PHOTOSYNTHETICA 35 (2): 265-268, 1998

BRIEF COMMUNICATION

The effect of irradiance on Hill reaction activity of atrazine-resistant and -susceptible biotypes of weeds

M. KÖRNEROVÁ*, D. HOLÁ* and D. CHODOVÁ**

*Department of Genetics and Microbiology, Faculty of Science, Charles University, Viničná 5, CZ-128 44 Praha 2, Czech Republic**
*Research Institute for Crop Production, CZ-161 06 Praha 6-Ruzyně, Czech Republic***

Abstract

Significantly lower Hill reaction activity together with greater sensitivity to photoinhibitory conditions was observed at various irradiances in atrazine-resistant biotypes of *Senecio vulgaris* L., *Amaranthus retroflexus* L., and *Poa annua* L. compared to the susceptible ones.

Additional key words: *Amaranthus retroflexus* L.; greenhouse and growth chamber; herbicides; photoinhibition; photosystem 2; *Poa annua* L.; *Senecio vulgaris* L.

The resistance of some weeds to triazine-based herbicides (*e.g.*, atrazine) results from the spontaneous $Ser^{264} \rightarrow Gly$ mutation of D1 protein of photosystem 2 (PS2). This mutation prevents binding of herbicide to the Q_B site of this protein, but at the same time it slows down the electron transport in PS2. Lower photosynthetic performance was reported for atrazine-resistant biotypes of weeds (Ort *et al.* 1983, Ireland *et al.* 1988, Jursinic and Pearcy 1988). These biotypes differently respond to low or high irradiance (Holt *et al.* 1981, Hart and Stemler 1990, Sundby *et al.* 1993) which can be due either to the direct effect of changes in PS2 structure or to different sensitivity of these biotypes to photoinhibition. Our previous studies (Kočová *et al.* 1988, Chodová and Mikulka 1992, Chodová *et al.* 1993, 1994, 1995) gave similar results. To compare the effects of various irradiances on atrazine-resistant and -susceptible biotypes we studied Hill reaction activity (AHR) of isolated chloroplasts in three weed species.

Atrazine-resistant and -susceptible biotypes of *Senecio vulgaris* L., *Amaranthus retroflexus* L., and *Poa annua* L. were grown either in the greenhouse (no additional

Received 30 April 1997, *accepted* 8 October 1997.
*E-mail: miromila@beba.cesnet.cz

irradiance) or in the growth chamber at irradiance 24 or 12 W m^{-2}. Air temperature averaged 20 °C, air humidity was 60-80 %. Four weeks-old plants (height 10-15 cm) were used for the measurements of AHR using the method of Kočová *et al.* (1988). The irradiance in the measurement chamber was 170 W m^{-2} PAR; but other irradiances (see Fig. 1) were also used.

Plants grown in the greenhouse generally displayed higher AHR values compared to those grown in the growth chamber. At all irradiances, resistant biotypes of *S. vulgaris*, *A. retroflexus*, and *P. annua* (Fig. 1) showed lower AHR compared to the susceptible ones; the differences were statisticaly significant. In each species, AHR gradually increased with increasing irradiance till reaching its limit at 170 W m^{-2}. The resistant and the susceptible biotype of *S. vulgaris* differed slightly more at lower PAR irradiances compared to the higher ones. Similar phenomenon was observed also in our previous studies (Chodová and Mikulka 1992, Chodová *et al.* 1995). In *A. retroflexus*, the differences in AHR between both biotypes first gradually increased with the growing irradiance, but remained constant from 170 W m^{-2} on. The differences between both biotypes of *P. annua* L. generally showed increasing tendency.

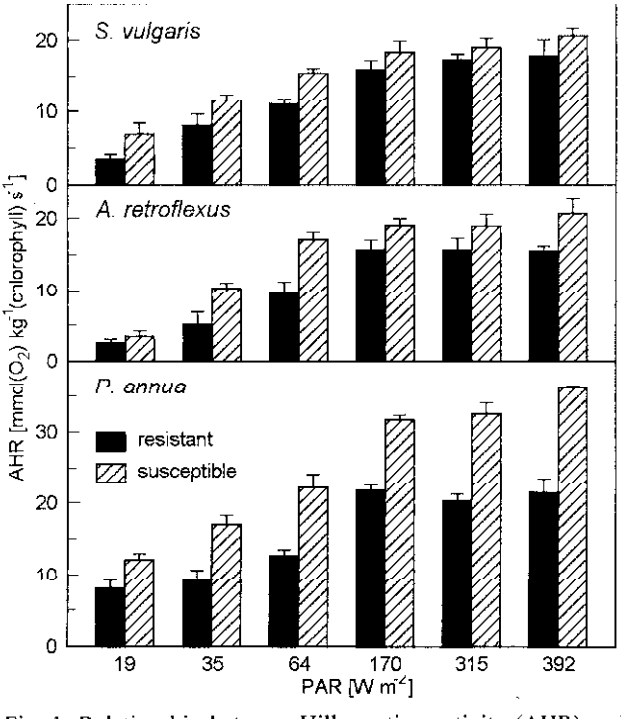

Fig. 1. Relationship between Hill reaction activity (AHR) and photosynthetically active radiation (PAR) in atrazine-resistant and -susceptible biotypes of *Senecio vulgaris* L., *Amaranthus retroflexus* L., and *Poa annua* L., grown in the greenhouse. Values are given ± SE ($n = 4$).

Analysis of AHR in chloroplasts isolated from plants grown at 24 or 12 W m^{-2} in the growth chamber revealed no differences for *S. vulgaris* or *P. annua*. Low

irradiance during plant growth probably has no significant effect on AHR in these species. As expected, plants of the resistant biotype of *A. retroflexus* grown at 24 W m^{-2} displayed lower AHR compared to the susceptible biotype. However, the situation was reverse for plants grown at irradiance 12 W m^{-2} (Table 1). *A. retroflexus* as C_4 plant probably cannot display full photochemical activity in such conditions - a phenomenon which is more prominent in the susceptible biotype than in the mutant, resistant one. Low irradiance can thus result even in a reversion of standard relationship between these biotypes.

Table 1. The Hill reaction activity (AHR) values [mmol(O_2) kg^{-1}(chlorophyll) s^{-1}] in atrazine-resistant (Res.) and -susceptible (Susc.) biotypes of *Senecio vulgaris* L., *Amaranthus retroflexus* L. and *Poa annua* L. grown in the growth chamber at irradiance 24 (*A*) or 12 (*B*) W m^{-2}. In each species, AHR was measured immediately after the isolation of chloroplasts; in addition to this, the plants of *P. annua* were also exposed to 60 or 90 min of photoinhibitory treatment prior to AHR measurements. Values are given ± SE; the number of AHR measurements is in parentheses.

Biotype	*Senecio vulgaris*	*Amaranthus retroflexus*	*Poa annua* 0	60	90
Res. (*A*)	3.40 ± 0.23 (5)	14.50 ± 0.46 (4)	17.45 ± 0.41 (2)	20.73 ± 0.67 (2)	18.08 ± 0.73 (2)
Susc. (*A*)	10.17 ± 0.38 (2)	18.23 ± 0.17 (4)	23.78 ± 0.77 (2)	24.70 ± 0.50 (4)	23.78 ± 0.70 (3)
Res. (*B*)	3.90 ± 0.20 (4)	13.28 ± 0.34 (4)	16.94 ± 0.36 (2)	12.98 ± 0.87 (2)	15.02 ± 0.43 (4)
Susc. (*B*)	10.46 ± 0.38 (2)	10.61 ± 0.36 (4)	22.40 ± 0.77 (2)	25.08 ± 1.09 (2)	18.98 ± 0.56 (3)

For the photoinhibitory treatment, whole plants of both biotypes of *P. annua* grown at 24 or 12 W m^{-2} (see above) were placed in the irradiation chamber for photosynthesis measurements in leaf discs (Šetlík *et al.* 1967) and irradiated by 500 W m^{-2} PAR for 60 or 90 min at constant temperature 25 °C and 1 % v/v CO_2 immediately before the isolation of chloroplasts. Sufficient water supply was maintained during the exposition of plants to the high irradiance. Photoinhibitory treatment had no decreasing effect on AHR of the plants grown at normal irradiance. On the contrary, AHR of both biotypes grown at low irradiance significantly decreased after 60 (resistant biotype) or 90 (susceptible biotype) min exposure of the plants to the high irradiance (Table 1). Similarly, Sundby *et al.* (1993) found higher response to photoinhibition in both atrazine-resistant and -susceptible biotypes of *Brassica napus* L. grown at low irradiance compared to plants grown at high irradiances. Hart and Stemler (1990) also reported higher susceptibility to photoinhibition for atrazine-resistant biotype of *B. napus*. Our results show that both high and low irradiances affect AHR of atrazine-resistant and -susceptible biotypes of weeds, depending on the plant species.

References

Chodová, D., Mikulka, J.: Comparing some biological and physiological differences of susceptible and resistant common groundsel. - Ochrana Rostlin (Praha) **28**: 263-272, 1992.

Chodová, D., Mikulka, J., Kočová, M.: Different growth of two biotypes of common groundsel grown in natural climatic conditions. - Rostlinná Výroba (Praha) **39**: 889-894, 1993.

Chodová, D., Mikulka, J., Kočová, M.: Comparison of chlorophyll fluorescence and chlorophyll content in triazine resistant and susceptible common groundsel. - Ochrana Rostlin (Praha) **31**: 185-194, 1995.

Chodová, D., Mikulka, J., Kočová, M., Janáček, J.: Different growth and photosynthetic efficiency of triazine resistant and susceptible biotypes of *Poa annua* L. - Biol. Plant. **36**: 341, 1994.

Hart, J.J., Stemler, A.: Similar photosynthetic performance in low light-grown isonuclear triazine-resistant and -susceptible *Brassica napus* L. - Plant Physiol. **94**: 1295-1300, 1990.

Holt, J.S., Stemler, A.J., Radosevich, S.R.: Differential light responses of photosynthesis by triazine-resistant and triazine-susceptible *Senecio vulgaris* biotypes. - Plant Physiol. **67**: 744-748, 1981.

Ireland, C.R., Telfer, A., Covello, P.S., Baker, N.R., Barber, J.: Studies on the limitations to photosynthesis in leaves of the atrazine-resistant mutant of *Senecio vulgaris* L. - Planta **173**: 459-467, 1988.

Jursinic, P.A., Pearcy, R.W.: Determination of the rate limiting step for photosynthesis in a nearly isonuclear rapeseed (*Brassica napus* L.) biotype resistant to atrazine. - Plant Physiol. **88**: 1195-1200, 1988.

Kočová, M., Chodová, D., Mikulka, J.: [Use of Hill reaction activity to distinguish between atrazine-resistant and -susceptible biotypes of weeds.] - Agrochémia **31**: 87-90, 1988. [In Czech.]

Ort, D.R., Ahrens, W.H., Martin, B., Stoller, E.W.: Comparison of photosynthetic performance in triazine-resistant and susceptible biotypes of *Amaranthus hybridus*. - Plant Physiol. **72**: 925-930, 1983.

Šetlík, I., Avratovščuková, N., Křítek, J.: An annular irradiation chamber for photosynthesis measurements in leaf discs. - Photosynthetica **1**: 89-95, 1967.

Sundby, C., Chow, W.S., Anderson, J.M.: Effects on photosystem II function, photoinhibition, and plant performance of the spontaneous mutation of serine-264 in photosystem II reaction center D1 protein in triazine-resistant *Brassica napus* L. - Plant Physiol. **103**: 105-113, 1993.