

Application Considerations for Successful Use of VIF and Metalized Mulches with Reduced Fumigant Rates in Tomato¹

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Methyl bromide (MBr) alone, or in combination with chloropicrin (Pic), has been the soil fumigant of choice since the early 1970s (Overman and Martin, 1978), because of its ease of use and high efficacy under a wide range of conditions. It is typically shank-injected at 350 lb/acre to a soil depth of 10 inches into raised beds that are simultaneously covered with LDPE mulch. Standard LDPE is inexpensive and easy to use, but it is highly permeable to MBr (Gamliel et al., 1998a, 1998b; Papiernik and Yates, 2001; Williams et al., 1999; Yates et al., 1996a, 1996b). MBr has been classified as a substance that contributes to depletion of stratospheric ozone. Consequently, a complete phase-out of the use and production of MBr in developed countries throughout the world was scheduled to occur by 2005, with critical use exemptions permitted under the Montreal Protocol (U.S. Environmental Protection Agency, 1999). Critical use exemptions (CUE) are important for minor crops because growers feel that an economically and technically viable MBr alternative is not yet commercially available. However, even

with permitted exemptions, reduced rates of MBr may be needed to offset the rising cost of the fumigant and to reduce atmospheric emissions. Reduced emissions probably will be a requirement for future CUEs.

To obtain a high degree of pest control with a fumigant, it is necessary to maintain a sufficient quantity of fumigant gas in the soil long enough to reduce the population of pests (Gamliel et al., 1998b; Minuto et al., 1999). This might be accomplished by using low rates of MBr under highly retentive or reduced permeability film. Virtually impermeable film (VIF) is so named due to the much higher fumigant retention capacity of this film compared to ldpe and hdpe which have been the historical mainstays of plasticulture. VIF has become commercially available in recent years and is much more retentive of fumigant gases than standard ldpe mulch (Papiernik and Yates, 2001). This type of film increases fumigant toxicity by increasing the duration of retention, which is caused by a barrier polymer, such as ethylene vinyl alcohol or nylon, placed between two layers of polyethylene (Papiernik and

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Yates, 2001). Wang et al. (1997) determined that atmospheric emission of MBr, when covered with polyethylene for 5 days, declined from 64% of applied MBr with conventional LDPE mulch to about 38% with VIF. With the soil covered by VIF for more than 10 days, only 1% to 3% of the MBr was lost.

In the past six years, considerable field research and grower trials have been conducted with these VIF mulches in Florida. Small plot studies demonstrated that nutsedge and stunt nematodes could be controlled and crop yields maintained with rates of MBr/Pic (67/33 formulation) as low as one-fourth (88 lb./treated acre) of the standard use rate of 350 lb./treated acre when combined with some VIF mulch films, while grower trials successfully established the commercial potential of one-half normal rates (Gilreath et al., 2005a; Santos et al., 2005). Additional research indicated that this improvement in fumigant retention and control of soilborne pests with VIF was not restricted to just MBr, but also included 1,3-D-based fumigants like Telone C-35 and Inline (Gilreath et al, 2004; Hochmuth et al, 2003). Preliminary data indicate similar results with other fumigants such as methyl iodide (Midas).

Unfortunately, there are two drawbacks to most VIF products: cost and handling characteristics. Today, all VIF is made in Europe and must be imported, thus resulting in much higher cost than standard film. Also, most of the VIF products are more difficult to lay than standard films in that they are prone to linear sheer if subjected to too much tension during laying. There is considerable difference in handling characteristics among VIF materials, but they are all based on polyamides, such as nylon, for their barrier properties and these polyamides do not stretch well. Also, none are embossed at the present time. High barrier films continue to be evaluated as they become available, but to date Bromostop® VIF has been the most consistent performer and appears to handle the best under our conditions.

Recognizing the problems associated with some of the existing VIF, we continue to search for other mulch films with enhanced barrier properties. Over the past 2 years, we have examined the barrier

properties of metalized films under field conditions, first with 1,3-D (Inline) and more recently with MBr. In each case, application of Inline or MBr in conjunction with metalized film greatly increased the retention of the fumigant (Gilreath et al., 2005b). In the case of MBr, we were able to obtain nutsedge control with 175 lb./acre of 67/33 under Canslit® metalized film that was equal or superior to that obtained with the full 350 lb./acre rate under standard lDpe or hDpe film in each of four experiments. Bromostop® VIF was included in each of these experiments and the field performance for gas retention under the mulch film, as well as nutsedge control and fruit production, was similar between Canslit® metalized film and VIF. Grower trials with Canslit® metalized film confirmed these results. Additionally, we determined that the retention of MBr and resultant nutsedge control with Canslit® metalized film was similar to what we obtained with VIF at every rate of MBr, ranging from 88 to 350 lb./acre of 67/33.

While it is possible to use Bromostop® VIF or Canslit® metalized film to reduce MBr usage rates by one-half, successful use involves more than just reducing gas flow and laying mulch film. MBr has a high vapor pressure, which means that at typical application temperatures it rapidly becomes a gas and can do so even within the tubing and gas knives of the application rig. This is an advantage for reduced rate application, but it does not solve one inherent problem - uniformity of application. Typical gas rigs employ 3 knives per bed. A good fumigation job requires that all 3 knives deliver the same amount of product per minute so that the application rate is uniform in the area being fumigated. When the rate is reduced, there is less fumigant in the system and more opportunity for the formation of bubbles as the MBr "boils". Inserting small sight glasses in the application equipment at the flow divider just ahead of the tubes which carry the fumigant to the knives will allow you to observe this "boiling" (Figure 1). Under normal conditions, a certain amount of back pressure exists in the application system and can be measured at the flow divider by installing a pressure gauge. Application of a full 350 lb./acre rate will generate in excess of 30 psi of back pressure at this point. Reducing the methyl bromide flow rate in order to deliver lower rates per acre will reduce the

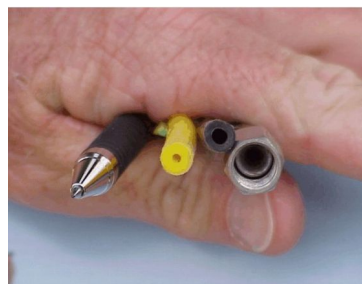
back pressure measured at the flow divider. Our experience indicates that back pressure below 15 psi results in nonuniform distribution to the three knives which means inequalities in rate across the bed. Usually the edges suffer the most and this effect can be observed later in the season as poor control of nutsedge on bed shoulders.



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In order to increase back pressure when using low rates of MBr or any other fumigant, you must decrease the flow capacity of the delivery system between the flow divider and the gas knives. This can be accomplished in two ways. First, you can use a smaller diameter tubing to deliver fumigant to the gas knives. Standard gas rigs use tubing which is one-quarter inch inside diameter. While this is fine for a gas with high vapor pressure like MBr or for high flow rates of other fumigants, it may not be suitable in other situations. We have found that the use of poly tubing ranging from one-sixteenth to one-eighth inch inside diameter is necessary in order to achieve balanced or uniform delivery of greatly reduced rates of MBr. Tubing of this size is not readily available, but it can be obtained and is an important modification if a grower is going to use reduced rates of MBr with a highly retentive film like Canslit® metalized or Bromostop® VIF. Fine tuning of flow capacity or rate of any tube can be accomplished by increasing or decreasing the length of the tube connecting the flow divider to the gas knife. There is a certain amount of friction loss of flow within any size tube and the effect of friction increases with increased length and decreased tubing inside diameter. Typical length for one-sixteenth and one-eighth inch tubing is 5 ft; although longer tubing has been used when trying to achieve really low rates. Color coded tubing is available which can be a big help when adjusting flow rates. Yellow tubing has the thickest walls and smallest inside diameter of one-sixteenth inch. Black tubing is available in

one-eighth inch inside diameter (Figure 2). These tubes all fit the same size connector, making it easy to switch from one flow capacity to another. Select the tube needed for the desired flow capacity, then once installed, adjust the flow regulator valve for the required flow rate on the flow meter, just like normal.



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A second way to decrease flow and increase back pressure is to use orifice plates (Teejet® flow regulators) in the tubing at the top of the gas knife fitting. In order to use these plates, you have to know what flow rate you need in each tube. Since the flow rates of orifice plates are based on water, you have to do some mathematical conversions to MBr or choose one on the high side and try it. In any event, you do not want a plate which gives you the exact same flow rate as what you need; you want one with a slightly higher flow rate so that clogging potential is lowered. If you are going to use orifice plates, you should keep a supply of various sizes on hand. The plates have numbers stamped on them which tell you the size of the hole in the plate (Figure 3). Be sure to keep your glasses handy because these can be hard to read. Orifice plates work over a more narrow range of rates than tubing because the restriction in flow occurs at one point rather than over a length of tubing.



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The system we use is commercially available (manufactured by Mirusso Enterprises, Inc., available through Chemical Containers, Inc.) and constitutes an easily installed, simple modification. It consists of a flow divider with a small sight glass for each knife, a 0 to 30 psi pressure gauge and small diameter poly

tubing. The sight glasses are equipped with standard quick connect (insert friction connectors) couplings on top so the poly tube easily can be connected and disconnected. Similar couplings are located on the top of the gas knives. Sight glasses are useful because they allow you to monitor flow and detect plugging of chisels or lines. Plugging can be a significant issue with low rates of fumigant. As a result, fumigant filtration is even more important and filters need to be checked periodically and maintained clean and free of trash to assure consistent flow through the fumigant distribution system.

One thing to remember when using reduced rates of fumigant: the flow rate has been greatly diminished so accuracy and uniformity of delivery are critical. A common observation on commercial farms is tractor movement as soon as the fumigant flow valve is opened. There is a much longer delay in supplying all the knives uniformly when the rate is reduced, so tractor movement should not begin until all lines are fully charged. You can monitor this condition easily by observing the sight gauges and back pressure gauge. Once the back pressure stabilizes, you can begin fumigation. Addition of an inline check valve at the top of each gas knife can be beneficial because it diminishes loss of fumigant out of the line to the knife. Keep the line full all the way to the gas knife to minimize delays in fumigant delivery and to avoid wasting time purging air from lines. This would be especially important for those growers who use radar-controlled fumigant delivery systems.

Rate reduction with MBr works when combined with a highly retentive mulch film like VIF or metalized film. In addition to the use of the right film, success requires close monitoring of fumigant delivery, assuring not only that the rate is correct, but also that it is applied uniformly to all three knives in the bed. Nonuniformity guarantees poor fumigant performance at any rate, but with reduced rates of MBr, the results can be even more dramatic. The simple modifications described above can greatly improve uniformity of delivery and performance. These modifications are relatively inexpensive and are readily available as a package. Before trying rate reductions growers should modify their fumigation equipment to allow better control over uniformity of

flow. This can mean the difference between success and failure. Under no conditions should a grower attempt to reduce his methyl bromide rate by more than 50% of the standard use rate the first time around. Rates lower than 50% are possible, but it is difficult to achieve the required level of application uniformity and accuracy without considerable experience and attention to detail. Growers should gain experience with rate reduction and use of barrier films because this will be the future and the future is now.

Important Facts To Consider

- Not all VIF or metalized films are the same.
- Gas retention with VIF mulch is fairly consistent among manufacturers, but handling properties may differ greatly.
- Gas retention among metalized films may vary by manufacturer. Not all have been tested at this time.
- One manifestation of non-uniformity of delivery of fumigant may be nutsedge on the bed shoulders but not in the middle of the bed.
- Rate reduction requires close attention to uniformity of application.
- Uniformity requires balanced flow between all chisels or knives.
- Balanced flow requires sufficient back pressure on gas lines (at least 15 psi at the flow divider).
- Back pressure can be achieved by impeding flow at the chisels.
- Reduced flow rate at the chisel can be obtained by reduction of line size (1/8th to 1/16th inch inside diameter) from the flow divider to the chisel or by using Teejet® flow regulators (orifice plates).
- Back pressure can be adjusted by selecting the length and inside diameter of small diameter tubing from the flow divider to the chisel or by selecting the proper size orifice plate based on mathematical calculations.

- Methyl bromide rates of 1/2 the normal 350 lb./treated acre rate generally require at least 5 ft of 1/8th inch inside diameter tubing from the flow divider to each chisel.
- Methyl bromide rates below 175 lb./treated acre may require 5 or more feet of 1/16 inch inside diameter tubing.

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