Growth-Inhibiting Action of Tris(1-Aziridinyl)-Phosphine Oxide in Grasses

Abstract. *Tris(1-aziridinyl)-phosphine oxide inhibits the growth of seedling grasses with concomitant accumulation of anthocyanins and exudation of sap. Treated plants are deficient in cell-wall materials. However, the percentage of other metabolic products, such as protein and simple sugars, is increased. We suggest that this compound inhibits cellular expansion by cross-linking with cellulose in the plant cell wall.*

It has been known for some time that tris(1-aziridinyl)-phosphine oxide (APO) is a suppressant of growth in tumors (*1*), an insect sterilant (*2*), and a crease-proofing and flame-retarding agent in textiles (*3*), probably all of which are dependent upon its high chemical reactivity; it also has a marked effect on the growth of higher plants (*4*). The general phytotoxicity, penetration, and translocation of this compound will be reported elsewhere (see *5*). This report presents data relevant to the mode of action of APO in grasses.

In general, grasses sprayed with APO become stunted and turn dark green; there is an accumulation of anthocyanins, and sap is exuded on the surface of the leaf. These observations suggest that carbohydrate metabolism is altered.

To examine this possibility, experiments were conducted with seedling grasses in the greenhouse. Two-week-old corn and sorghum seedlings were sprayed to the point of run-off with aqueous solutions containing various concentrations of APO and 0.1 percent wetting agent. Approximately 2 weeks after spraying, plants were harvested, weighed, and analyzed for sugars. All samples were harvested between 8 and 9 a.m. so as to minimize diurnal fluctuations in sugar content. Five-gram portions of plant tissue were extracted twice for 20 minutes each with boiling 80 percent ethanol. The combined extracts were filtered, decolorized with activated charcoal, and a sample was assayed for reducing substances (*6*). Another portion of the treated extract was incubated with invertase (*7*) at 35°C for 4 hours (*8*) and then assayed for reducing substances. The difference between the two assays was interpreted as the sucrose content. Neither activated charcoal nor 1 percent APO interfered with the determination of either glucose or sucrose added to plant extracts.

Results of such tests with sorghum and corn seedlings are summarized in Table 1. Although there is a marked depression of fresh weight associated with APO treatment, there is not a concomitant depression of dry weight. In sorghum seedlings a marked increase of reducing sugars and sucrose is also associated with low doses of APO. There is a similar increase of sucrose in corn seedlings that were treated at the lower rates.

Table 1. Weight and sugar content of sorghum (*Sorghum vulgare*) and corn (*Zea mays*) 2 weeks after treatment of foliage with tris(1-aziridinyl)-phosphine oxide (APO). Values are averages of four replications of 40 sorghum plants or 4 corn plants. Reducing sugars and sucrose are expressed as milligrams per gram, fresh weight.

APO (%)	Fresh wt. (g)	Dry wt. (g)	Reducing sugars	Sucrose
		Sorghum		
0	5.2	0.61	1.03	2.35
0.1	2.9	.51	4.80	17.50
.2	1.9	.36	4.05	21.85
.3	1.7	.49	5.25	19.35
		Corn		
0	27.7	2.80	0.497	0.409
0.025	19.4	1.74	.596	.964
.05	4.03	1.02	.971	4.61
.1	2.66	0.81	1.64	2.36
.2	3.33	.95	1.54	2.92

These findings, together with the fact that APO has been found to cross-link cellulose in the treatment of fabrics, suggested to us that this compound might cross-link cellulose in vivo. If this were the case, plants treated with APO should stop growing, and the ratio of other metabolites to cell-wall constituents should be increased. To test this hypothesis, grass that had been treated with APO in the field was analyzed for cell-wall constituents as well as other components. Results of these analyses, summarized in Table 2, indicate that plants that had been treated with APO have a composition markedly reduced in crude fiber, Van Soest fiber, lignins, and cell-wall constituents. However, other cellular components, such as ether extractables, protein, and carbohydrates of intermediary metabolism (Table 1) are markedly increased.

Quite clearly APO inhibits the accumulation of cell-wall materials in seedling grasses, possibly from cross-linking with cellulose. As the result of this inhibition, plant growth ceases. Since there is an accumulation of other cellular components, apparently metabolism is otherwise unaffected.

Table 2. Analysis of orchard-brome grass hay harvested 40 days after treatm ent with tris(1-aziridinyl)-phosphine oxide (APO) (*9*).

Composition on dry basis ± standard deviation (%)					
Ether extract	Protein	Crude fiber	Van Soest fiber*	Lignin	Cell-wall constituents†
			No APO added		
2.94 ± .47	8.59 ± .47	30.88 ± 1.29	33.44 ± 1.24	4.46 ± .21	56.55 ± 2.19
			APO (1 lb/acre)‡		
3.58 ± .23	12.60 ± .43	25.96 ± .96	29.13 ± .57	3.83 ± .31	50.43 ± 1.19
			APO (2 lb/acre)		
3.74 ± .21	14.22 ± .60	24.85 ± 1.00	29.25 ± .77	4.03 ± .33	49.59 ± 1.56

* "Van Soest fiber" is the residue from an acid detergent boiling. † "Cell-wall constituents" is the residue from neutral detergent solubility. There were four replications in the experiment. ‡ One pound per acre is equivalent to approximately 1 kg/hectare.

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References and Notes

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