BACK TO THE FUTURE: PROGRESS AND PROBLEMS WITH STEAM AS A PRE-PLANT TREATMENT OF FIELD SOIL

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Fumigation with methyl bromide has played a critical role in management of weeds and diseases in Yoder Brother's chrysanthemum stock production facilities since it replaced steam about 30 years ago. Targets include those affecting productivity and quality as well as some with regulatory implications. Those affecting productivity and quality include *Fusarium oxysporum, Erwinia carotovora, Pythium spp. Rhizoctonia solani,* and diverse weeds; freedom from certain species of nematodes (e.g. *Radopholus similis,* the burrowing nematode) is essential to meet quarantine standards established by some states.

A task team established in 1992 to reduce dependence on methyl bromide as a soil fumigant established the following criteria for selection of alternatives:

- Efficacy equal to methyl bromide
- We must be able to treat 16 growing areas per week (approximately 1.6 acres)
- Choices of alternatives to be made with due consideration of worker safety and present or anticipated regulatory impact

Given concerns over efficacy and regulatory uncertainty surrounding a number of chemical fumigants, and the lack of demonstrated efficacy of biological alternatives, we focussed on the development of steam treatment of soil. While we anticipated that steam would involve greater elapsed time, its general biocidal activity, readily available technology, and minimal concerns raised with regard to environmental impact or worker safety made it attractive.

Initial deployment of steam technology involved mobile high efficiency oil-fired boilers acquired from a German vendor. These supply superheated steam to a mobile hood drawn by a winch. The hood covered 120 sq ft and each batch took approximately 1 hr. We have since replaced the rolling hood with tarps that cover a larger area (4760 sq ft) and are simpler to use, though each batch process takes longer (approximately 8 hr). Since initial deployment we have used steam extensively in those field areas covered with fiberglass roofs; these roofs are in place to protect the crop from rain as a control measure for bacterial leaf spot.

The outline of the process for steaming is simple: the steam manifold and tarp are laid out, thermometers are introduced at several sites around the tarp, and steam is applied until soil temperatures at 8" depth reach 85°C. In the early stages of process development monitoring for survival of *Fusarium oxysporum* in soil and *Erwinia carotovora* in crop debris was frequent and intensive. When the process was fully developed and effectiveness became predictable these indicators were monitored less

frequently. Rye grass seed is still routinely introduced prior to treatment as a process check. We are not in a position to experiment with or monitor nematodes of quarantine significance, but routine monitoring by state agencies indicates that the steam treatment process is effective.

Our successes with steam do not indicate that it would be readily transferable to other crop systems. Our crop system is perhaps uniquely suited to steaming, benefiting from a pattern of continuous planting and a soil type that approaches 100% sand. While we may need to treat 70 acres, we need only treat a fraction of that each week. Steam penetrates our sandy soil rapidly and freely.

At present we are capable of routinely applying steam to 20% of our acreage as a preplant soil treatment. While highly effective as used at present, our steam process has limitations that have led us to examine chemical alternatives once again as the time runs out on methyl bromide. Problems with steam include:

- High capital and maintenance cost of boilers.
- High capital cost and short life of tarps.
- Problems of application where soils are exposed to rain immediately prior to or during a scheduled treatment.
- Fuel and labor costs