The Importance of Soil Fumigation:

Southeast Vegetables

Not Fumigated

Fumigated

Pepper Field: Georgia

Fumigant Application

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Key Points

- Vegetable production in the Southeast is very important in the diet of Americans
- Fumigation has greatly increased the production of vegetables in the Southeast
- Without fumigation, southeastern vegetable fields would be overrun with weeds
- Herbicides, fungicides and nematicides would have to be applied multiple times to substitute for fumigants
- In an organic system, more than 300 hours of handweeding per acre would be required

Technical Summary

Tomato, pepper, squash, cucumber, cantaloupe, watermelon and cabbage are grown in the Southeast in open fields on raised beds covered with plastic tarps. Production is dependent on the use of fumigants. Because of the climate, growers have the ability to produce multiple crops from a single fumigation and tarping. For example, growers often fumigate once in the spring for a pepper crop, which is followed by a summer cucurbit (squash, cucumber, cantaloupe, watermelon) crop and a late fall or winter cabbage crop before removing the plastic tarp to begin the next fumigation cycle. Tomato, pepper, cantaloupe and watermelon are usually the initial crop following fumigation. Squash, cucumber and cabbage are a second or third crop in the production cycle following fumigation [1].

In the seven southeastern states (Alabama, Georgia, Mississippi, North Carolina, South Carolina, Tennessee and Virginia), there are 121,000 acres of squash, pepper, cucumber, cantaloupe, watermelon, cabbage and tomato with an annual production of 2.5 billion pounds and value to growers of $700 million. The crops are harvested for the fresh market. The production in the Southeast accounts for about 25% of the total U.S. fresh market production of these crops.

Fumigation under plastic tarps of vegetable crops in the Southeast increased greatly in the early 1970s in conjunction with the adoption of trickle irrigation. This system resulted in remarkable yield increases [2]. The fresh vegetable industry in the Southeast has been growing continuously since the early 1970s. Watermelon yields in Georgia have doubled since the 1970s [10]. The plastic tarp system increased tomato yield three-fold [16]. The plastic warms the soil, allowing earlier planting and harvesting during periods of premium commodity prices. Early research in the 1970s showed that three crops of cucumbers could be grown after one application of fumigants with a tripling of total marketable yield [2].

Fumigants are applied to 93,000 acres of squash, pepper, cucumber, cantaloupe, watermelon, cabbage and tomato in southeastern states; this amounts to 95% of pepper and tomato, 85% of cucumber and cantaloupe, 75% of watermelon and squash and 25% of cabbage acres treated [1] [13] [14]. The cost of custom fumigation of an acre of vegetable crops in the Southeast is approximately $800/acre, excluding the cost of equipment, materials and labor associated with laying the drip tape and plastic tarp [3][15]. Fumigants are applied two to four weeks before the crop is planted to avoid the risk of crop injury. A three-way fumigant system consisting of 1,3-D, chloropicrin and metam sodium is increasingly being used in the Southeast.

Fumigants are used to suppress populations of parasitic nematodes, soilborne diseases (R*hizoctonia, Pythium, Fusarium)* and weeds beneath the plastic tarp.

The population density of *Pythium, Fusarium* and *Rhizoctonia* in soil has been shown to be reduced by over 90% with fumigation [4]. Populations of nematodes have been reduced by 90% with fumigation treatments [8].

Purple nutsedge and yellow nutsedge are the most troublesome weeds of vegetable crops in the Southeast. Purple nutsedge has been ranked as the world's worst weed species (infesting at least 52 different crops in 92 countries); yellow nutsedge has been ranked the world's 15th worst weed. In the U.S. purple nutsedge is limited to the coastal plains of the Southeast and Gulf Coasts and also the Pacific Coast of California and Oregon. Purple nutsedge thrives only in areas where the soil freezes infrequently. Yellow nutsedge is found throughout the U.S.

The nutsedge weed species have pointed shoots which cut through the plastic. Research has shown that fumigation prevents the emergence of 99% of the nutsedge plants for 33 days following laying plastic and 93% emergence prevention up to 81 days following laying plastic [11]. The three-way mixture of fumigants has been shown to reduce the emergence of nutsedge plants from 76 to zero per 20 square feet of plastic [6].

Without fumigation, weeds would also emerge through the holes that are cut in the plastic for crop transplants, where interference with the crop is maximized.

In experiments, the use of fumigants doubled pepper yields in comparison to the untreated check [5][11]. The number of marketable squash and cucumbers were doubled with fumigation treatment [7]. Research has shown that the yield of a second crop of cantaloupes was increased ten times as a result of fumigation of the first crop [9]. The yield of a second crop of squash tripled as a result of fumigating the first crop (pepper) [12]. At a north Carolina research site with no nematode problems and relatively low nutsedge populations, tomato yield in the nonfumigated plots were 20% lower than the fumigated plots [15].

Considerable research has been conducted in the Southeast to determine the potential of using herbicides as a substitute for fumigants. Results tend to underscore the need for fumigants in addition to herbicides for weed control efficacy [16]. Herbicide application alternatives include applying herbicides under the plastic, applying herbicides directly to weeds that emerge through the holes near the crop and applying herbicides over the top of established transplants.

One drawback of herbicide use for vegetable crops in the Southeast is the potential for injury. Research has demonstrated that herbicides applied under the plastic can reduce cucurbit plant growth 19–23% in comparison to the fumigant treatment. Most of the injury is a reduction in plant size (smaller plant diameters) [17]. Sensitivity may limit the use of herbicides to less than the full rates, which would jeopardize adequate weed control.

Preemergence herbicide treatment under the plastic provides about 70% control of weeds [18]. One possible explanation for the low efficacy is the limited soil longevity of the herbicides. The reported soil half-life of the herbicides ranges from 4–34 days in southern areas depending on soil moisture and temperature [16]. Furthermore, the increased soil surface temperature due to the plastic mulch, combined with soil moisture constantly near field capacity from drip irrigation, may accelerate herbicide degradation. None of the preemergence herbicides applied alone are effective in completely preventing yellow nutsedge puncturing the plastic [16].

Field studies in Georgia have evaluated combinations of herbicides for nutsedge control in pepper and cucumber. A combination of s-metolachlor, clomazone and fomesafen provided early season nutsedge control. However, nutsedge became a major problem by midseason. By the end of the season for pepper, the purple nutsedge control with the herbicide combination was 60% as compared to 95% for the fumigant [19]. In this experiment it was determined that the nematicide thiazosulfene provided nematode control equivalent to the fumigants while equivalent control of diseases was provided by the fungicides fluopicolide and mefenoxam [19].

For tomato, research has shown that a combination of s-metolachlor applied under plastic followed by postemergence applications of trifloxysulfuron and halosulfuron effectively controlled nutsedge and produced yields equivalent to fumigation [20]. Similarly, a tomato experiment with metribuzin and s-metolachlor applied under the plastic tarp provided nutsedge control equivalent to fumigation [21].

Many *Brassica* plants, such as turnip and mustard, produce glucosinolates naturally. Glucosinolates degrade into compounds such as methyl isothiocyanates (MITC) that are lethal to soilborne pests. In fact, the fumigant metam sodium degrades to MITC, which accounts for its activity as a soil fumigant. Research in the Southeast has examined the potential effects of incorporating a *Brassica* cover crop into the soil as a biofumigant. Research in tomatoes and peppers demonstrated that early season yellow nutsedge control from incorporated *Brassica* cover crops was less than 53% at two weeks after transplanting and declined to 18% later in the season [22].This research demonstrated that *Brassica* cover crops have marginal potential and cannot be used as stand-alone fumigant replacements. The limited weed suppression is the result of the low amount of MITC released into the soil after incorporation [23]. Research has shown that the total amount of potential isothiocyanate release from a biofumigant plant mixture was 70 times lower than the MITC produced by metam sodium.

In a plastic tarp organic pepper research plot, it was determined that 320 hours of handweeding per acre was required for effective nutsedge control [24].

References

1. Hall, C. and Culpepper, A.S. 2006. Responses to the Chloropicrin Risk Assessment (Phase 3 of 6) EPA-HQ-OPP-2006-0661;FRL-8087-4. Georgia Fruit and Vegetable Growers Association and The University of Georgia.
2. Johnson, A.W., Sumner, D.R and Jaworski, C.A. 1979. Effects of management practices on nematode and fungus populations and cucumber yield. *Journal of Nematology*, 11(1):84.
3. 2009 Maltag Conventional Vegetables Planning Budgets. 2009. University of Georgia Ag Econ-09-004.
4. Seebold Jr., K.W. and Csinos, A.S. 2002. Effect of selected fumigants on soilborne fungi. *Proceedings of the 2002 Georgia Vegetable Conference*. January 11-13, Savannah, Georgia.
5. Culpepper, A.S. et al. 2009. Methyl bromide alternatives update. *Proceedings of the 2009 Southeast Regional Vegetable Conference*. January 9-11, Savannah, Georgia.
6. Culpepper, A.S. et al. 2007. Methyl bromide alternatives – best options for 2007. *Proceedings of the 2007 Southeast Regional Vegetable Conference*. January 4-7, Savannah, Georgia.
7. Csinos, A.S., Seebold, K.W., Timper, P. and Laska, J.E. 2001. Telone C-17, metam sodium combinations for efficacy and evaluation of phytotoxicity in squash. *Georgia Vegetable Extension – Research Report 2001*. The University of Georgia and USDA.
8. Csinos, A.S., Seebold, K.W., Timper, P., Davis, R.F. and Laska, J.E. 2001. Application methods of soil chemical treatments on nematodes, disease and yield of cucumber. *Georgia Vegetable Extension – Research Report 2001*. The University of Georgia and USDA.
9. Csinos, A.S., Desaeger, J.A.J. and Laska, J.E. 2002. Evaluation of drip-applied fumigants on cantaloupe, following a crop of eggplant, for yield increase and nematode control. *Georgia Vegetable Extension – Research Report 2002*. The University of Georgia and USDA.
10. Fonsah, E.G. 2006. Historical perspectives and market trends for watermelons in Georgia. *Proceedings of the 2006 Southeast Regional Vegetable Conference*. January 5-8, Savannah, Georgia.
11. Culpepper, A.S. and Langston Jr., D.B. 2003. Performance of methyl bromide alternatives in pepper. *Proceedings of the 2002 Georgia Vegetable Conference*. January 10-12, Savannah, Georgia.
12. Webster, T.M. et al. 2001. Methyl bromide alternatives in a bell pepper-squash rotation. *Crop Protection*, 20:605-614.
13. Norsworthy, J.K. and Meister, C.W. 2007. Tolerance of cantaloupe to postemergence applications of rimsulfuron and halosulfuron. *Weed Technology*, 21:30-36.
14. Davis, R.M. et al. 1998. The Importance of Pesticides and Other Pest Management Practices in U.S. Tomato Production. USDA National Agricultural Pesticide Impact Assessment Program No. 1-CA-98.
15. Sydorovych, O. et al. 2008. Economic evaluation of methyl bromide alternatives for the production of tomatoes in North Carolina. *Hort Technology*, 18(4):705-713.
16. Adcock, C.W. et al. 2008. Herbicide combinations in tomato to prevent nutsedge (Cyperus esulentus) punctures in plastic mulch for multi-cropping systems. *Weed Technology*, 22:136-141.

17. Webster, T.M. 2001. Sandea® has a variable affect on squash growth and yield. *Georgia Vegetable Extension – Research Report 2001*. The University of Georgia and USDA.
18. Jennings, K.M., Buckelew, J.K and Monks, D.W. 2005. Post-directed herbicides for plasticulture tomato. *Proceedings of the 2005 Southern Weed Science Society*, 58:166.
19. Ji, P., Langston, D.B., Grey, T.L. 2011. Non-fumigants as methyl bromide alternatives for managing vegetable diseases and weeds. *Proceedings of 2011 Annual International research Conference on Methyl Bromide Alternatives and Emissions Reductions*. San Diego, California.
20. Devkota, P. et al. 2011. Effectiveness of herbicide programs compared to methyl bromide for weed control in plasticulture tomato. *Proceedings of the Southern Weed Science Society*, 64:310.
21. Langston, D., Sanders, F.H., Culpepper, S., and Foster, M.J. 2002. Methods of controlling soil-borne pests of vegetables utilizing non-fumigant pesticides. *Proceedings of the 2002 Georgia Vegetable Conference*. January 10-12, Savannah, Georgia.
22. Bangarwa, S.K. et al. Biofumigation potential of Brassicaceae cover crops for weed control in plasticulture tomato and bell pepper. *Proceedings of the 2010 Southern Weed Science Society*, 63:171.
23. Bangawara, S.K, Norsworthy, J.K., Rainey, R.L. and Gbur, E.E. 2010. Economic returns in plasticulture tomato production from Crucifer cover crops as a methyl bromide alternative for weed management. *Hort Technology*, 20(4):764.
24. Bangawara, S.K, Norsworthy, J.K., Jha, P. and Malik, M. 2008. Purple nutsedge (Cyperus rotundus) management in an organic production system. *Weed Science*, 56:606-614.