

MAPPING YOUR ROUTE TO THE FUTURE

Great Lakes Fruit, Vegetable & Farm Market EXPO

DeVos Place Convention Center
Grand Rapids, MI
December 7-9, 2004



Asparagus

Tuesday morning 9:00 am

Where: Gallery Overlook Room E-F (upper level)

Recertification credits: 1 (Private, 1B)

CCA Credits: IPM(1.5)

Moderator: Norm Myers, Oceana Co. MSU Extension

- 9:00 a.m. Michigan Asparagus Advisory Board Update and the Results of the 2004 Length of Harvest Study
- John Bakker, MI Asparagus Advisory Board
- 9:30 a.m. Fumigating Asparagus - Lessons Learned From Other Crops
- Brian Cortright, Plant Pathology Dept. MSU
 - Mary Hausbeck, Plant Pathology Dept., MSU
- 9:50 a.m. Foliar and Soil Borne Diseases of Asparagus
- Mary Hausbeck, Plant Pathology Dept., MSU
- 10:30 a.m. Asparagus Weed Control Update
- Bernard Zandstra, Horticulture Dept., MSU

Fumigating Asparagus-Lessons Learned From Other Crops

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The persistent soil-borne pathogens *Fusarium* and *Phytophthora* are present in many asparagus fields and threaten to shorten the time commercial fields will remain productive. Crop rotation is the most cost effective control measure and is the cornerstone for managing disease. However, crop rotation alone is not adequate for *Phytophthora* and *Fusarium* control. There are no asparagus varieties available at this time that are resistant to soil-borne pathogens. Soil fumigation has been used successfully on other vegetable crops to control related soil-borne pathogens. Fumigation can be expensive due to cost of product and application techniques. Proper application of fumigants maybe helpful in limiting soil-borne pathogens if the pathogen is not reintroduced to the field by infected crop residue, soil, water, or other means.

FUMIGATION TECHNIQUES

Proper application of all fumigants is reliant on adequate soil temperatures, soil moisture, soil structure and sealing the fumigant into the soil. Fumigants become a gas when they are released into the soil and encounter moisture. This gas can penetrate most soil types if conditions are correct. Fumigants act by exposing soil-borne pests to high concentrations of toxic gases for a specific amount of time. Dense soil clods, too much moisture, and excessive organic matter from previous crops can limit the movement of the fumigant and allow pockets of pests to survive.

Soil temperature and moisture: For most fumigants to be effective, soil temperature needs to be maintained above 50°F. This insures that the fumigant will become a gas and that the target pests are actively respiring and will be affected by the fumigant. If soil temperatures are too high, the fumigant will escape the soil too rapidly and will not remain in contact with the pest for the required amount of time. Proper soil moisture is important as it allows the fumigant to become a gas that can move through the soil. Ideal conditions are when the soil is at 50 to 80% field capacity. This can be easily checked by compressing a ball of soil with your hands. If the soil moisture is correct, the ball of soil will just maintain its shape when released from your grip. If the ball falls apart easily, then the soil is too dry for fumigation. Soil that is too dry will again allow the gas escape too quickly. To determine if the soil is dry enough, you should be able to poke the ball of soil and have it crumble apart. Soil that is too wet will not allow the gas to move throughout the soil and be ineffective against the target pest. Adequate soil moisture is critical for drip-applied fumigation in very sandy soils. Soils with higher silt and clay content allow for more uniform movement of water and better pest control when using drip-applied treatments.

Soil structure and sealing: The soil should be well worked and in seed-bed condition before fumigation. Cover crops should be killed and worked into the soil at least 4-6 weeks before fumigating. The soil should be worked to the depth that the injection knives will be set to insure proper depth of application. Soil and residue clumps should be destroyed to insure exposure of the pest to the fumigant. After application, most fumigants will need to be sealed into the soil using either plastic tarp or by packing the soil with machinery. Both methods form a moisture seal at the top of the soil which traps the fumigant for the required exposure time.

Application depth: Fumigants need to be placed at the proper depth to control the target pathogens. Most fumigants will move downward into the soil and can spread up to 12 in. from the injection point. Other fumigants can travel only a limited distance and need to be injected at multiple locations in the soil or incorporated. Other fumigants can be applied with water and drenched through the soil. While this latter method can be very effective, care must be taken not to wash the fumigant out of the target area by over applying the water. It is also important to apply enough water to move the fumigant across the entire target area.

Timing of application: Soil and weather conditions are more favorable in the fall and allow for more time for proper fumigation application. Spring fumigation can be done with proper planning and if fumigants with short plant-back intervals are used. Some fumigants can require up to 21 days of off-gassing before a crop can be planted. Cooler temperatures and excessive moisture can lengthen the plant-back interval.

Fumigation products: Different fumigants can be more effective on certain pests than others. Some products work very well on soil-borne fungi but cannot control weed or nematode populations. Other products are only effective on controlling nematodes or weeds, but are ineffective against fungal pathogens. For this reason many fumigants are applied as tank-mixes or used in combination with other fumigants to increase the spectrum of activity. This makes fumigation more cost-effective as the tank-mixes and combinations control a wider range of pests.

Most of the existing soil-applied fumigants are labeled for use on all crops. Methyl bromide is most commonly used in combination with chloropicrin in either a 50:50 or 67:33 ratio. This combination is widely used for all soil-borne pests and is considered to be the most effective fumigant under a wide range of soil and temperature conditions. The use of Methyl bromide has been curtailed due to ozone depletion concerns, and future use will be strictly limited to critical use exemptions. Other products such as chloropicrin alone (100%), metam sodium (Vapam™), metam potassium (K-Pam™), and the combination of 1,3-dichloropropene and chloropicrin (Telone C-35™) have been proven effective for some soil-borne pests. Further work is needed to find the right combination of products that provide the broadest pest control range.

FUMIGATION RESEARCH

Fumigant tests on vegetable crops: Preliminary studies have been conducted by Michigan State University for the last three years on a wide range of vegetable crops including; eggplant, melon, pepper, pumpkins, tomatoes, winter squash, water melon, and zucchini. The goal of these studies is to find a replacement product or combination of products for the use in place of Methyl bromide. The main pest of the studies was *Phytophthora capsici*, a species of soil-borne *Phytophthora* which affects a large number of vegetable crops. Trials were done on commercial vegetable farms that have had a history of severe *Phytophthora* pressure. Materials were applied via swept-back knives or through installed drip tape to 6 in. high raised beds. All of the treatments were covered with LDPE plastic at the time of bed formation. Drip applications were made using two drip tapes per bed to ensure proper placement of product and thorough water movement. Results from these trials are encouraging with products such as K-pam HL™ (metam potassium), Telone C- 35™ (1,3-dichloropropene/chloropicrin), and Midas™ (iodomethane) providing significant control of *P. capsici* (Table 1) similar to Methyl bromide. Multiple years of testing these products have shown that proper application of both the shank-injected and drip applied treatments was needed to obtain consistent control. Treatments that had combinations of chloropicrin applied by shank then followed by drip applied K-Pam HL™ were the most effective in 2004. Drip-applied applications of the experimental product SEP-100 (sodium azide) was also very effective but did cause some early plant stunting of seeded and transplanted crops.

Wet soil conditions in 2004 formed soil clods when the soil was worked, which could have hindered gas movement of the shank-applied materials. The soil needed additional cultivation to remove the soil clods and form uniform soil structure before fumigation.

Table 1. Plant death evaluations of fumigants for managing *Phytophthora* crown and fruit rot of melon and watermelon, 2004.

Treatment	Rate/acre	Application method ^z	Plant death ^x	
			Melon	Watermelon
Untreated			8.8 cd ^y	3.3 b
SEP 100	42 gal	Drip	4.3 ab	0.5 a
Methyl bromide/Chloropicrin (67/33) .	350 lb	Shank	2.0 a	1.0 ab
Telone C35 TM	35 gal	Shank	6.0 bc	3.3 b
Chloropicrin K-Pam TM	25 gal 30 gal	Shank Drip	0.0 a	0.0 a
Chloropicrin K-Pam TM	25 gal 60 gal	Shank Drip	0.0 a	0.0 a
Midas TM /Chloropicrin (33/67)	300 lb	Shank	0.0 a	2.3 ab
Propozone TM	80 gal	Shank	9.0 d	3.8 b
Chloropicrin	25 gal	Shank	1.8 a	3.0 b
K-Pam TM	60 gal	Drip	0.3 a	0.8 a
K-Pam TM	30 gal	Drip	0.8 a	0.0 a

^zMaterials were applied at time of bed formation using swept back knives or pre-plant through drip tape.

^yColumn means with no letter or a letter in common are not significantly different, SNK, $P=0.05$.

^xMean number of melon and watermelon plants killed by disease out of nine original plants.

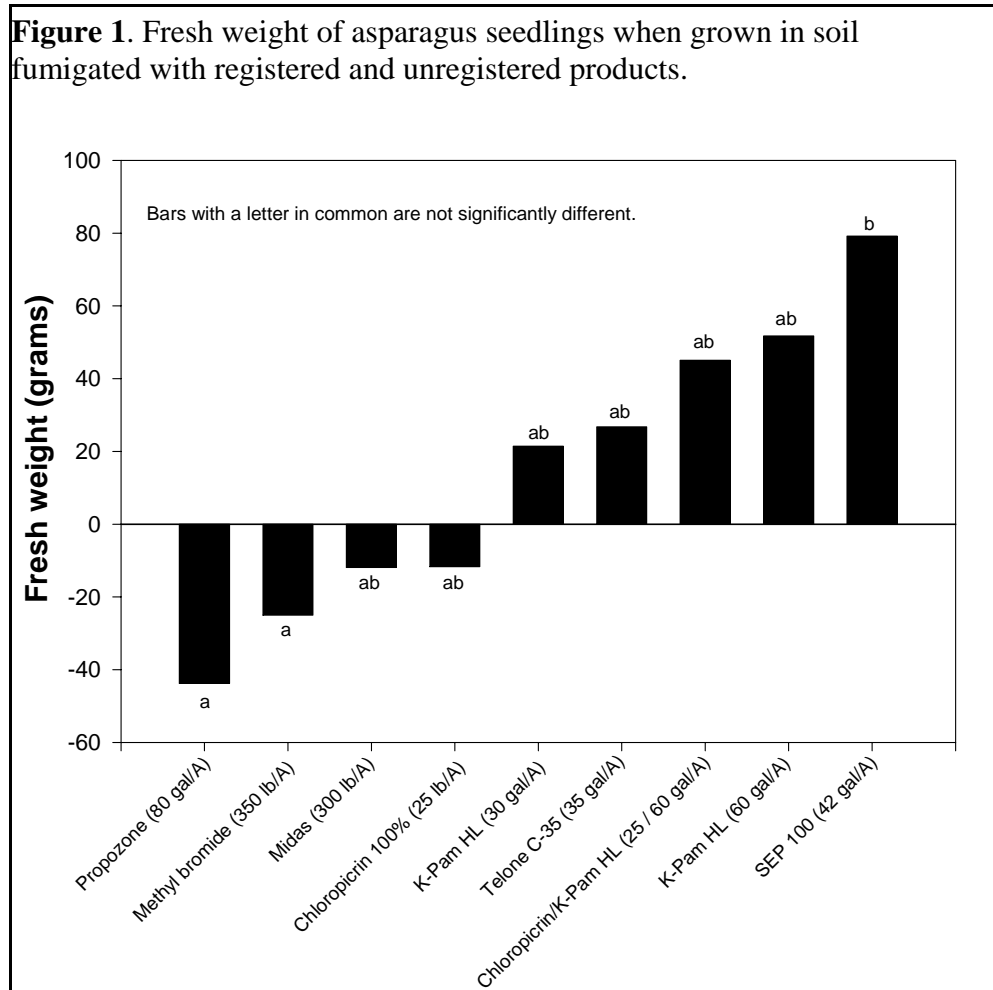
Fumigant tests on asparagus: A similar trial was conducted on asparagus seedlings in 2004 to determine the effectiveness of fumigants for the control of *Fusarium* crown and root rot. The study was conducted on a cooperators farm with a known history of *Fusarium*. Prior to bed formation, the plot was worked to a depth of 10 to 12 in. Raised beds were formed (Rainflo 2550 bed former) with shank-injected treatments being applied on 26 May. Treatments were applied using swept back gas knives on an 8-in spacing at a depth of 10 to 12 in. from bed top. Treatment beds were covered in black plastic mulch (1.25 mil embossed) that were 40-ft long and 25-in. wide at the top and 27-in. wide on the bottom. Beds were 6-in. high with a slight crown and with a 64-in spacing of bed centers. Two drip lines (8 mil with 8 in. emitter spacing and a flow rate of 0.4 GPM for 100 ft of row) were installed 8 in. apart and 1 in. below the plastic during bed formation. Drip treatments were applied on 28 and 29 May using a stainless steel nitrogen apparatus. Applications consisted of pre-irrigating for 30 min, treatment application for 90 min, and post-irrigating of 30 min. Treatments were premixed with water in a 1:1 ratio to form an emulsion before application into the drip tape system. Applications were made at a drip tape operating pressure of 12-15 psi and treatment application at a operating pressure of 25-30 psi regulated with flow regulators (TeeJet CP4916-16) with material being prevented to back flow using spring loaded check valves.

Each treatment row had five 6-in. wide by 8-ft. long sections removed in the center of the beds leaving 12-in. strips to keep the plastic from blowing and was done to facilitate planting. Beds were planted on 15 Jun using a V-belt planter with an approximate seed spacing of 1-in. and a depth of 1 in. Seedlings were harvested on 28 Sep and transported in coolers to storage. Seedlings were weighed and root lengths measured. Crown rating consisted of counting lesions on roots and fern, root health (1=healthy, 10=dead), fern health (1=healthy, 10=dead), and plant vigor (1=clean robust seedlings, 10=dead). All seedlings in the 40-ft. row were evaluated for crown ratings and root length, while 50 random selected seedlings were used for seedling weight.

This plot received heavy rains prior to and after bed formation. Prior to planting the plot received an inch of rain in approximately 15 minutes that washed over and destroyed several beds. SEP 100 showed early phytotoxicity and a reduced stand but was able to recover by the end of the study to have some of the healthiest seedlings.

In evaluating the seedlings, treatments of K-Pam HL™ (60 gal/A), SEP 100 (42 gal/A), and Chloropicrin/K-Pam HL™ (25 gal/A, 60 gal/A) consistently had better ratings than the rest of the treatments. Treatments that had less desirable ratings were typically ones that were shank-injected, however, this may be due to movement of the gas down the row between treated and untreated sections. When comparing the yields between the untreated and treated sections treatments of K-Pam HL™(30 & 60 gal), Telone C-35™, Chloropicrin/K-Pam HL™, and SEP 100 had positive increases in seedling weights compared to the untreated (Fig 1.). The treatment SEP 100 had significantly higher yields than the Propozone™ and Methyl bromide treatments.

Results from the asparagus study are preliminary and additional studies are needed to determine which products will offer consistent control of *Fusarium*. Since this study only looked at shallow-rooted seedlings, results could differ if fumigants were applied to commercial production fields. Future studies will utilize data collected from 2004 to develop a test program for screening fumigants on asparagus seedlings.



Foliar and Soil-Borne Diseases of Asparagus

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Rust

Rust disease of asparagus is caused by the fungus, *Puccinia asparagi*, and is a problem on fern following harvest of spears. Rust pustules do not occur on harvested spears. The rust fungus produces several types of spores. Basidiospores develop in very early spring on the overwintering asparagus debris which harbors the overwintering teliospores from the previous fall. When the basidiospores infect asparagus fern, the resulting lesions are oval and light orange. The lesions eventually turn a bright orange color due to the production of aeciospores. Aeciospores are an early source of inoculum for rust epidemics and are typically first seen on volunteer asparagus and on young plants that are not harvested. Air currents and splashing rains carry the orange aeciospores from the pustules to other branches and needles (cladophylls) where they germinate and cause new pustules when dew or rain occurs.

The next stage of the rust life cycle that occurs is the repeating or uredial stage. Uredospores are produced in great numbers and may resemble a reddish dust. They germinate in the presence of moisture and within 10 to 14 days cause infections and yield a new generation of spores. A relatively small number of uredia can reproduce rapidly to cause significant and damaging levels of disease. Uredial lesions occur in mid- to late- summer. The final stage occurs in late summer with production of the black teliospores, which overwinter in plant debris.

The fungus causing rust can attack all aboveground parts, and severe infections can stunt or kill young shoots, and can defoliate plants. Damage is most severe when fern is attacked several years in a row. During spear harvest, asparagus plants deplete stored carbohydrates from the root and crown which are replenished during fern growth. If the fern becomes infected by rust, it may turn yellow, then die early in the summer, thereby reducing the time for replenishing the reserves in the crown. When the storage reserves are reduced in the crown, subsequent yields are reduced. Plants stressed by rust infection may be more susceptible to Fusarium crown and root rot. Research studies indicate that the disease can have an additive negative impact over time on yield. For instance, yield losses ranged from 2-23% (depending on the cultivar) after one year of rust infection. However, after two years of rust infection, yield losses increased and ranged from 11-54%.

Since rust can reduce the yield and longevity of an asparagus field, disease management is needed. Resistance to rust in some asparagus varieties has been identified and found to reduce the intensity of rust infection. Varieties with this type of resistance are called "slow-rusting." However, even slow-rusting varieties can become severely diseased. Interrupting the aeciospore stage in the early spring prevents development of the repeating uredospore stage and dramatically decreases the need for fungicide sprays later in the season. Using slow-rusting varieties, removing volunteer plants, scouting fields and applying fungicides early in the season before rust becomes established is a sound management practice.

A field trial in 2004 tested registered and unregistered products for ability to manage rust on asparagus (Table 1). All treatments, with the exception of Switch, significantly reduced rust compared to the

untreated plants (foliar rating = 6.5) (Table 2). Folicur (0.25 or 0.38 pt) alternated with Bravo Ultrex proved especially effective (foliar rating = 1.8) for controlling rust. Folicur has been available to Michigan growers through a yearly Section 18 label. Treatments that limited disease development to a rating <3.0) included the industry standard, Bravo Ultrex, alone or in alternation with the reduced risk fungicides, Amistar, or Pristine.



Fig. 1A. Watersoaked spears

Table 1. Products used in the 2004 asparagus trial.

Product	Active ingredient	Company	Registered
Amistar 80WG	azoxystrobin	Syngenta Crop Protection Inc.	yes
Bravo Ultrex 82.5WDG	chlorothalonil	Syngenta Crop Protection Inc.	yes
Captan 50WP	captan	Helena Chemical Co.	no
Endorse 2.5WP	polyoxin D zinc salt	Cleary Chemical Corp.	no
Endura 70WG	boscalid	BASF Ag Products	no
EXP 1	experimental	–	no
Folicur 3.6SC	tebuconazole	Bayer CropScience	Section 18
Penncozeb 75DF	mancozeb	Cerexagri Inc.	yes
Pristine 38WG	pyraclostrobin + boscalid	BASF Ag Products	no
Serenade Max 20WP	<i>Bacillus subtilis</i>	AgraQuest Inc.	no
Switch 62.5WDG	cyprodinil + fludioxonil	Syngenta Crop Protection Inc.	no

Table 2. Evaluation of fungicides for control of rust of asparagus.

Treatment and rate/A, applied at 14-day intervals	Foliar rating*	
Untreated	6.5	e**
Folicur 3.6SC 0.25 pt alternate Bravo Ultrex 82.5WDG 1.82 lb	1.8	a
Folicur 3.6SC 0.38 pt alternate Bravo Ultrex 82.5WDG 1.82 lb	1.8	a
Amistar 80WG 0.31 lb alternate Bravo Ultrex 82.5WDG 1.82 lb	2.4	ab
Pristine 38WG 1.16 lb alternate Bravo Ultrex 82.5WDG 1.82 lb	2.5	ab
Bravo Ultrex 82.5WDG 1.82 lb	2.8	ab
Captan 50WP 4 lb + Endorse 2.5WP 2.2 lb	3.3	ab
Endura 70WG 0.5 lb alternate Bravo Ultrex 82.5WDG 1.82 lb	3.4	ab
Penncozeb 75DF 1 lb alternate Bravo Ultrex 82.5WDG 1 lb	3.8	abc
Penncozeb 75DF 2 lb	3.8	abc
Bravo Ultrex 82.5WDG 0.6 lb	4.0	abc
Serenade Max 20WP 2 lb alternate Bravo Ultrex 82.5WDG 1.82 lb	4.0	abc
EXP 1 + Bravo Ultrex 82.5WDG 0.6 lb	4.5	bcd
Switch 62.5WDG 0.63 lb	5.8	cde
Switch 62.5WDG 0.31 lb	6.0	de

*Rated on a scale of 1 to 10, where 1=no disease, 5=needle drop, 10=100% defoliation.

**Column means with a letter in common are not significantly different (Student-Newman-Keuls; $P=0.05$).

Phytophthora crown and spear rot

Phytophthora crown and spear rot is caused by the soilborne organism *Phytophthora megasperma* Drechs. *Phytophthora megasperma* is self-fertile and requires only one mating type to produce oospores. Oospores can survive in soils for prolonged periods of time, and their germination is favored by excessive rain and warm temperatures. *Phytophthora megasperma* also produces swimming spores (zoospores) that are easily spread through water, particularly during very wet years.

In spring 2004, Phytophthora crown and spear rot was detected on asparagus samples collected from fields in northwest and southwest Michigan and the Michigan State University Plant Pathology Farm. Initially, emerging spears appeared water-soaked with lesions at just above or below the soil line (Fig. 1A). Lesions rapidly enlarged and turned light brown. As disease progressed, the infected side of the spear flattened, while the rest of the spear became extremely curved and shriveled, leading to collapse (Fig. 1B). Infected storage roots were firm but eventually appeared water-soaked and shriveled as lesions expanded (Fig. 2A). Root mass and vigor were extremely reduced (Fig. 2B).



Fig. 1B. Shriveled spear

Tests are being conducted to determine whether the *Phytophthora* isolated from asparagus can infect cucurbit fruits (cucumbers, zucchini, and acorn squash) and alfalfa, red clover, and soybean. Preliminary tests on pickling cucumbers showed that *Phytophthora megasperma* from asparagus could cause fruit rot. Testing the ability of *Phytophthora* isolated from asparagus to infect these crops will help determine which crops could be used in rotation.

Molecular methods are being used for DNA fingerprinting of the *Phytophthora* recovered from asparagus to investigate differences between *P. megasperma* sampled from asparagus fields in the same region and from different geographic locations.



Fig. 2A. Watersoaked roots

Phytophthora megasperma isolates were tested for sensitivity to the fungicide Ridomil Gold EC (mefenoxam), and all isolates were sensitive. Therefore, this fungicide could potentially be helpful in limiting *Phytophthora* on asparagus. A preliminary study to evaluate the performance of Ultra Flourish, a mefenoxam-based fungicide, was conducted in a *P. megasperma*-infested field. The fungicide was applied every 21 days at the rate of 4 pt/A through drip irrigation, from June to September 2004. The number of dead or diseased plants was low in treated rows and was reduced up to 32% compared to untreated plants (Fig. 3).



Fig. 2B. Healthy (left) and infected (right) roots.

These results suggest that Ridomil Gold EC and Ultra Flourish have potential in reducing Phytophthora crown and spear rot on asparagus; however, getting the fungicide to the affected crown region will be a challenge.

Fig. 3. *Phytophthora* on Asparagus

