Arsenic Residues in Soybean Seed From Simulated MSMA Spray Drift

R. D. Wauchope and C. G. McWhorter
[1]USDA-ARS, Southern Weed Science Laboratory, Stoneville, MS 38776

MSMA (sodium methanearsonate, $NaCH_3AsO_3H$), a cost-effective, widely used herbicide for grass control in cotton, is applied either over-the-top to cotton and weeds or as a directed spray to the foliage of the weeds. It may not be applied after cotton begins to produce flowers. Applications after flower initiation result in arsenic residues[2] in the seed (BAKER, et al. 1969).

Spray drift of MSMA onto soybeans, which are often grown adjacent to cotton, is of concern because the herbicide may injure the soybeans, delay maturity, reduce yields, and produce arsenic residues in the harvested seed. BODE and MCWHORTER (1976) applied MSMA over-the-top in 1973 and 1974 to soybeans at different stages of growth, using 1/20 to 1/5 the normal application rate to assess damage under simulated drift conditions. The present report concerns the arsenic residues found in the mechanically harvested seed from that experiment.

Materials and Methods

Soybeans were sprayed at four stages of growth: 2-4 trifoliolate leaves, 6-8 trifoliolates, 9-11 trifoliolates, and at mid-bloom. Rates of MSMA were 0.11, 0.22, and 0.44 kg/ha. Treatments were replicated three times in each of the two years. At maturity, soybeans were harvested from each treatment plot and from unsprayed control plots and were stored in a freezer until analysis. Soybeans were oven-dried and ground in a Wiley mill[3]. Four-gram subsamples were digested with a Bethge condensor system and perchloric-nitric acid as described by GRIFFEN et al. (1975), except that 40 ml of nitric acid was used to obtain complete digestion, and the resulting digests were diluted to 50 ml.

Arsenic analysis was by arsine generation and flameless atomic absorption (WAUCHOPE, 1976). Injections of 1 ml of solutions into a modified arsine generator similar to that of THOMPSON and THOMERS(

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[1]Mississippi Agricultural and Forestry Experiment Station cooperating.

[2]In this report, an "arsenic residue" is defined as higher-than-background arsenic level.

[3]Mention of a trademark or proprietary product does not constitute a guarantee or warranty of the product by the U.S. Department of Agriculture and does not imply its approval to the exclusion of other products that may also be suitable.

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(1974), followed by detection of the arsine with a heated quartz tube absorption cell, as described by CHU et al. (1972), allowed rapid and sensitive analysis (3 ng/ml detection limit; 100 ng/ml full scale; 5 determinations/minute). Iodide-treated digests, standard solutions, digests of arsenic spiked seed meal, and digestion reagent blanks were analyzed. Arsenic spike recoveries were 80-85% and a correction factor of 85% was used on all results.

Soybeans with arsenic residues were washed thoroughly with water which was then analyzed for evidence of surface contamination of the beans. No arsenic was found in the washings, indicating that the arsenic determined by digestion is located in the seed interior.

Results and Discussion

Total elemental arsenic levels are given in Table 1. Significant arsenic residues (0.9 ppm and larger) were found in the mature soybean seed, even at the lowest application rate, when the plant's foliage was exposed to MSMA late in the season. Conversely, treatments applied at the early growth stages did not result in arsenic residues even though soybean injury and significant yield reductions occurred (BODE and MCWHORTER, 1976).

TABLE 1

Arsenic content of mature soybean seed--average for 2 years

Soybean stage at application	MSMA application rates (kg/ha)		
	0.11	0.22	0.44
	µg As/g dry weight and standard deviation		
2-3 trifoliolates	0.06±0.02	0.09±0.03	0.08±0.05
6-7 trifoliolates	0.09±0.03[a]	0.19±0.18[b]	0.16±0.02[a]
9-10 trifoliolates	0.9 ±0.3	1.8 ±0.6	2.4 ±0.6[a]
Midbloom	0.9 ±0.3	1.8 ±0.3[a]	1.9 ±0.9
	untreated check: 0.1±.05		

[a]One year data only.

[b].05, 0.27 averages for different years.

These results contrast with arsenic residues from root uptake in arsenic-treated soil. Because of the strong "inactivation" (sorption) of arsenic compounds by soils (WAUCHOPE, 1975; WOOLSON, 1975) very high soil arsenic levels (typically 100 ppm or more) are required before arsenic residues appear in most crops--usually levels that are toxic to the plants (WOOLSON, 1975). BAKER, et al. (1976) found that 120X normal application rates of MSMA (269 kg/ha) were required to produce arsenic residues in soybean seed if the herbicide was incorporated into the soil before planting.

Our study suggests that soybeans absorb foliar-applied MSMA efficiently, and arsenic applied late in the season can accumulate in the seed.

The absence of residues from early-season application of MSMA indicates that there is little danger of MSMA drift leading to arsenic residues in neighboring soybean crops when the herbicide is used in accordance with label restrictions for its use in cotton. Thus, precautions against drift, and the following of label restrictions to early season application on cotton should, even in cases where drift damage occurs, prevent arsenic residues in soybeans.

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