that the difference only between weed species was significant at $P< 0.01$. Among the varieties, PBW-154, PBW-343, PBW-443, UP-1109 and UP-2425 were resistant and susceptible in rest of the varieties.

## Carotenoid content

The carotenoid content (mg/g fresh weight) was significantly reduced in all varieties each with *A. conyzoides, C. album, M. alba, P. hysterpphorus, P. minor* and *S. nigrum* and nine with *C. dactylon*. However, it was increased in PBW-154 with *C. dactylon* in comparison to control (Table 3). The per cent reduction was maximum in PBW-502 with *M. alba* (98) and minimum in UP-2425 with *A. conyzoides* (26). Among the weed extracts, the per cent reduction was 90 % with *A. conyzoides, C. dactylon, P. minor* and *S. nigrum*; 80 % with *C. album* and *P. hysterophorus* and 10 % of the varieties with *M. alba*. The total carotenoid content was positively correlated with seedling dry weight in PBW-154 ($r^2$ = 0.473), PBW-502 ($r^2$ = 0.533) and UP-262 ($r^2$ = 0.495) ($P<0.05$). The ANOVA values indicated that the difference only between weed

**Table 3.** Effect of different weed species extracts on carotenoid content (mg/g fresh weight) in different varieties of wheat.

| Varieties | Control | Weed species | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | *A. conyzoides* | *C. album* | *C. dactylon* | *M. alba* | *P. hysterophorus* | *P. minor* | *S. nigrum* |
| PBW154 | 0.239 | 0.147 (39) | 0.075(69) | 0.317(+32) | 0.043(82) | 0.042(83) | 0.176(27) | 0.032(87) |
| PBW343 | 0.333 | 0.113 (66) | 0.162(51) | 0.166(50) | 0.081(76) | 0.012(96) | 0.182(45) | 0.012(96) |
| PBW373 | 0.288 | 0.206 (29) | 0.208(28) | 0.259(10) | 0.026(91) | 0.010(97) | 0.146(49) | 0.038(87) |
| PBW443 | 0.253 | 0.07 (72) | 0.054(79) | 0.198(22) | 0.013(95) | 0.015(94) | 0.143(44) | 0.008(97) |
| PBW502 | 0.268 | 0.172 (36) | 0.030(89) | 0.203(89) | 0.006(98) | 0.010(96) | 0.162(40) | 0.011(96) |
| RR-21 | 0.294 | 0.011 (96) | 0.018(94) | 0.070(76) | 0.010(97) | 0.064(78) | 0.167(43) | 0.012(96) |
| UP-262 | 0.276 | 0.03 (88) | 0.055(80) | 0.081(71) | 0.019(93) | 0.012(96) | 0.102(63) | 0.013(95) |
| UP-1109 | 0.237 | 0.172 (27) | 0.167(30) | 0.018(93) | 0.008(97) | 0.080(66) | 0.182(24) | 0.059(75) |
| UP-2382 | 0.310 | 0.049 (84) | 0.021(93) | 0.071(77) | 0.010(97) | 0.044(86) | 0.095(70) | 0.010(97) |
| UP-2425 | 0.180 | 0.132 (26) | 0.092(49) | 0.097(46) | 0.004(98) | 0.032(82) | 0.155(14) | 0.024(87) |

Values in parentheses indicate per cent reduction or stimulation (+) (percentage of control).

species was significant at P< 0.01. Among the varieties, PBW-154, PBW-373, UP-1109 and UP-2425 were the resistant and susceptible in rests of the varieties.

## Proline content

The proline content (µmol $g^{-1}$ fresh weight) in different varieties showed much variation among both varieties and weed extracts (Table 4). The proline content in different varieties of wheat was significantly increased (stimulated) with all the weed extracts, except PBW-154 with *C. dactylon;* RR-21 both with *C. album* and *C. dactylon* and PBW-343, PBW-443 and UP-2382 with *C. dactylon,* where it was reduced as compared to control. The per cent increase (stimulation) was maximum in UP-1109 (96) with *S. nigrum* and minimum in PBW-373 (11) with *C. dactylon*. Djanaguiraman *et al.* (2005) studied the physiological responses of *Eucalyptus globulus* leaf leachates and reported increased the proline content in rice, sorghum and blackgram. The ANOVA values indicated that the difference only between weed species was significant at P< 0.01. The proline content was positively correlated with seedling dry weight in PBW-154 ($r^2$ = 0.583), PBW-343 ($r^2$ = 0.742) and UP-262 ($r^2$ = 0.594) (P<0.05). Thus, the present study depicted that the variety UP-262 was susceptible and PBW-373 was resistant in terms of proline content. Among the extracts, *A. conyzoides* is the most deleterious and *C. dactylon* is least effective on different varieties compared to other weed species.

## Photosynthetic rate, transpiration rate and stomatal resistance

The net photosynthetic rate (P) (µ mol/$m^2$/s) was reduced in different varieties of wheat at the end of experiment (after 15 days) with all weed extracts (Table 5). The per cent reduction was maximum in PBW-443 with *P. hysterophorus* (93) and minimum in PBW-443 with *P. minor* (3). The net transpiration rate (E) (mili mol/$m^2$/s) was reduced in different varieties with all weed extracts. The per cent reduction was maximum in UP-1109 with *P. hysterophorus* (81) and minimum in PBW-373 with *C. dactylon* (12) (Table 5). The net stomatal resistance (R) ($m^2$s/mol) was also reduced in different varieties at the end of experiment with all extracts. The per cent reduction was maximum in UP-1109 with *P.*

**Table 4.** Effect of different weed species extracts on proline content (µmol proline $g^{-1}$ fresh weight) in different varieties of wheat.

| Varieties | Control | Weed species | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | *A. conyzoides* | *C. album* | *C. dactylon* | *M. alba* | *P. hysterophorus* | *P. minor* | *S. nigrum* |
| PBW154 | 6.35 | 39.83(+84) | 17.32(+63) | 5.77(9) | 23.37(+73) | 35.79(+82) | 15.29(+59) | 37.80(+84) |
| PBW343 | 4.61 | 72.15(+94) | 59.45(+92) | 3.46(25) | 21.06(+78) | 59.45(+92) | 10.53(+92) | 34.05(+87) |
| PBW373 | 4.61 | 69.26(+93) | 9.24(+50) | 5.19(+11) | 27.13(+85) | 12.70(+64) | 7.94(+64) | 41.99(+89) |
| PBW443 | 5.77 | 102.74(+94) | 10.39(+45) | 4.62(20) | 25.39(+78) | 16.16(+64) | 5.92(+64) | 30.16(+81) |
| PBW502 | 2.89 | 26.55(+89) | 16.74(+83) | 5.77(+50) | 18.76(+85) | 16.74(+83) | 8.95(+83) | 91.48(+97) |
| RR-21 | 6.35 | 20.20(+69) | 5.19(18) | 4.62(27) | 19.91(+68) | 18.47(+66) | 9.24(+66) | 40.98(+85) |
| UP-262 | 2.31 | 20.78(+89) | 2.89(+20) | 6.35(+64) | 29.73(+92) | 25.40(+91) | 15.04(91) | 32.03(+93) |
| UP-1109 | 2.31 | 38.67(+94) | 2.89(+20) | 4.62(+50) | 48.63(+95) | 16.16(+86) | 7.36(86) | 56.71(+96) |
| UP-2382 | 5.19 | 25.40(+80) | 5.19(0) | 4.62(11) | 13.28(+61) | 16.16(+68) | 7.79(68) | 77.92(+93) |
| UP-2425 | 2.31 | 46.18(+95) | 7.50(+69) | 9.81(+77) | 13.70(+83) | 20.20(+89) | 5.25(89) | 47.18(+95) |

Values in parentheses indicate per cent reduction or stimulation (+) (percentage of control).

**Table 5.** Effect of different weed species extracts on net photosynthetic rate (P), transpiration rate (E) and stomatal resistance (R) in different varieties of wheat.

| Varieties | Control | Weed species | | | | | | | LSD P<0.05 |
|---|---|---|---|---|---|---|---|---|---|
| | | *A. conyzoides* | *C. album* | *C. dactylon* | *M. alba* | *P. hysterophorus* | *P. minor* | *S. nigrum* | |
| **Net Photosynthetic rate (μ mol/m²/s)** | | | | | | | | | |
| PBW154 | 3.19 | **1.37** (57) | **1.26** (61) | **0.76** (76) | **0.98** (69) | **0.71** (78) | **0.47** (85) | **0.86** (73) | 1.174 |
| PBW343 | 3.35 | **0.65** (81) | **0.59** (82) | **1.33** (60) | **0.93** (72) | **0.57** (83) | 2.58 (23) | **1.08** (68) | 1.955 |
| PBW373 | 3.70 | **1.32** (64) | **0.43** (88) | **1.28** (65) | **0.74** (80) | **0.76** (80) | **0.68** (82) | **0.81** (78) | 0.751 |
| PBW443 | 3.33 | **0.44** (87) | **0.94** (72) | **1.03** (69) | **0.87** (74) | **0.22** (93) | 3.22 (3) | 1.92 (42) | 1.574 |
| PBW502 | 2.96 | **0.60** (80) | **0.96** (68) | **1.15** (61) | **0.80** (73) | **0.30** (90) | **1.09** (63) | **0.87** (71) | 0.694 |
| RR-21 | 3.98 | **1.34** (66) | **0.98** (75) | **1.25** (69) | **0.62** (84) | **0.34** (92) | 2.53 (36) | **1.28** (68) | 0.931 |
| UP-262 | 3.9 | **1.13** (71) | **1.40** (64) | **3.22** (17) | **1.22** (69) | **1.20** (69) | **1.42** (64) | **1.14** (71) | 1.105 |
| UP-1109 | 3.21 | **1.57** (51) | **1.07** (67) | **2.34** (27) | **0.66** (79) | **0.58** (82) | **1.58** (51) | **1.12** (65) | 0.847 |
| UP-2382 | 3.39 | **1.49** (56) | **1.31** (61) | **1.50** (56) | **0.93** (73) | **0.75** (78) | **1.64** (52) | **0.99** (71) | 0.976 |
| UP-2425 | 3.31 | **1.37** (59) | **0.86** (74) | **1.38** (58) | **1.01** (70) | **0.89** (73) | 2.29 (31) | **0.81** (76) | 1.123 |
| **Net Transpiration rate (mM/m²/s)** | | | | | | | | | |
| PBW154 | 1.34 | **0.31** (77) | **0.44** (67) | **0.41** (69) | 1.44 (22) | 1.01 (25) | **0.87** (35) | **0.72** (46) | 0.567 |
| PBW343 | 2.82 | **0.91** (68) | **0.74** (74) | **0.99** (65) | **0.97** (66) | **1.56** (45) | **0.99** (65) | **1.07** (60) | 0.812 |
| PBW373 | 1.68 | **0.98** (42) | 1.04 (38) | 1.48 (12) | 1.33 (21) | **0.84** (50) | 1.17 (30) | 1.04 (38) | 0.655 |
| PBW443 | 2.44 | **1.11** (55) | 1.52 (38) | **1.17** (52) | **1.28** (48) | **1.05** (57) | 1.53 (37) | **1.12** (54) | 1.077 |
| PBW502 | 1.85 | **1.33** (28) | **1.02** (45) | **1.21** (35) | **1.36** (27) | **0.86** (54) | **1.30** (30) | **1.20** (35) | 0.442 |
| RR-21 | 3.55 | **2.06** (42) | **1.48** (58) | 2.54 (29) | **1.68** (53) | **0.99** (72) | **1.48** (58) | **1.00** (72) | 1.431 |
| UP-262 | 3.74 | **1.75** (53) | **0.91** (76) | **1.18** (69) | **1.28** (66) | **0.87** (77) | **1.08** (71) | **1.26** (67) | 1.186 |
| UP-1109 | 3.34 | **1.38** (59) | **1.02** (69) | **1.58** (53) | **0.96** (71) | **0.62** (81) | **2.05** (39) | **1.42** (58) | 0.795 |
| UP-2382 | 2.84 | **1.36** (52) | **1.38** (51) | **1.86** (35) | **1.18** (59) | **0.68** (76) | **1.46** (49) | **1.67** (41) | 0.740 |
| UP-2425 | 2.71 | **1.80** (34) | **1.29** (52) | **1.88** (31) | **1.17** (57) | **0.83** (69) | 1.99 (27) | **1.28** (53) | 0.794 |
| **Stomatal resistance (m²s/mol)** | | | | | | | | | |
| PBW154 | 19.0 | **13.0** (32) | 14.33 (25) | 10.55 (44) | 10.44 (45) | 13.56 (29) | 17.0 (11) | 12.33 (35) | 13.986 |
| PBW343 | 30.0 | **19.8** (34) | 15.67 (48) | 13.67 (54) | 13.56 (55) | 13.88 (54) | 11.0 (63) | 18.44 (39) | 12.445 |
| PBW373 | 35.2 | **10.89** (69) | **12.67** (64) | **22.33** (37) | **19.33** (45) | **12.22** (65) | **11.11** (68) | **11.00** (69) | 9.411 |
| PBW443 | 35.56 | **17.56** (51) | **14.55** (59) | **14.89** (58) | **8.99** (75) | **8.89** (75) | **24.22** (32) | **18.56** (48) | 10.309 |
| PBW502 | 30.11 | **9.56** (68) | **9.44** (69) | **13.78** (54) | **8.89** (70) | **8.57** (72) | **13.44** (55) | **14.33** (52) | 6.916 |
| RR-21 | 42.33 | **19.78** (53) | **14.56** (66) | **19.67** (53) | **9.89** (77) | **9.00** (79) | **20.89** (51) | **14.11** (67) | 8.613 |
| UP-262 | 38.78 | **15.55** (60) | **9.22** (76) | **22.11** (43) | **14.78** (62) | **11.22** (71) | **22.33** (42) | **13.45** (65) | 11.483 |
| UP-1109 | 39.57 | **16.57** (58) | **12.00** (70) | **25.11** (36) | **10.00** (74) | **7.78** (80) | **18.56** (53) | **18.22** (54) | 9.700 |
| UP-2382 | 41.56 | **22.89** (45) | **19.0** (54) | **20.33** (51) | **13.67** (67) | **9.56** (77) | **23.33** (45) | **16.67** (60) | 7.161 |
| UP-2425 | 51.89 | **24.67** (52) | **10.89** (79) | **30.45** (41) | **13.67** (74) | **11.11** (79) | **21.56** (58) | **16.78** (68) | 7.106 |

Bold figures in the Table indicate significantly different from control..
Values in parentheses indicate per cent reduction (percentage of control).

*hysterophorus* (80) and minimum in PBW-154 with *P. minor* (11) (Table 5), which showed similarity with the observation of Deka *et al.* (2004). The rate of stomatal conductance and transpiration of *Raphanus sativus* were reduced by allelopathic compounds secreted by weed extracts - *Drymaria cordata* and *Oplimenus sp.* Nie *et al.* (2004) studied the allelopathic potential of aqueous extract of *Weedelia trilobata* on rice. The extract inhibited chlorophyll content, net photosynthetic rate, respiratory rate but increased the membrane permeability. The LSD values at $P< 0.05$ with different weed species extracts were significantly different when compared to control in all (PBW- 154, PBW-373, PBW-502, UP-1109 and UP-2382), six (PBW-343, RR-21, UP-262 and UP-2425) and five (PBW-443) of varieties in net photosynthesis; all (PBW-343, PBW-502,UP-262, UP-1109 and UP-2382), six (RR-21 and UP-2425), five (PBW-154 and PBW-443) and two (PBW-373) of varieties in net transpiration rate; and in all varieties except PBW-154 and PBW-343 for stomatal conductance. The ANOVA values indicated that the difference between varieties and weed species were significant at $P< 0.01$. The net photosynthetic rate and net transpiration rate were positively correlated with seedling dry weight in PBW-343 ($r^2 = 0.586$), PBW-443 ($r^2 = 0.658$) and UP – 262 ($r^2 = 0.524$); and only in UP-2425 ($r^2 = 0.526$) ($P<0.05$), respectively. Among the varieties, PBW-154, PBW-443 and UP-1109 were resistant in terms of photosynthetic rate, transpiration rate and stomatal resistance to different weed extracts and susceptible in rest of the varieties. Among the different weeds species, *P. hysterophorus* is the most deleterious and *P. minor* is least effective weed species compared to others.

## CONCLUSION

The experimental results clearly showed the influence of weed extracts on seedling dry weight, chlorophyll, carotenoid and proline contents, net photosynthetic rate, net transpiration rate and stomatal resistance on different varieties of wheat. It may be due to the presence of allelochemicals, particularly phenolics (Alssadawi and Rice 1982 a and 1982 b, Hussain *et al.* 1992, Chakraverty *et al.* 2005) and other secondary metabolites like growth regulators, alkaloids (Patterson 1981), terpenoids and toxins (Wu *et al*. 2000, Saxena *et al*. 2003). These allelochemicals significantly influenced all the physiological parameters along with protein content particularly the stress protein *i.e.,* proline which got increased in all the varieties with all the weed extracts. On the basis of results PBW-154, PBW-373, PBW-443 and UP-1109 varieties were grouped as resistant. Among the weed extracts, the inhibitory effect on different varieties of wheat on these parameters followed the order: *P. hysterophorus* > *M. alba* > *A. conyzoides* > *S. nigrum* > *C. album* > *P. minor* and > *C. dactylon*. Natural conditions are however, more complicated than laboratory bioassays, hence, field experiments are necessary before any final conclusions drawn on allelopathic effect of these weed species.

## ACKNOWLEGEMENTS

The authors are highly thankful to the unknown reviewers for their critical comments on the ms and also thankful to Dean, C.B.S. & H. and Dr. U.S. Singh, Department of Plant Pathology, G.B. Pant University of Agriculture & Technology, Pantnagar for providing necessary facilities during the study period.

## REFERENCES

Agarwal, A.R., Gahlot, A., Verma, R. and Rao, P.B. (2000). Influence of weed extracts on seedling growth of thirteen varieties of wheat. *Nature and Biosphere.* **5:** 17-26.

Alssadawi, I.S. and Rice, E.L. (1982a). Allelopathic effect of *Polygonum aviculare* (L.) Vegetational patterning. *J. Chem. Ecol.* **8:** 993-1009.

Alssadawi, I.S. and Rice, E.L. (1982b). Allelopathic effect of *Polygonum aviculare* (L.) Isolation, characterization and biological activities of phytotoxins. *J. Chem. Ecol.* **8:** 1011-1023.

Arnon, D.I. (1949). Copper enzymes in isolated chloroplasts: Polyphenoloxidases in *Beta vulgaris. Plant Physiology.* **24:** 1-15.

Bates, L.S., Waldren, R.P. and Teare, I.B. (1973). Rapid determination of free proline for water stressed studies. *Plant and Soil.* **39:** 205-207.

Chakraverty, S., Sharma, K., Kumar, S., Sand, N.K. and Rao, P.B. (2005). Effect of three weed extracts on nutrient uptake in different varieties of wheat through radio tracer technique and autoradiography. *In*: Gupta *et al.* (Eds.) 'Ecology and Environmental Management: Issues and Research needs'. *Bull. Nat. Inst. Ecology.* **15:** 171-180.

Deena, S., Rao, Y.B.N. and Sairaja, M. (2003). Effect of *Anderographis paniculata* aqueous extracts on cowpea (*Vigna ungiculata*). *J. Med. and Aromatic Plant Sci.* **25:** 369-374.

Deka, S.J., Ahmed, M. and Basumatary, S.K. (2004). Allelopathic effects of weed plants on germination and growth of seeds of crop plants. *Environ. and Ecol.* **22:** 781-783.

Djanaguiraman, M., Vaidyanathan, R., Sheeba, J.A., Devi, D.D. and Bangarusamy, U. (2005). Physiological responses of *Eucalyptus globulus* leaf leachate on seedling physiology of rice, sorghum and blackgram. *International J. Agric Biol* **7:** 35-38.

Harborne, J.B. (1997). Plant Secondary Metabolism. *In*: Crawley, M. J. (ed.): *Plant Ecology*. Oxford: Blackwell Science pp. 132-155.

Hejl, A.M., Einhilling, F.A. and Rasmussen, J.A. (1993). Effect of juglone on growth, photosynyhesis and respiration. *J. Chem. Eco.* **19:** 559-568.

Hiscox, J.D. and Israelsham, G.F. (1979). A method for extraction of chlorophyll from leaf tissue without maceration. *Can. J. Bot.* **57:** 1332-1334.

Hussain, F., Abidi, N., Ayaz, S. and Rahman, A. (1992). Allelopathic suppression of wheat and maize seedling growth by *Imperata cylindrica* (L.). *J. Agric.* **8:** 443-449.

Inderjit and Dakshini, K.M.M. (1992). Interference potential of *Pluchea lanceolata*: growth and physiological responses of asparagus bean. *Am. J. Bot.* **79:** 977-981.

Nie, C.R., Zeng, R., Luo, S., Li, H.S., Hong, M.Q. and Cheng, L.Q. (2004). Allelopathic potentials of *Weedelia trilobatai* L. on rice. *Acta-Agronomica-Sinica.* **30:** 942-946.

Pandey, D.K. (1994). Inhibition of *Salinia* by *Parthenium hysterophorus*. Effect of leaf residue and allelochemicals. *J. Chem. Eco*. **20:** 3111-3122.

Patterson, D.T. (1981). Effects of allelopathic chemicals on growth and physiological response of soybean (*Glycine max*). *Weed Sci.* **29:** 53-59.

Qasem, J.R. and Hill, T.A. (2006). Possible role of allelopathy in the competition between tomato, *Senecio vulgaris* L. and *Chenopodium album* L. *Weed Res.* **29:** 349-356.

Qian, J.R., Yan, M., Shou, W. and Qin, T.N. (2005). Preliminary study of Allelopathy mechanism of *Artimissia annua. Xibei-Zhiwz-Xuebao.* **25:** 1025-1028.

Rice, E.L. (1974). "Allelopathy". Academic Press, New York.

Saxena, S., Sharma K., Kumar, S., Sand N.K., and Rao, P.B. (2003). Effect of weed extracts on uptake of P and Zn in wheat varieties. *Allelopathy Journal*. **11:** 201-216.

Singh, H. P., Batish, D. R., Kaur, S. and Kohli, R. K. (2003). Phytotoxic interference of *Ageratum conyzoides* with wheat (*Triticum aestivum*). *J. Agron. Crop Sci.* **189:** 341-346.

Snedecor, G.W. and Cochran, W.G. (1969). *Stastistical Methods.* 6th ed. New Delhi: Oxford and IBH.

Suseelamma, M., Venkata, R.R., Tauro, P. and Narwal, S.S. (1992). Allelopathic effect of *Digera muricata* (L.) Mart. on the germination and early seedling growth of horse gram. Proceedings. First National Symposium. Allelopathy in agroecosystems, held at CCS Haryana Agriculture University, Hisar. 89-91.

Wu, H., Haig, T., Prately, J., Lemerle, D., An, M., Wu, H.W. and An, M. (2000). Distribution and exudation of allelochemicals in wheat. *J. Chem. Ecol.* **26:** 2141-2154.

Yang, C. M., Lee, C. and Chau, C.H. (2002). Effect of three allelopathic phenolics on chlorophyll accumulation of rice seedlings: Botanical Bulletin of Academia Sinica. **43:** 299-304.

Yu, J.Q., Ye, S.F., Zhang. M.F. and Hu, W.H. (2003). Effects of root exudates and aqueous extracts of cucumber and allelochemicals, on photosynthesis and antioxidant enzymes in cucumber. *Biochemical Systematics and Ecology.* **31:** 129-139.