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Mutant Weeds of Iowa: V. S-triazine Resistant *Setaria faberi* Herrm.[1]

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S-triazine resistance in giant foxtail (*Setaria faberi* Herrm.) has been reported previously, but not in the midwestern U.S. corn belt or Iowa. A study was conducted using a chlorophyll fluorescence assay to confirm the presence of resistance in one *S. faberi* population in Iowa. Variable chlorophyll fluorescence assays confirmed that a population of this species with this type of resistance exists in Iowa. This is the first report of s-triazine resistance in *S. faberi*, and the fourth species with this type of herbicide resistance, found in an Iowa agroecosystem.
INDEX DESCRIPTORS: foxtail, herbicide resistance, atrazine, *Setaria*

S-triazine resistance in higher plants was first discovered in 1968 in *Senecio vulgaris* L. by Ryan (1970). Subsequent studies revealed that this type of herbicide resistance was a consequence of reduced herbicide binding to the 32kD chloroplast protein, D-1, in the resistant (R) biotype (Pfister et al. 1981; Steinback et al. 1981). S-triazine herbicides act by binding to the D-1 protein in the chloroplast thylakoid membranes and thereby inhibiting photosynthetic electron transport. Chlorophyll fluorometry is an intrinsic probe of photosystem II function (Krause and Weis 1984). When s-triazine herbicides bind to the D-1 protein and block electron transport, light energy absorbed by chloroplasts is quickly re-emitted as fluorescence. The relative strength of the fluorescence signal is an ideal indicator of s-triazine susceptibility and resistance.

S-triazine resistance has been reported previously in *S. faberi* (Ritter et al. 1989) at several locations, but not in Iowa. This type of herbicide resistance has been confirmed in three other plant species in Iowa: common lambsquarters (*Chenopodium album* L.) (Dekker and Burmester 1989); Pennsylvania smartweed (*Polygonum pensylvanicum* L.) (Dekker et al. 1991); and kochia (*Kochia scoparia* (L.) Schrad.) (Dekker et al. 1987). The objective of this study was to determine whether a population of *S. faberi* discovered in an Iowa agricultural field with a history of continuous s-triazine use possessed s-triazine resistance. We provide evidence that this population is s-triazine resistant.

MATERIALS AND METHODS

The putative R *S. faberi* plants evaluated in this study came from plants gathered in one 60 acre field. This central Iowa field was located near Pella in Marion County, and had been cropped continuously with corn (*Zea mays* L.) for at least 20 years by two members of the same family. Atrazine (6-chloro-*N*-ethyl-*N'*-(1-methylethyl)-1,3,5-triazine-2,4-diamine) had been applied at ca. 3.3 kg/ha active ingredient in every year from 1974-1989, except in 1987 and 1988. EPTC (s-ethyl dipropyl carbamothioate) plus dichlormid (2,2-dichloro-N,N-di-2-propenylacetamide) was applied in 1987 and Alachlor [2-chloro-N-(2',6'-diethylphenyl)-N-(methoxymethyl) acetamide] plus Atrazine (6-chloro-*N*-ethyl-*N'*-(1-methylethyl)-1,3,5-triazine-2,4-diamine). Both S and R plants of *S. faberi* were established from seed. Leaf disks showing no evidence of senescence or injury were taken from fully expanded leaves just prior to analysis. Leaf disks were analyzed with variable chlorophyll *a* fluorescence (VCF) methodologies reported previously (Ahrens et al. 1981; Ali and Souza Machado 1981; Truelove and Hensley 1982) and as modified by Dekker et al. (1991). Briefly, two 8 mm disks were taken, both from one leaf of each plant of each biotype (R, S). Both leaf disks were placed in separate dishes containing a phosphate buffer solution (pH 7.5). VCF measurements were made after the disks in the dishes were incubated in the dark for 10 min. After the initial VCF measurement, one leaf disk from each plant was treated by placing them in a 1 x 10^{-4} M atrazine (technical grade) and phosphate buffer solution. The other (untreated) leaf disk from the same leaf remained in phosphate buffer solution. VCF evaluations were made just prior to treatment and again at 203 min after treatment. Between these evaluations the disks were maintained under metal halide lights providing light of ca. 300 μmol quanta m^{-2} s^{-1}. Due to the consistent fluorescence yield of similar tissue under similar experimental conditions, the data presented represent the set of disks of each biotype.

RESULTS AND DISCUSSION

Several consistent changes in VCF occurred due to genotype and herbicide treatment. Untreated R and S leaf disks showed VCF yields typical of uninhibited tissues (Fig. 1). The higher fluorescence onset (F_o), peak fluorescence (F_p) and F_v/F_p (F_v, variable fluorescence) data (Krause and Weis 1984) found in the R disks relative to that in the S disks is consistent with previous observations of less efficient electron transport in the R biotype (Arntzen et al. 1979; Burke et al. 1982; Dekker and Westfall 1987a, b). When disks were incubated for 203 min in light and atrazine, the S tissue VCF yields (F_p, F_v/F_p) (Fig. 2) were greater than VCF yields before treatment with s-triazine. This change in VCF yield in S response to atrazine is consistent with blocked electron transport in the chloroplast. This is definitive evidence of s-triazine susceptibility. VCF yields observed in R disks were similar in both the control and atrazine treated disks, before and after treatment (Fig. 3). This similarity in VCF (F_p, F_v/F_p) (Fig. 3) in the

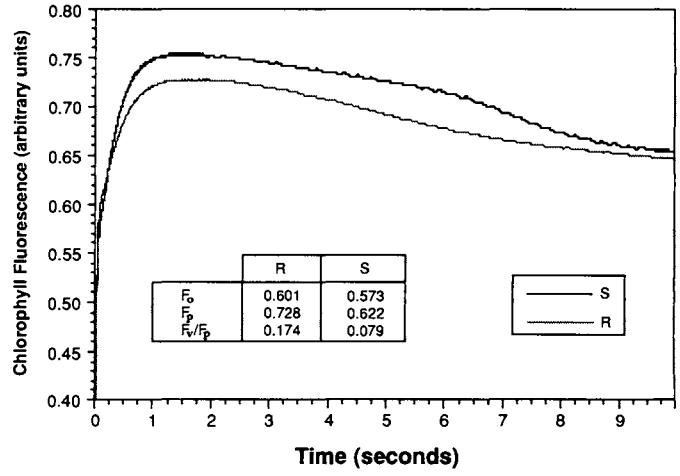

Fig. 1. Relative chlorophyll fluorescence (arbitrary units) with time (seconds) from s-triazine susceptible (S) and resistant (R) *Setaria faberi* leaf disks at the start of the experiment, before treatment with atrazine. F_o, onset of variable fluorescence; F_p, peak fluorescence; F_v, variable fluorescence.

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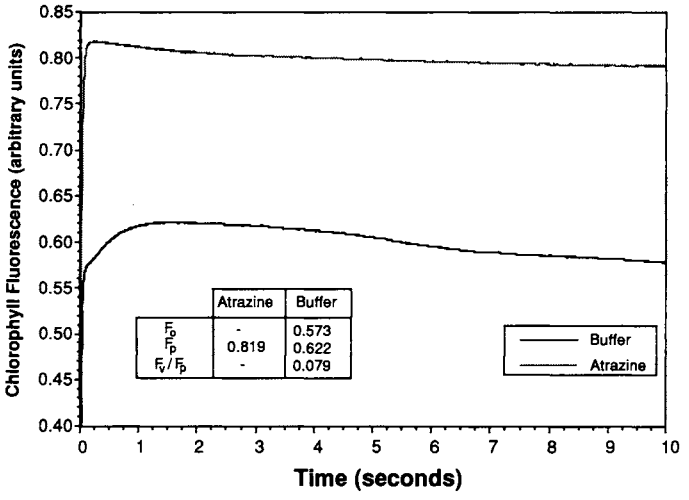

Fig. 2. Relative chlorophyll fluorescence (arbitrary units) with time (seconds) from s-triazine susceptible (S) *Setaria faberi* leaf disks treated with (10^{-4} M plus buffer) and without atrazine (buffer only) for 203 min. in the light. F_o, onset of variable fluorescence; F_p, peak fluorescence; F_v, variable fluorescence.

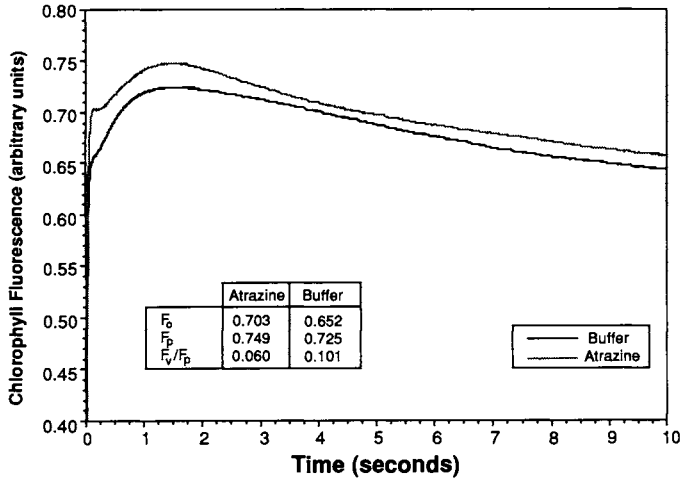

Fig. 3. Relative chlorophyll fluorescence (arbitrary units) with time (seconds) from s-triazine resistant (R) *Setaria faberi* leaf disks treated with (10^{-4} M plus buffer) and without (buffer only) atrazine for 203 min. in the light. F_o, onset of variable fluorescence; F_p, peak fluorescence; F_v, variable fluorescence.

presence and absence of atrazine is evidence in support of an altered herbicide binding site associated with s-triazine resistance (Pfister et al. 1981; Steinback et al. 1981).

The R *S. faberi* plants were found in an agricultural field with a minimum of 20 years of continuous corn production and the use of atrazine in 15 of those years. This observation is consistent with previous reports of R weeds appearing in fields in which weed flora are subjected to continuous s-triazine herbicide selection pressure. This is the first evidence of R in *S. faberi* in Iowa or in the midwestern corn belt. This is also the first instance of a grassy R weed in these agroecosystems. This report is the fifth in a series (Dekker and Burmester 1987; Dekker and Dekker 1987; Dekker et al. 1987, 1991).

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REFERENCES

AHRENS, W.H., C.J. ARNTZEN, and E.W. STOLLER. 1981. Chlorophyll fluorescence assay for determination of triazine resistance. Weed Sci. 29:316-322.

ALI, A. and V. SOUZA MACHADO. 1981. Rapid detection of 'triazine' resistant weeds using chlorophyll fluorescence. Weed Res. 21:191-197.

ARNTZEN, C.J., C.L. DITTO and P.E. BREWER. 1979. Chloroplast membrane alteration in triazine resistant *Amaranthus retroflexus* biotypes. Proc. Natl. Acad. Sci. USA 76:278-282.

BURKE, J.J., R.F. WILSON, and J.R. SWAFFORD. 1982. Characterization of chloroplasts isolated from triazine-susceptible and triazine-resistant biotypes of *Brassica campestris* L. Plant Physiology 70:24-29.

DEKKER, J. and R. BURMESTER. 1989. Mutant weeds of Iowa: S-triazine resistant plastids in *Chenopodium album* L. Journal of the Iowa Academy of Science 96:61-64.

DEKKER, J., R. BURMESTER, K.C. CHI, and L. JENSEN. 1987. Mutant weeds of Iowa: S-triazine-resistant plastids in *Kochia scoparia*. Iowa State Univ. J. of Res. 62:183-188.

DEKKER, J., R. BURMESTER, and J. WENDEL. 1991. Mutant weeds of Iowa: IV. S-triazine resistant *Polygonum pensylvanicum* L. Weed Technology 5:211-213.

DEKKER, J. and R.G. DEKKER. 1987. Mutant weeds of Iowa. Fasciation in *Taraxacum officinale*. Phytologia 63:155-156.

DEKKER, J. and B. WESTFALL. 1987a. Circadian oscillations in chlorophyll fluorescence in a triazine-resistant chronomutant of *Brassica napus*, pp. 81-93. In J.E. PAULY and L.E. SCHEVING (eds.). Progress in clinical and biological research. Advances in Chronobiology, Pt. A. Alan R. Liss, Inc., New York.

DEKKER, J. and B. WESTFALL. 1987b. A temporal phase mutation of chlorophyll fluorescence in triazine-resistant *Brassica napus*. Z. Naturforsch 42c:135-138.

KRAUSE, G.H. and E. WEIS. 1984. Chlorophyll fluorescence as a tool in plant physiology. II. Interpretation of fluorescence signals. Photosynth. Res. 5:139-157.

PFISTER, K., K. STEINBACK, G. GARDNER, and C. ARNTZEN. 1981. Photoaffinity labeling of a herbicide receptor protein in chloroplast membranes. Proc. Natl. Acad. Sci. USA 78:981-985.

RITTER, R.L., L.M. KAUFMAN, T.J. MONACO, W.P. NOVITSKY, and D.E. MORELAND. 1989. Characterization of triazine-resistant giant foxtail (*Setaria faberi*) and its control in no-tillage corn (*Zea mays*). Weed Sci. 37:591-595.

RYAN, G.F. 1970. Resistance of common groundsel to simazine and atrazine. Weed Sci. 18:614-616.

STEINBACK, K., L. McINTOSH, L. BOGORAD, and C. ARNTZEN. 1981. Identification of the triazine receptor protein as a chloroplast gene product. Proc. Natl. Acad. Sci. USA 78:7463-7467.

TRUELOVE, B. and J.R. HENSLEY. 1982. Methods of testing for herbicide resistance, pp. 117-131. In H.M. LeBaron and J. Gressel (eds.). Herbicide resistance in plants. Wiley-Interscience, New York.