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Uptake of Monosodium Methanearsonate by Johnsongrass

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Arsenical compounds are widely used as herbicides for general contact weed control, as well as selective control of undesirable grasses mixed with coastal Bermuda (MUSSER 1950). Although all salts of the methanearsonic acids are effective herbicides, monosodium methanearsonate (MSMA) may be better in control of Johnsongrass, cocklebur, nutsedge, Dallis grass, barnyard grass, ragweed, sandbur, and puncturevine (Ansul Bull. 1971) in turf and roadside applications. Disodium methylarsonate (DMA) has use in turf applications (LUCAS 1964) as does monoammonium methanearsonate (MAM) which is effective against carpet grass, cudweed (CONCH et al. 1964) and Dallis grass (BOCKHOLT 1957, CAMPBELL & SHACKELFORD 1962). Further, MAM and disodium methanearsonate (DSMA) will effectively control Vervain, Verbena, (spp.) and Johnsongrass, when used with dimethyl sulfoxide (DMSO) (LAPHAM 1966).

Bermudagrass, a desirable species, is highly tolerant to MSMA at recommended doses. Thus, the high degree of selectivity afforded to MSMA, coupled with generally low mammalian toxicity, has made the compound one of the most commonly used herbicides in the United States, with annual applications at 3.3×10^6 pounds to roadside rights of way alone (POURCEAU 1977). There have however, been incidents involving litigation for loss of livestock which arose out of alleged misuse of the compound, or from cattle feeding through fence lines onto treated highway rights of way (WINSTON vs State of Louisiana).

Oral, acute LD_{50}'s for MSMA in Holstein calves was initially published as 230-250 mg/kg (Ansul Bull. HB-10), but this range is considered high by other investigators (NICHOLSON 1973, DICKENSON 1972). Dickenson reported deaths of 4 out of 5 whiteface yearlings at a total dose of 80-100 mg/kg, following administration at 10 mg/kg /day. Gastrointestinal symptoms have been observed in calves fed 118 mg/kg for as little as 24 h, while calves fed as little as 40 mg/kg daily, with normal rations, still exhibited loss of appetite within four to seven days (Ansul Bull. HB-10).

The quantity of MSMA deposited on grasses during application is of concern from several standpoints. Although primary concern may vary with the locale in which spraying is carried out, the possibility of grazing animals reaching the site before sprayed grasses lose their palatability is paramount. With cattle, this is especially true due to their characteristic sensitivity to arsenic (DICKENSON 1972). The internal concentration of MSMA in grass is also important as it represents the level of arsenic which will persist after rain and be

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available until the treated vegetation decays and the material is released to soil and water (MASON et al. 1975).

MATERIALS AND METHODS

Sites used in the study included three previously untreated plots (averaging 380 x 30 ft) adjacent to secondary highways in Southeast Louisiana. Adsorption of MSMA was determined on 560 grass samples consisting of leaves and stems of Johnsongrass taken from moderately dense stands of approximately 2 - 3 ft height. Paired 100 g (wet wt.) samples were collected at 14 locations in each of the three plots prior to and at 1, 6, 12, 24 and 48 h following application of MSMA at 4 lb/acre, by highway spraying equipment.* Additional samples were taken 192 h after application in the first test plot. Paired samples were treated as follows: one sample was flushed with tap water, and stored in polyethylene bags, while the second sample was stored without washing. Samples were then kept under refrigeration until analysis.

Arsenic analyses were performed on one gram aliquots taken from the 100 g composite samples following chopping and digestion with a 5:1 (vol/vol) mixture of concentrated nitric and sulfuric acids. Digested samples were diluted with distilled water and suitable portions transferred to reaction flasks for determination of total arsenic using the silver diethyldithiocarbamate (SDCC) method (Standard Methods 1971).

Environmental conditions (temperature, relative humidity and rainfall) were noted during sampling for correlation with observed uptake rates.

RESULTS AND DISCUSSION

Application of 1.90 lb As^{o}/acre (4.0 lb MSMA/acre) to Johnsongrass resulted in a nominal grass concentration of 770 μg/g As^{o} (Figure 1 - Unwashed). Nominal levels include both absorbed and adsorbed herbicide, which would be immediately available to animals grazing on the site, and represent the maximum potential for absorption following application. Concentrations of 770 μg/g could prove toxic to cattle. For a 350-lb calf, approximately 100 lb of grass receiving direct application would provide the median lethal dose, based on the Ansul values while values determined by Dickenson indicate that ingestion of 41 lb of treated grass could be fatal.

Adsorption of MSMA (Figure 1 - Washed) proceeded regularly with essentially complete internationalization within 192 h. Absorption was found to be biphasic and rapid, with approximately 50% of the total

*Single high beam aluminum boom with 47 K-15 flood jets and single DC-40 nozzle at boom end. Application rates were verified by in-plot analyses and are reported elsewhere. (MASON et al. 1975)

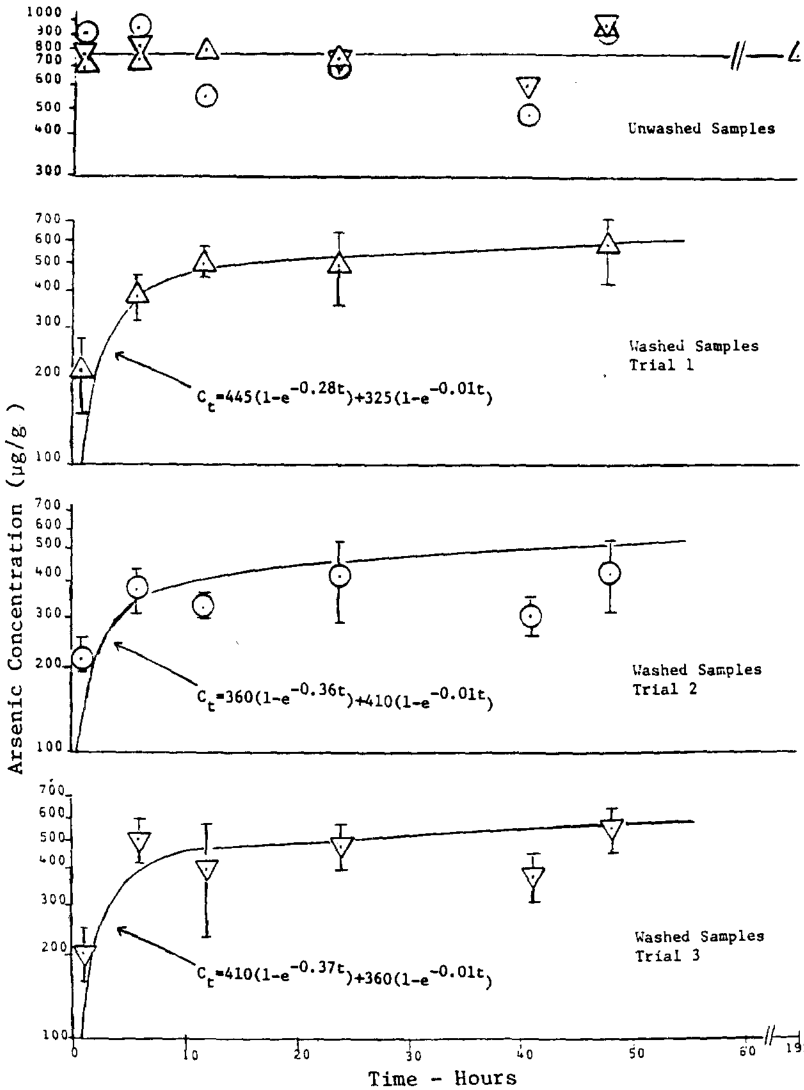

Figure 1. Accumulation of MSMA (as Arsenic) in Unwashed and Washed Johnsongrass Samples Following a Nominal Application of 4 lb /acre.

I = ±2 x Standard Error of the Means.

dose absorbed in 10 h. While absorption is proportional to the difference between the absorbed level and nominal or applied dose ($C_{env.} - C_{tissue}$), Figure 1 shows that there is a marked change in the rate of absorption after approximately 6 h; apparently as a result of plant dysfunction, and equilibration between the internal and external concentrations.

Absorption into leaves and stems as shown by the solid lines in Figure 1, can be described by:

$$C = K_1 \ (1-e^{-at}) + K_2 \ (1-e^{-bt})$$

where,

C = absorbed or tissue concentration (μg/g)

K_1, K_2 = distribution constants (Equilibrium) for the fast and slow processes, μg/g, respectively

a, b = summarized rate constants, h^{-1}

t = time, hours

Constants in Equation 1 were estimated as means of the three trials, (560 observations) and are cited in Table 1.

Environmental conditions during the three trials were similar with respect to temperature (90-95° high, 70-75°F low) and relative humidity (40-50%) in the first two trials. However, in the third trial humidity was somewhat higher, (72%). In the second and third trials, heavy dews during the early evening hours affected the absorption of MSMA (Figure 1: Trials 2 & 3, t = 12, 41 h). Dew was effective in reducing absorption probably by removing the herbicide from the leaf surface, as well as dilution of the concentration at the leaf surface. LD_{50}'s for MSMA in Johnsongrass have not been reported, but observation in this study confirmed leaf kill at the 50% absorption levels.

TABLE 1

Kinetic Parameters for the Absorption of MSMA by Leaves and Stems of Johnsongrass (Sorghum halepense):

$$C_t = K_1 \ (1-e^{-at}) + K_2 \ (1-e^{-bt})$$

Trial	K_1(μg/g)	K_2(μg/g)	a*, h^{-1}	b,h^{-1}
1	445	325	0.28	0.01
2	360	410	0.36	0.01
3	410	360	0.37	0.01
MEAN	405	365	0.34	0.01

*to base e

CONCLUSIONS

On the average, it would appear that at least six h are needed, without rain, to insure 50% absorption of MSMA by Johnsongrass - but as much as 155 h would be needed before absorption reaches the 90% level. The latter is practically impossible owing to loss of physiological function by the plant. Rapid initial absorption is highly desirable in terms of herbicidal effectiveness since it allows use of the compound under threat of rain. Unfortunately, the same rapidity suggests that quick action would be needed to reduce internalized and thus persistent levels in treated areas in the case of access by grazing animals.

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REFERENCES

BOCKHOLT, E.B.: Proc. SWC, 10:170-72 (1957)

BURKE, J.A. and C.R. SKOGLEY: Proc. NEWCC 15, 289 (1961)

CAMPBELL, R.W. and T.B. SHACKELFORD: Proc. NCWCC 19, 5152 (1962)

CONCH, R.W., R.J.D. MURPHY, D.E. DAVIS and H.H. HUNDERBURK: Proc. SWC 17, 107 (1964)

DICKENSON, J.O.: Am. J. Vet. Res. 33, 1889 (1972)

KATES, A.: Va. Agric. Exp. Circ. 820, 1 (1961)

LAPHAM, V.T.: Proc. SWC 19, 438 (1966)

LUCAS, R.E.: Proc. SWC 17, 62 (1964)

MASON, J.W., A.J. ENGLANDE, JR., A.C. ANDERSON, A.A. ABDELGHANI, and R.M. SMITH: Int. Conf. on Env. Sens. & Assessment, Vol. 2, #37-5, 1975

MUSSER, B.H.: Turf Management. McGraw-Hill, Inc., New York, N.Y. (1950)

NICHOLSON, S.: Proc. La. Pest. Applicators Assn. (1973)

POURCEAU, O.M. and S. LAW: La. Dept. of Highways - Personal Communication (1977)

WINSTON, JR., S.L. and S.L. WINSTON, III vs. State of Louisiana Department of Highways 352 So. 2d. 752, (1977)

Weeds Controlled by the Methanarsonates. Ansul Herbicide Bulletin (1971)

Toxicity of Ansar 529 Herbicide to Livestock. Ansul Herbicide Bull. HB-10