Propargyl Bromide: Preliminary Efficacy and Environmental Results

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With the phase-out of methyl bromide (MeBr) to be completed by 2005 in the U.S., an intensive search for effective replacement fumigants is being conducted. Propargyl bromide (PBr; 3-bromopropyne), used in the soil fumigant Trizone in the 1960s, is a potential chemical alternative. Propargyl bromide is structurally very similar to MeBr, but it has a low ozone-depleting potential and would not be subject to phase-out under the Clean Air Act. However, PBr has never been registered as a commercial pesticide/fumigant and presently, very little information exists with regard to its efficacy and behavior in the environment. Therefore, development of this information is critical before a decision can be made whether PBr should be used as a soil fumigant. Preliminary results are reported here.

To evaluate the effectiveness of PBr to control weed seed germination, experiments were conducted which assessed the effect of fumigation rate on the germination of barnyard grass seeds (*Echinochloa crusgalli*). For comparison purposes, methyl isothiocyanate (MITC), a MeBr alternative, was also used. Fresh Arlington sandy loam soil (50 g dry wt.) was mixed with 50 barnyard seeds, allowed to stand overnight, then spiked with PBr or MITC at a range of concentrations (3.2 to 13.0 mg kg^{-1}). Each of the treatments were then sealed in gas-tight jars and incubated at 20, 30 and 40°C. At the lowest fumigant concentration tested, the time required to inhibit 50% of seed germination (T_{50}) was 68.4, 17.9 and 8.7 h for MITC and 32.1, 22.8 and 17.7 h for PBr, at 20, 30 and 40°C, respectively. At each of the temperatures tested, T_{50} values decreased with increasing fumigation rate, as shown in Figure 1 at 30°C. Overall, PBr exhibited a similar activity to MITC for barnyard grass control. The LC_{50} (mg kg^{-1}) of PBr was also determined for *Fusarium oxysporum*, barnyard grass and yellow nutsedge using a similar setup. Very different LC_{50} values were found for the Arlington sandy loam and an organic-rich Florida muck soil (Figure 2). At 30°C, the LC_{50} of PBr in the muck soil was 16, 17 and 9 times greater than in Arlington sandy loam for the control of *Fusarium oxysporum*, barnyard grass and yellow nutsedge, respectively. The poor efficiency of PBr in the muck soil may be attributed to its rapid degradation in this soil. The degradation half-life ($T_{1/2}$) of PBr in Florida muck was only 0.3 days, compared to 1.9 days in the Arlington soil. These results suggest that use of PBr in organic-rich soils may be limited due to its rapid degradation. Results, on the efficacy of PBr on the citrus nematode *Tylenchulus semipenetrans*, will be available at the meeting time.

Another important aspect in assessing the suitability of PBr as a MeBr alternative is its potential for environmental implications. For soil fumigants, atmospheric emission of the fumigant vapor is an important concern for regulators and the general public. We conducted a series of soil column experiments to compare the emission potential of PBr with that of MeBr and methyl iodide (MeI), which is also being considered as an alternative. In columns packed with Arlington sandy loam, the emission potential of PBr was significantly less than that of MeBr or MeI (Figure 3). Under nontarped conditions, the cumulative loss of PBr was 1.9 and 2.3 times less than MeBr and MeI, respectively. Tarping the soil produced a similar response, however, the cumulative loss of all fumigants was only slightly reduced. Although tarping can help reduce fumigant emissions, plastic tarps currently used have been shown to be permeable to fumigant vapors, resulting in appreciable losses to the atmosphere. Mass transfer coefficients for the diffusion of several fumigants through various plastic tarps are shown in Table 1. Compared to MeBr, the diffusion of PBr through 1-mil HDPE is an order of magnitude higher, but diffusion rates for both MeBr and PBr were substantially reduced with Hytibar, a virtually-impermeable film. Based upon these results, the use of Hytibar should be considered when tarping is used to control PBr emissions. In addition to tarping, alternative emission reduction methods are also available. One such method involves the application of ammonium thiosulfate (ATS), a sulfur and nitrogen fertilizer, to a thin layer at soil surface. ATS is known to reduce fumigant emissions by enhancing degradation. When ATS was applied with 100 mL of water at 64 g m^{-2}, only 3% of the applied PBr was lost by emission after 12.5 days, compared to 29% from a similar treatment without ATS amendment (Figure 3). This represents a reduction of 90%. Overall, PBr will likely have an emission potential smaller than that of MeBr. However, under traditional application conditions, even with the use of polyethylene plastics as surface tarps, emission of PBr can still expected to be substantial. Therefore, measures to reduce its emission should be considered in the early development of this chemical alternative.

Table 1. Mass Transfer Coefficients (cm h^{-1}) for Fumigants Diffusing Through Plastics, Measured Using Static Permeability Cells ± Standard Error of the Estimate

	PBr	MeBr	Chloropicrin
HDPE (1-mil)†	1.54 ± 0.07	0.38 ± 0.01	0.69 ± 0.06
Black HDPE (4-mil)†	0.48 ± 0.02	0.14 ± 0.01	0.25 ± 0.03
Hytibar‡	0.02	0.02	0.002

†Conducted at 20°C

‡ Conducted at 40°C

Figure 1. Effect of PBr and MITC on Barnyard Grass Seed Germination in Arlington Sandy Loam (30^{o}C)

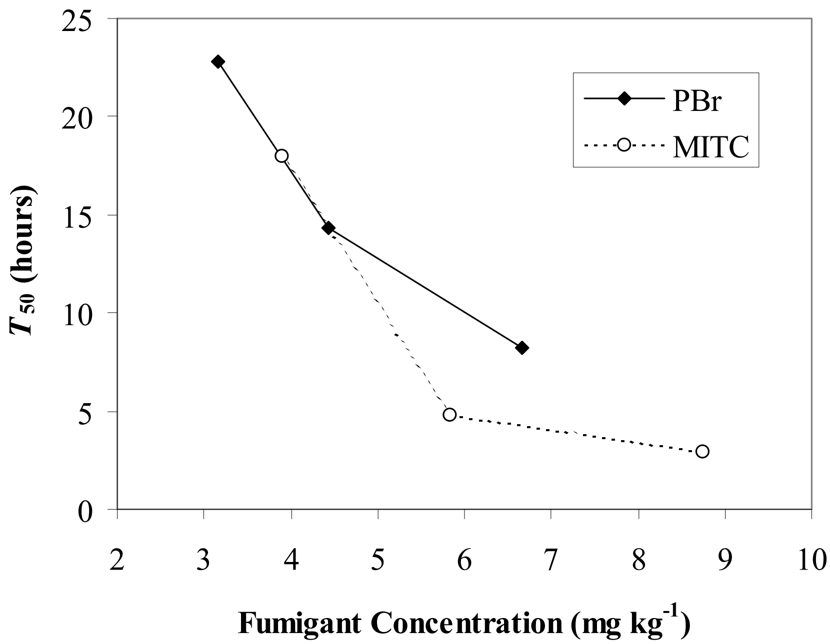

Figure 2. LC_{50} (mg kg^{-1}) of PBr for *Fusarium oxysporum*, Barnyard Grass and Yellow Nutsedge in Arlington Sandy Loam and a Florida Muck Soil (30^{o}C)

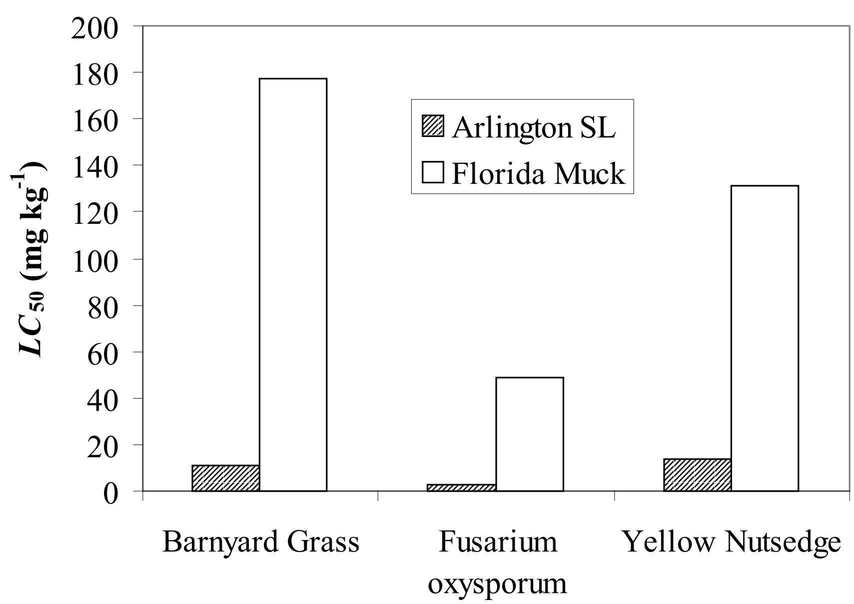

Figure 3. Volatilization of Fumigants from Packed Soil Columns