Uptake, Translocation, and Metabolite Partitioning of $^{14}$C-Labeled Metribuzin in Plant Growth-Regulated Soybean (*Glycine max*)

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Abstract. Plant growth regulator (PGR) application decreased uptake of $10^{-6}$ M $^{14}$C-labeled metribuzin (4-amino-6-(1,1-dimethylethyl)-3-(methylthio)-1,2,4-triazin-5(4H)-one) into leaf interveinal areas of 21-day-old soybean seedlings. BAS 140 810, (N-allyl-N-2-(2,4,6-trichlorophenoxy)ethyl-piperidinium-bromide), as a seed treatment or $10^{-6}$ M triapenthenol or RSW 0411 (B-(cyclohexaimethylene)-gamma-(1,1-dimethylethyl)-1H-1,2,4-triazole-1-ethanol) in nutrient solution slowed interveinal unloading of metribuzin and altered metabolite pools. Stems and roots of MR-treated plants exhibited significantly greater water-soluble metabolite pools than untreated controls. TLC metabolite identification indicated an increase in metribuzin conjugates. This may contribute to the mode of action involved in the apparent safening mechanism. Furthermore, floating leaf disk studies with metribuzin showed plant growth regulation figured prominently in safening against the cessation of oxygen evolution.

Genetically defined tolerance to metribuzin (Souza-Machado et al. 1978, Edwards et al. 1976) resides in the ability of the plant to detoxify the herbicide moiety before it reaches the chloroplast (Souza-Machado and Ditto 1982). Recently, however, Vavrina and Phatak (1986) and Vavrina (1986) have shown that even susceptible soybean cultivars received some safening against metribuzin injury after treatment with plant growth regulators (PGR). Differential rates of metribuzin metabolism appear to determine intraspecific soybean tolerance; polar metabolites play the major role (Falb and Smith 1984, Mangeot et al. 1979). Frear et al. (1985) have identified a homoglutathione-metribuzin conjugate as the major polar metabolite in soybean; in tomato, a beta-D-(N-glucoside) conjugate appears the dominant moiety (Frear et al. 1983). Phatak et al. (1985) have shown that the growth regulator daminozide (butanedioic acid...
mono (2,2-dimethylhydrazide) applied foliarly in potato (Solanum tuberosum L.) can safely against metribuzin injury while correspondingly increasing plant-soluble solids.

The objective of this study was to characterize the uptake, translocation, and metabolite partitioning in 14C metribuzin-treated soybean seedlings previously treated with PGRs. A metribuzin-tolerant soybean cultivar, Braxton, was used to determine possible alterations in the genetically defined tolerance of soybean to metribuzin.

Materials and Methods

Greenhouse studies were conducted in Athens and Griffin, Georgia (1985, 1986), with certified Braxton soybean seed obtained from the Georgia Seed Development Commission. The use of the tolerant variety Braxton insured the survival of plants after the application of metribuzin in the greenhouse and complemented ongoing field studies. Greenhouse temperatures were maintained between 26 and 30°C throughout the studies. Supplemental light (200 µE/m²/sec) was added when necessary to produce a 16-h/8-h light/dark photoperiod.

Soybeans germinated in quartz sand were transplanted when the cotyledons stood erect to floating styrofoam mats (40 plants per mat) in 8-L containers of one-quarter strength modified Hoagland’s solution (Hoagland and Arnon 1950). Prior to planting, some seeds received a seed treatment of BAS 140 810 at 3.63 ml/454 g of seed (100 g/1000 ml active material). Triapenthenol at 10⁻⁶ M was added to the nutrient solution, specific to that treatment, at the time of transplanting. Three treatments were thus established: a control, triapenthenol-treated, and BAS 140 810-treated. Plants were thinned to 24 per mat at cotyledon leaf stage. Deionized water was used to replace transpiration losses.

Twenty-one days after planting, all seedlings received fresh nutrient solution containing 10⁻⁶ M 0.51 µCi/L, ring-labeled, 14C metribuzin. The specific activity of the radioactive metribuzin was 4.44 mCi/mmol. Test plants had two trifoliolate leaves; however, PGR treated plants were generally smaller.

Time Course

A time course study of uptake and translocation was undertaken via harvests at 12, 24, 48, and 96 h of six plants from each container. One plant from each replication was autoradiographed, and five were separated into leaf, stem, and root segments and lyophilized. Some lyophilized tissue was combusted by a Packard Tri-Carb model B306 sample oxidizer for total 14C, and some tissue was extracted with 80% ethanol via procedures of Falb and Smith (1984) and Smith and Wilkinson (1974) to delineate polar and nonpolar metabolite pools. Modifications in the extraction procedure involved metabolite identification from fluorescent TLC plates under 245-nm UV light rather than color tests or the radiochromatogram scanner identification and ammonium hydroxide:ethanol:n-butanol (1:1:2) rather than water:ethanol:n-butanol as the TLC solvent.