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RESEARCH

Seeking alternatives for methyl bromide

Nothing is ready as the ban nears, but some products show promise for fumigating prospective turf sites.

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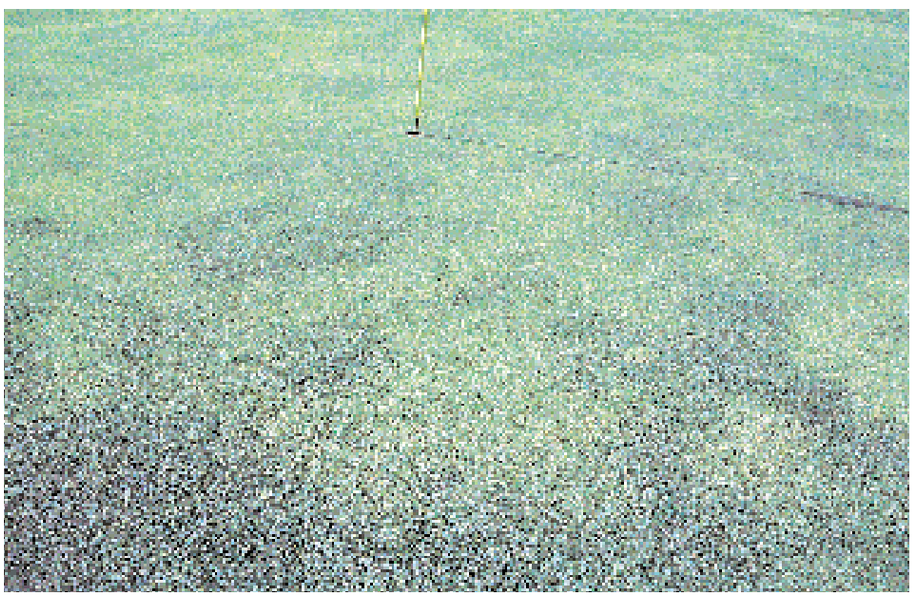
The first use of methyl bromide as a soil fumigant in turf applications was probably at the Greensboro (N.C.) Country Club in 1958 during putting green renovation (3). Since then, methyl bromide's value as a "soil disinfectant" has made it a mainstay in golf course and athletic field construction and renovation.

As new turfgrass varieties (especially warm-season grasses) enter the market, re-grassing of existing turfgrass sites, including greens, tees and fairways, requires a clean planting bed. Similarly, sod growers also recognize the benefits of fumigation in the bermudagrass market, where off-type contamination is prevalent and lawsuits over contaminated sod are commonplace. Many state sod and seed certification agencies require fumigation and inspection of sod fields before growers receive a "certified" label.

A total ban of this effective pest-management tool is approaching because of environmental concerns. Methyl bromide has been designated an ozone-depleting substance. Ozone



GCM file photo

Fumigation is a key weapon in the fight against contamination of bermudagrass cultivars with undesirable types.

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Key points

- Fumigation is a key management practice in establishing turfgrass stands, particularly where tough weeds such as off-type bermudagrass are prevalent.
- A total U.S. ban of the fumigant methyl bromide may occur because of its potential harm to the earth's protective ozone layer.
- Alternatives such as methyl iodide or a combination treatment of tear gas with metham sodium may be suitable replacements for methyl bromide if legal and safety issues are resolved.

is an unstable, pale-blue gas that forms a layer within the stratosphere and extends from nine to 18 miles above the earth's surface. This layer absorbs ultraviolet radiation and prevents some heat loss from the earth. If more ultraviolet radiation reaches the earth's surface, the risk of skin cancer and cataracts would increase.

The methyl bromide ban has been highly controversial. Skeptics in the scientific community challenge models that predict the impact methyl bromide has on the environment. Because research to date has failed to produce a viable, cost-effective alternative

Fumigant control of nutsedge (%)

		WFREC*		Southern Florida			
Treatment	Rate	Sept. 7 '98	Jun. 28 '99	Sept. 11 '98	Sept. 30 '98	Nov. 24 '98	Dec. 9 '98
Methyl bromide No. 1	500 lb/acre	100a	89a	100a	96a	84ab	83a
MBA No. 200	100 lb/acre	75a-d	73a-d	100a	97a	78ab	79ab
Ronstar G Telone II	150 lb/acre 15 gal/acre	0f	86ab	0c	0d	56b	74ab
Dazomet	350 lb/acre	80abc	57de	78b	56c	58b	58bcd
Dazomet Chloropicrin	350 lb/acre 150 lb/acre	81ab	63bcd	81b	74b	68ab	48cd
Dazomet Telone II	350 lb/acre 15 gal/acre	51de	31f	76b	70b	68ab	41d
Methyl iodide	300 lb/acre	—	84abc	100a	96a	90a	81a
Metham sodium	80 gal/acre	43e	26f	71b	74b	75ab	73ab
Metham sodium Chloropicrin	80 gal/acre 150 lb/acre	55cde	38ef	72b	66bc	63ab	76ab
Metham sodium Chloropicrin (tarped)	80 gal/acre 150 lb/acre	64b-e	56de	100a	97a	88a	79ab
Metham sodium Telone II	80 gal/acre 15 gal/acre	69bcd	50def	87ab	76b	75ab	70abc
MBA No. 300	40 gal/acre	84ab	60cde	100a	97a	84ab	88a
Methyl bromide No. 2	500 lb/acre† 800 lb/acre‡	—	93a	100a	98a	88a	84a
Untreated control		0f	0g	0c	0d	0c	0e
LSD (P = 0.05)		25	24	17	13	28	23

Note. — Nutsedge (*Cyperus* spp.) includes numerous sedge species, such as purple nutsedge, yellow nutsedge and globe sedges. Numbers followed by the same letter(s) are not significantly different.
*WFREC = West Florida Regional Extension Center.
†500 lb/acre rate used at the Florida No. 1 and Georgia site only.
‡800 lb/acre rate used at the Florida No. 2 site only.

to methyl bromide, many grower organizations, including the Turfgrass Fumigation Working Group, have staged an aggressive campaign against the ban on this tool. Congressional hearings have been conducted, and the agricultural community is awaiting the outcome.

Regardless of legal outcomes, turfgrass managers need a soil fumigant. Our research assessed the potential efficacy of methyl bromide alternatives.

Many researchers have sought fumigant alternatives on crops such as tomatoes and strawberries, where diseases and nematodes are the primary targets of fumigation.

Fumigant control of weedy grasses (%)

		WFREC*		Southern Florida			
Treatment	**Rate**	**Sept. 7 '98**	**Jun. 28 '99**	**Sept. 11 '98**	**Sept. 30 '98**	**Nov. 24 '98**	**Dec. 9 '98**
Methyl bromide No. 1	500 lb/acre	100a	98a	100a	98a	70abc	74ab
MBA No. 200	100 lb/acre	100a	90a	100a	96a	79ab	78ab
Ronstar G Telone II	150 lb/acre 15 gal/acre	0b	53b	13c	0d	41d	71ab
Dazomet	350 lb/acre	98a	93a	83b	45c	49cd	44cd
Dazomet Chloropicrin	350 lb/acre 150 lb/acre	96a	93a	91ab	70b	53cd	38d
Dazomet Telone II	350 lb/acre 15 gal/acre	100a	95a	90ab	70b	63bcd	54bcd
Methyl iodide	300 lb/acre	—	98a	100a	99a	91a	80ab
Metham sodium	80 gal/acre	98a	88a	87b	69b	61bcd	65abc
Metham sodium Chloropicrin	80 gal/acre 150 lb/acre	100a	89a	92a	66b	65bcd	69abc
Metham sodium Chloropicrin (tarped)	80 gal/acre 150 lb/acre	100a	94a	100a	99a	78ab	70abc
Metham sodium Telone II	80 gal/acre 15 gal/acre	96a	94a	95ab	71b	73abc	59a-d
MBA No. 300	40 gal/acre	100a	94a	100a	100a	85ab	79ab
Methyl bromide No. 2	500 lb/acre†; 800 lb/acre‡	—	98a	100a	99a	85ab	81a
Untreated control		0b	0c	0c	0c	0e	0d
LSD (P = 0.05)		35	13	13	17	24	27

Note. — Grass species include *Cynodon* spp. and *Brachiaria* spp. Numbers followed by the same letter(s) are not significantly different.
*WFREC = West Florida Regional Extension Center.
†500 lb/acre rate used at the Florida No. 1 and Georgia site only.
‡800 lb/acre rate used at the Florida No. 2 site only.

Perennial weeds (specifically common bermudagrass, off-type bermudagrass contaminant and nutsedge) are the primary focus of fumigation in turfgrass systems. We evaluated alternative fumigants for their efficacy in controlling common turfgrass pests and attempted to develop management systems for using such chemicals as replacements for methyl bromide.

Materials and methods

This study was conducted in northwestern Florida, southern Florida and east-central Georgia, although only the two Florida sites produced sufficient data for analysis. The study in southern Florida's subtropical climate was on a large commercial sod farm with a sandy muck soil. The northwestern Florida site was a temperate region with a sandy loam soil.

Fumigants evaluated

In our studies, we looked at several commercially available fumigants either alone or in combination with other fumigants:

- 1,3-dichloropropene (1,3-D or Telone II) provides excellent control of nematodes and some soil-borne insects, but has little activity against soil-borne pathogens or weeds (4). 1,3-D is frequently combined with other fumigants such as chloropicrin and metham sodium to control some pathogens and weeds. Like methyl bromide, 1,3-D has been targeted by environmental groups.
- Chloropicrin or trichloronitromethane (tear gas) is a very effective fungicide, often controlling soil-borne pathogens better than methyl bromide. Although direct control of weeds is limited with chloropicrin (6), it is used extensively in combination with methyl bromide and more recently in combination with 1,3-D. Chloropicrin will scarify hard-coated seeds, allowing the primary fumigant to achieve greater control.
- Metham sodium (Vapam, Sectagon) is a water-soluble pre-plant soil fumigant used in the turf industry to control soil fungi, nematodes, soil insects and weeds. Because metham sodium must first decompose to the biocidal methyl isothiocyanate (MITC), inconsistent pest control often results as temperature and soil moisture affect conversion (2). If soil temperatures are too high and soil moisture is low, conversion to MITC accelerates, and the chemical may diffuse out of the soil too quickly for the active biocide to accumulate and control pests. If soil temperatures are cool and the soils are too wet, the rate of decomposition to MITC is slowed, and lethal concentrations are not achieved.
- Dazomet (Basamid) is a granular product (although it looks like talcum powder) that reacts with soil moisture to produce the same biocidal agent (MITC) as metham sodium. Soil moisture and temperature play crucial roles in activating this compound. Its physical characteristics impose application limitations. Its label states that 24 days are needed for effective fumigation. Although this might be acceptable for sod production, it is probably unacceptable for existing golf course situations where reducing downtime during re-establishment is critical. In another research project, we are looking at the viability of dazomet incorporation during the soil blending process for putting green mixes (1).
- Methyl iodide is in early stages of evaluation, with limited results demonstrating that it is equal to or better than methyl bromide for control of weeds, nematodes and soil-borne plant pathogenic fungi (5, 7). In particular, methyl iodide was 1.5 times more effective than methyl bromide in controlling purple nutsedge (7). Methyl iodide decomposes in light, resulting in very short residence time in the atmosphere, so it is not considered harmful to the ozone layer, but it is not a registered pesticide.
- Oxadiazon (Ronstar) is the only herbicide safe for newly sprigged bermudagrass. Oxadiazon is a pre-

emergence herbicide used for controlling crabgrass, goosegrass and crowsfootgrass and is not labeled for common bermudagrass or nutsedge control. Fumigation critics have suggested oxadiazon as a potential methyl bromide replacement.

- MBA No. 200 and MBA No. 300 are two experimental materials identified and evaluated for their efficacy in controlling common turfgrass pests. Although there is much interest in these two materials, neither is labeled for use at the present time.

Fumigant application

Methyl bromide, methyl iodide and chloropicrin were injected to an

Fumigant control of broadleaf weeds (%)

		WFREC*	Southern Florida				
		Winter annuals†	*Ipomoea* spp.‡				*Amaranthus* spp.
Treatment	Rate	Sept. 7 '98	Jun. 28 '99	Sept. 11 '98	Sept. 30 '98	Nov. 24 '98	Dec. 9 '98
Methyl bromide No. 1	500 lb/acre	75c	100a	84ab	95a	68ab	73ab
MBA No. 200	100 lb/acre	92a	100a	90ab	90ab	80a	54b
Ronstar G Telone II	150 lb/acre 15 gal/acre	83abc	10c	10d	81abc	83a	80ab
Dazomet	350 lb/acre	83abc	93ab	50c	80abc	60abc	70ab
Dazomet Chloropicrin	350 lb/acre 150 lb/acre	77bc	95a	71bc	85abc	76ab	75ab
Dazomet Telone II	350 lb/acre 15 gal/acre	82abc	80b	81ab	75abc	68ab	75ab
Methyl iodide	300 lb/acre	84abc	100a	92ab	91a	25cd	55b
Metham sodium	80 gal/acre	86abc	92ab	78ab	61bcd	55abc	75ab
Metham sodium Chloropicrin	80 gal/acre 150 lb/acre	88ab	92ab	74ab	65bcd	43bc	100a
Metham sodium Chloropicrin (tarped)	80 gal/acre 150 lb/acre	87ab	100ab	91ab	78ab	53abc	100a
Metham sodium Telone II	80 gal/acre 15 gal/acre	88ab	92ab	92ab	73abc	68ab	100a
MBA No. 300	40 gal/acre	78bc	100a	95a	85ab	83a	95a
Methyl bromide No. 2	500 lb/acre§ 800 lb/acre‖	85abc	100a	94a	83abc	63ab	80ab
Untreated control		0d	0c	0d	0e	0d	0c
LSD (P = 0.05)		11	14	23	24	35	48

Note. - Numbers followed by the same letters are not significantly different.
*WFREC = West Florida Regional Extension Center.
†Winter annual species include *Geranium carolinianum*, *Oenothera laciniata* and *Gnaphalium pensylvanicum.*
‡*Ipomoea* spp. include *I. purpurea* and *I. trichocarpa.*
§500 lb/acre rate used at the Florida No. 2 site only.
‖800 lb/acre rate used at the Florida No. 2 site only.

8-inch depth, and the treated area was covered with a polyethylene tarpaulin, which remained on the plots for a minimum of 14 days. Telone II and MBA No. 300 were applied using a broadcast applicator with injection tubes mounted on chisel plows. Approximate depth was 8 inches.

Dazomet was applied through a Gandy Orbit-flow applicator mounted on a rototiller that incorporated the material 2 inches deep. A counter-spinning roller attached to the rototiller smoothed the soil surface to provide a seal.

Three irrigation cycles, each delivering 0.5 inch of water, were applied 6-10 hours apart to activate the dazomet.

MBA No. 200 was dissolved in water and sprayed on the soil surface at a rate of 50 gallons per acre and immediately incorporated with a rototiller.

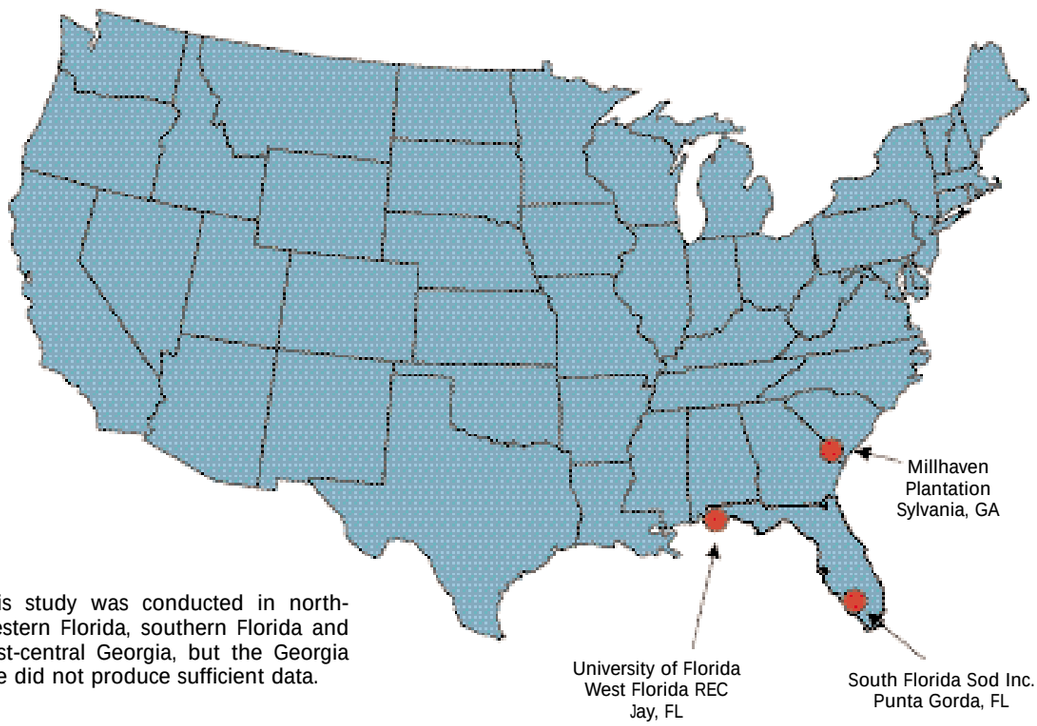
Metham sodium was applied using the same equipment, calibrated to deliver 80 gallons per acre. For the chloropicrin co-application with metham sodium, shanks delivered the material directly below the rototilled soil.

Oxadiazon (Ronstar 2G) was applied at 150 pounds per acre using a broadcast spreader.

Western Florida

Two weeks before fumigation at the No. 1 Florida site at West Florida Regional Extension Center in Jay, the plot area was sprayed with glyphosate (5 quarts per acre) to kill all existing Coastal bermudagrass and Pensacola bahiagrass. The plots were harrowed, moldboard-plowed and rototilled mul-

Research locations



This study was conducted in northwestern Florida, southern Florida and east-central Georgia, but the Georgia site did not produce sufficient data.

tiple times to prepare the soil for fumigation treatments.

Treatments (excluding methyl iodide and methyl bromide No. 2) were applied on July 28, 1998. Because of difficulties with importing, methyl iodide application was delayed until Sept. 9. A comparative methyl bromide treatment was also applied at this time. After the appropriate waiting periods, the tarpaulin was removed, and plots were rototilled and sprigged with Tifdwarf bermudagrass on Sept. 15, 1998. Plots measured 30 feet by 65 feet and were arranged in a completely randomized block design with four replications. Irrigation was applied to encourage rapid establishment of the bermudagrass.

Southern Florida

Before fumigation, the plot area at the No. 2 Florida site at South Florida Sod Inc. in Punta Gorda was sprayed with glyphosate (5 quarts per acre) to kill all existing vegetation. The plots were then moldboard-plowed and cultivated to prepare the soil for fumigation treatments. All treatments were applied over a three-day period starting Aug. 15, 1998. Because of rapid vegetative regrowth in plots with ineffective treatments, the plot area was rototilled before planting of Tifdwarf bermudagrass on Oct. 29, 1998. Care was taken to minimize soil movement from one plot to another. Plots measured 30 feet by 50 feet and were arranged in a completely randomized design with four replications.

Results and discussion

We found that no single, commercially available alternative performed as well as methyl bromide. As expected, methyl bromide performed well under conditions in both southern and western Florida. The 800-pound-per-acre rate evaluated on the southern Florida site was no more efficacious than the 500-pound rate.

MBA No. 200 and MBA No. 300

MBA No. 200 and MBA No. 300 performed well compared with methyl bromide. Both compounds provided effective control of the weedy grass species, including common and off-type bermudagrass and *Brachiaria* species. However, MBA No. 200 only provided 75 percent control of purple nutsedge at the western Florida site. Both materials tended to perform better in the more sandy soils of southern Florida.

MBA No. 200 performed as well as or better than methyl bromide for control of broadleaf weeds. MBA No. 300 was similar to methyl bromide.

Oxadiazon and Telone II

The pre-emergence herbicide oxadiazon had little success in controlling sedges and contaminant bermudagrass. Although data from both locations indicate a significant level of nutsedge control late in the study, this can be attributed more to the competition from other weeds not controlled by oxadiazon.

Dazomet (and combinations)

Although dazomet initially performed well against the weedy grass species, many weeds tended to rebound quickly, indicating that complete kill had not been achieved, particularly on the southern Florida site, where the weed pressure was extreme. The combination of dazomet and chloropicrin provided initial control of the weedy grass species equal to control by methyl bromide. However, by one month after treatment, control had dropped to 70 percent for this combination treatment.

Methyl iodide

Methyl iodide performed well against the troublesome weeds, including broadleaf weeds. At the southern Florida site, methyl iodide maintained control of the weedy grass species for several months, whereas at the western Florida site, 98 percent control was noted one year after treatment. Nutsedge control at both locations was similar to that of methyl bromide.

Metham sodium (and combinations)

Metham sodium applied alone pro-

vided unacceptable control of most species at both locations. The addition of chloropicrin increased weed control; however, it was still less than acceptable. A last-minute decision to cover one-third of the metham sodium/chloropicrin plots with a plastic tarpaulin provided some surprising results. At the southern Florida site, control of the nutsedge species and the grassy weeds with the combination equaled that of methyl bromide. Similar results were noted for the broadleaf weed species as well.

Conclusions

To date, there is no single drop-in replacement for methyl bromide as a pre-plant soil fumigant. The only exception might be methyl iodide, which performed very well in both locations against the weedy grasses, nutsedge species and the broadleaf weeds. It is not EPA registered, however, and there are no data to support registration at this time.

A non-U.S. company has reportedly purchased rights to this material and is putting the registration package together. This material also has a use patent, which will probably increase its cost. Given the five- to seven-year time frame required for EPA registration, methyl iodide will not be available for several years after the complete methyl bromide ban is imposed on Jan. 1, 2005.

MBA No. 200 and MBA No. 300 show great promise as soil fumigants, but they are not EPA registered. Data to support registration are lacking, and basic toxicological research is needed. Whether these materials will be labeled remains unknown.

Although analysis suggests that dazomet (and combination) treatments provided good control of weedy grasses at the western Florida site, control was not consistent at the southern Florida site. Control of nutsedge was also poor. Additionally, sporadic failure was observed. Any failure to uniformly incorporate this product into the soil will produce unacceptable results. Control was variable in tire ruts and where the rototiller overlapped between successive passes.

Metham sodium and the various combinations provided some control of the weeds evaluated. Specifically, the metham sodium co-applied with chloropicrin under a tarpaulin provided the best results. Sporadic failure, similar to that observed with dazomet, was also seen with these materials. In addition, worker-protection issues and protective equipment requirements for metham sodium application are impractical in extremely hot climates such as southern Florida.

Because there is no single replacement for methyl bromide, and the best alternatives are either not labeled or not cost-effective or present unacceptable risks to labor, research must continue to find suitable alternatives. Meanwhile, the countdown to phase out methyl bromide continues. ■

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