# Asparagus

## Tuesday morning 9:00 am

**Where:** Grand Gallery (lower level) Room C

**Recertification credits: 1 (1B, PRIV OR COMM CORE)**
**CCA Credits: PM(0.5) CM(1.0)**

**Moderator:** Norm Myers, Oceana Co. MSU Extension

9:00 a.m. Managing Replant Suppression with Horticultural Strategies

- Mathieu Ngouajio, Horticulture Dept., MSU
- Buck Counts, Plant Pathology and Horticulture Dept., MSU

9:30 a.m. Michigan Asparagus Advisory Board Update

- John Bakker, Michigan Asparagus Advisory Board, Dewitt, MI

9:45 a.m. New Management Techniques for Fusarium and Phytophthora Control in Asparagus Production

- Mary Hausbeck, Plant Pathology Dept., MSU
- Brian Cortright, Plant Pathology Dept., MSU

10:25 a.m. Irrigation and Rye Living-Mulch in Asparagus Production

- Daniel Brainard, Horticulture Dept., MSU

# MANAGING REPLANT SUPPRESSION WITH HORTICULTURAL STRATEGIES: TRANSPLANTS AND SOIL AMENDMENT

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## Introduction and rationale

Asparagus replant suppression is a major threat to asparagus production worldwide. The problem is more pronounced in areas with a long tradition of asparagus production where virgin land is limited. Under those conditions early decline and stand reduction are observed in newly replanted fields and the life span of the fields can easily be reduced to 5-10 from 15-20 years as they are abandoned prematurely. Fungicides and soil fumigants are use to help reduce the impact of the problem. If proven effective, disease free planting materials like greenhouse-grown transplants and crop management practices that help improve soil quality could potentially be added in the tool box for management this scourge.

## Objective

The overall goal of this work is to test effects of alternative planting methods and soil amendments on asparagus replant suppression. Specific objectives were 1) Determine optimum plug cell size for transplant production in the greenhouse, 2) test the effect of soil amendment and biofumigants cover crops in a replant situation.

## STUDY I. Effect of plug cell size on transplant growth

### *Methodology*

Millennium asparagus seed was surface disinfested using a solution of benomyl and acetone following the procedure described by Damicone (Damicone). Plug trays (38 to 200 cells per tray) were filled with soilless potting media (Baccto Professional Planting Mix, Michigan Peat Company, Houston, TX) and a single seed was planted 1.25 cm deep in the center of a plug and covered with potting media. Trays were placed in a completely randomized design in a greenhouse at Michigan State University. Water was applied as needed with 50-75 ppm of 20N-20P-20K (MoraLeaf) fertilizer being applied once plants emerged at the time of watering and all watering events thereafter. The average temperature in the greenhouse was 24 Celsius and with supplemental lighting provided by high pressure sodium lamps (P.L. Light Systems, Beamsville, ON, Canada) day length was 12 hours.

Evaluation of transplant growth was initiated 2 weeks after seedlings emerged and was repeated every 2 weeks for a total of 7 samplings. Three sets of 5 plugs were taken for each of the cell sizes. The growing media was removed and the root balls were washed to remove any remaining media. Fern was then cut from the crown with the number of shoots, shoot length, shoot fresh weight, root length and root fresh weight recorded. Seedlings were then placed in paper bags and placed in an air dryer (temp) for 14 days with the shoot and root dry weights recorded at that time.

### *Results*

Asparagus transplants are normally grown for a minimum of 8 weeks (8-10 weeks) in the greenhouse prior to being transplanted in production fields. Therefore, only results for transplants 8- weeks or older are presented here.

Asparagus root size is the most important factor that determines successful field establishment. The shoot is important during transplant production but the fern present at planting normally dies and the new fern is formed using reserves stored in the crown. As a general trend, transplant weight increased as plug cell size increased (Table 1and 2). Shoot and root weights were maximized with larger cells (38-cell flats) compared to smaller cells (200-cell flats). This observation was true for both fresh and dry weight. This study can be summarized into to two key observations:

1) Use large cells whenever possible for asparagus seedling production. The ultimate cell size will depend on the final cost of each transplant since trays with large cells take more space and time per plug.

2) Extend the growing period of the seedling to match the specific cell size used. It is important to remember that once the cell volume is filled with the root system, there is no additional advantage of extending the growth period of the seedling. For example the root system filled the cells in about 8 to 10 weeks for the 128 and 200 cell trays. In contrast, the root system was still growing even after 14 weeks in the 38 cell trays.

**Table 1. Asparagus shoot fresh weight at 8, 10, 12, and 14 weeks after emergence for 9 plug sizes in 2007.**

| **Treatment** | **8 weeks** | **10 weeks** | **12 weeks DAE** | **14 weeks** |
|---|---|---|---|---|
| **(Cell number)** | weight (g) | weight (g) | weight (g) | weight (g) |
| 38 deep | 5.50 b | 11.33 a | 23.39 a | 27.03 a |
| 38 shallow | 7.80 a | 11.04 a | 18.83 b | 28.68 a |
| 50 | 4.97 bc | 9.54 b | 16.04 c | 15.85 b |
| 72 square | 4.17 cd | 6.11 c | 8.98 d | 10.59 c |
| 72 octagon | 3.60 d | 5.40 c | 9.38 d | 9.80 c |
| 84 | 2.37 e | 4.42 d | 6.00 f | 7.16 d |
| 98 | 2.58 e | 4.42 d | 7.71 de | 8.45 cd |
| 128 | 2.32 e | 3.38 e | 6.72 ef | 6.39 d |
| 200 | 1.57 e | 2.21 f | 2.91 g | 3.60 e |
| **LSD** | **1.02** | **0.83** | **1.70** | **2.34** |
| **p-value** | **<0.0001** | **<0.0001** | **<0.0001** | **<0.0001** |

**Table 2. Asparagus root fresh weight at 8, 10, 12, and 14 weeks after emergence for 9 plug sizes in 2007.**

| **Treatment** | **8 weeks** | **10 weeks** | **12 weeks DAE** | **14 weeks** |
|---|---|---|---|---|
| **(Cell number)** | weight (g) | weight (g) | weight (g) | weight (g) |
| 38 deep | 8.75 a | 19.54 a | 22.67 a | 35.63 a |
| 38 shallow | 6.50 b | 14.22 b | 17.53 b | 34.88 a |
| 50 | 6.37 b | 10.58 c | 17.46 b | 19.39 b |
| 72 square | 3.44 cd | 7.27 d | 10.04 d | 11.00 c |
| 72 octagon | 4.14 cd | 9.01 c | 12.60 c | 11.59 c |
| 84 | 2.93 de | 5.80 d | 7.16 e | 7.68 d |
| 98 | 4.40 c | 5.76 d | 8.97 de | 9.66 cd |
| 128 | 2.90 de | 3.98 e | 6.97 e | 8.83 d |
| 200 | 1.85 e | 2.67 e | 3.80 f | 4.44 e |
| **LSD** | **1.43** | **1.61** | **2.38** | **2.07** |
| **p-value** | **<0.0001** | **<0.0001** | **<0.0001** | **<0.0001** |

**STUDY II. Effect of soil amendment**

***Methodology***

Two trials were established on commercial farms in Oceana County, MI in the spring of 2007. All sites were replant situations. The two studies followed production practices for each grower cooperator. Field one used non-treated (cannonball) crowns planted in a non-fumigated seedbed. The major difference between the two sites was that one field (A) was unfumigated and the other (B) was fumigated with Sectagon 42 at 75 gal/A.

Field A used untreated crowns planted into an unfumigated seedbed. This trial was planted on 23 May 2007 using Millennium crowns (about 77 g each). Rows were spaced 5 ft on center and crowns were spaced every 12 inches.

Field B used treated (cannonball) crowns planted in a fumigated seedbed. The crowns were planted on 6 June 2007, using Millennium asparagus crowns (about 60 g each). Double rows were spaced 5 ft on center and crowns were spaced every 14 inches in each of the two staggered rows.Treatments included:

1) Dairy compost (10 t/acre in 2007 and 5t/acre in 2008);
2) Mustard bran (2 t/acre);
3) SoilBuilder® (2 gal/acre after TerraClean® at 2 gal/acre) Microbial soil amendment;
4) Control with treated crowns;
6) Frame (proprietary soil amendment combination; not registered)
5) Control with untreated crowns (site A only)
6) TerraClean® (site B only)

In 2007 all treatments were applied at planting except for TerraClean which was applied about two weeks later. In 2008, treatments were applied on May 9 and 13 for site B and site A, respectively using the same rates used in 2007 except for the compost that was reduced to 5 t/A. Plot management was conducted by the growers following commercial production standards.

Ratings were taken for fern health, fern height, plant stand, and shoots per 10 plants on 25 Oct 2007 for both trials. Due to a heavy cover crop only fern health and shoots per 10 plants were recorded for field B in 2007. In 2008, ratings were, taking on Aug 12 and 20. Soil samples were also collected at 6 and 12 inches on Aug 12 and Sept 3 for soil microbial analyses.

***Results***

For the 2008 season there were no significant benefits of applying any of the soil amendments at Site B (Table 3 and 4). At Site A, compost treatments had significantly more dead shoots than the untreated control or any of the other amendments. It is important to note that shoots in the compost treatment looked taller and larger probably due to the additional nutrients provided by the compost.

In all trials (Site A and B) soil samples from the compost treatment showed the highest microbial biomass (Table 5). However, the high microbial biomass in the compost treatment did not translate into higher microbial functional diversity. This suggests that compost application alone increased the size of the microbial population but without any change in the composition of the microbial population. On the other hand, mustard bran treatment showed high microbial diversity suggesting that there are more functional groups under that treatment (Table 7).

**Table 3. Effect of soil amendment on asparagus performance under a replant situation in non-fumigated beds (Site A). 2008 evaluation**

| Treatment | Plants per 25 ft | Number of shoots | Dead shoots | Plants with dead shoots |
|---|---|---|---|---|
| Untreated control | 24.5 | 81.2 | 9.7 b* | 9.7 b |
| Mustard bran | 24.0 | 86.0 | 9.5 b | 7.0 b |
| Soil Builder® | 23.7 | 83.2 | 10.5 b | 8.5 b |
| Treated control | 24.2 | 81.0 | 9.0 b | 6.2 b |
| Compost | 25.0 | 77.2 | 22.2 a | 15.5 a |
| **LSD** | **NS** | **NS** | **8.2** | **4.1** |

* Treatments with the same letter are not significantly different (P = 0.05, LSD)

**Table 4. Effect of soil amendment on asparagus performance under a replant situation in fumigated beds (site B). 2008 season evaluation.**

| Treatment | Plants per 25 ft | Number of shoots | Dead shoots | Plants with dead shoots |
|---|---|---|---|---|
| Treated control | - | 193.2 | 3.0 | 3.0 |
| Mustard bran | - | 195.5 | 3.0 | 2.7 |
| TerraClean® | - | 167.2 | 4.0 | 3.7 |
| SoilBuilder® | - | 166.0 | 3.7 | 3.5 |
| Compost | - | 194.5 | 5.2 | 4.7 |
| **LSD** | **-** | **NS** | **NS** | **NS** |

* Treatments with the same letter are not significantly different (P = 0.05, LSD)

**Table 5. Effect of various soil amendments on soil microbial biomass in asparagus fields (Site A is an unfumigated field and Site B is a fumigated field).**

| Treatment | Soil microbial biomass * | | Soil microbial diversity** | |
|---|---|---|---|---|
| | Site A | Site B | Site A | Site B |
| Treated control | 8.35 cd | 3.34 b | 2.75 c | 2.77 b |
| Untreated control | 8.99 c | - | 2.98 ab | - |
| Mustard bran | 10.75 b | 3.82 b | 3.00 ab | 3.04 a |
| TerraClean® | - | 3.78 b | - | 2.54 c |
| SoilBuilder® | 8.09 d | 3.39 b | 2.91 bc | 2.85 b |
| Compost | 13.29 a | 5.23 a | 2.80 c | 2.88 ab |
| Frame | 8.93 c | 4.07 b | 3.09 a | 2.94 ab |
| **LSD** | **0.77** | **1.02** | **0.17** | **0.19** |

*Fumigation incubation method with 10 day incubation. Unit is ug $CO_2$-C/g soil/day. **BIOLOG method with 10 day incubation. Treatments with the same letter are not significantly different (P = 0.05, LSD).

**Acknowledgments**

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# NEW MANAGEMENT TECHNIQUES FOR *FUSARIUM* AND *PHYTOPHTHORA* CONTROL IN ASPARAGUS PRODUCTION

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***Fusarium* and *Phytophthora* Effects on Asparagus Production.** *Fusarium* species and *Phytophthora* species can attack and kill asparagus crowns in both nursery and commercial fields. Both of these pathogens can be introduced early in the crown's life as small infections on either the crown or roots. Over a period of growing seasons and under the right weather conditions, heavy rainfall or drought, these early infections can spread to healthy parts of the crown and start the process of crown death. This process of disease spread on the crown occurs after planting (when the crown is no longer visible) making proper diagnosis of the problem difficult. The deterioration of the crowns can occur unnoticed over several years.

Both cultural and chemical controls have limitations in controlling these pathogens and have been mostly ineffective. Many of the commercial asparagus growing areas have large populations of these pathogens already in the soil. This fact coupled with the long growth cycle of the crop limits the effectiveness of crop rotation as a disease management tool. Research into tolerant varieties has been limited and no commercial lines are currently available for planting that show resistance to both pathogens. The practice of planting crowns deep into the soil limits the ability to apply chemical or biological control products at a site where they would be effective. Other factors that can limit the length of productivity of commercial asparagus fields include; drought stress, low pH that can favor the devolvement of Fusarium, defoliation of the fern by purple spot and rust, and the use of herbicides that may stress the crown potentially increasing its susceptibility to disease.

A new system of asparagus production needs to be adopted to ensure that newly established fields remain viable and productive to allow for adequate return on establishment investment. This new system will rely on the use of clean crowns grown in properly fumigated fields. Additional measures for crown disease management are also needed to help lengthen field productivity. Crown soaks of effective chemicals will help limit disease on newly planted crowns. Fumigation of production fields will help reclaim fields that have high levels of disease. Controlling foliar pathogens with fungicides will ensure that summer foliage growth has time to recharge the crown for next harvest season. Proper rotation of crops and management of soil pH and soil moisture can help keep crowns vigorous and resistant to infection. Research has been and is currently being conducted on commercial farms to help growers become aware of the benefits of these disease control strategies.

**Fumigating Crown Nurseries.** Research from our previous studies has shown that both Telone C35 and metam fumigant products (KPam, Secatagon) are very effective in reducing Fusarium colonies in a commercial field (see Fig. 1). The studies also indicated that the highest concentration of disease causing organisms is located in the top 12 inches of the soil profile. Common application equipment is available that can apply both types of fumigants into the top layer of soil where the pathogens populations are the highest. Fumigants need to be applied under favorable environmental conditions (soil temperature and moisture, soil texture, and adequate soil sealing) to ensure they remain the in the soil at a high enough concentrations to kill the target pathogens. Fall fumigation is preferred as both soil moisture and temperature are more suited for effective applications. Applications in fall also offer more time for field preparation and off gassing needed for crop safety, though minimum soil temperature should remain high enough to ensure effective treatment. Soils that are too cold can limit the amount of fumigant available to kill soilborne pathogens such as *Fusarium* and *Phytophthora*.

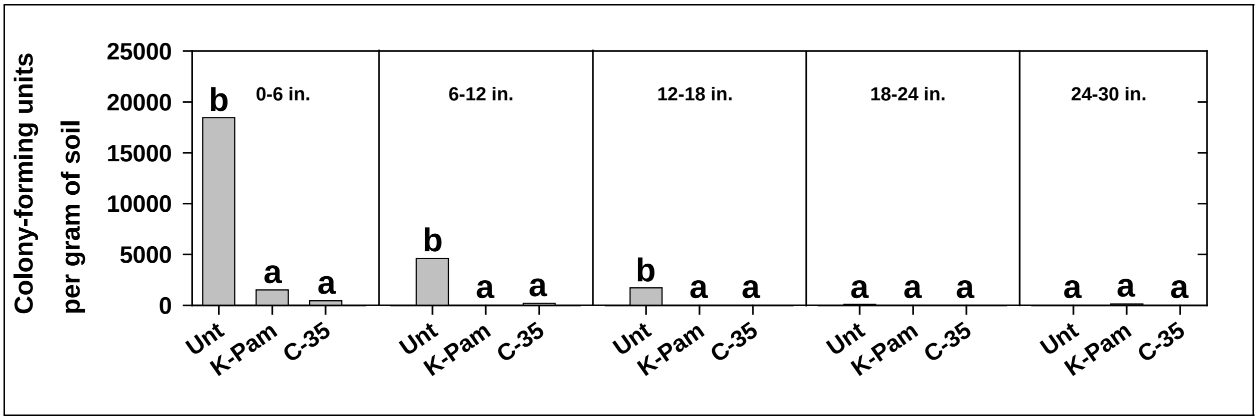

Figure 1. Colony forming units (CFU) of Fusarium in soil after fimigation.

**Crown soaks.** Even with the best fumigation application, disease levels will be reduced by not eradicated and may result in some diseased crowns used in a production field planting. Additional disease protection can be achieved using a crown soak of effective fungicides. Crowns should be soaked for a minimum of 10 minutes in a registered chemical solution before being planted in the field. Results from the past year's study shows that the registered product Cannonball has some activity on crown disease and can promote more spear production and taller fern (Table 1).

Table 1. Asparagus crown soak study for Fusarium crown rot.

| Treatment and rate | Application | Mean height (in.) | | Number of fern/20 ft | |
|---|---|---|---|---|---|
| Untreated | -- | 24.9 | ab* | 68.8 | b |
| Cannonball 50WP 0.1 oz/100 gal | crown soak | 25.2 | Ab | 71.8 | b |
| Cannonball 50WP 0.3 oz/100 gal | crown soak | 24.2 | B | 70.3 | b |
| Cannonball 50WP 0.5 oz/100 gal | crown soak | 26.2 | A | 87.3 | a |
| Cannonball 50WP 8.6 oz/acre | soil drench | 25.9 | A | 69.3 | b |

*Column means with a letter in common are not significantly different (Fisher LSD Method; *P*=0.05).

Studies from 2008 (Table 2) shows that other products are also effective in promoting more fern growth compared to untreated crowns. The combination of Topsin M and Presidio had a significant increase in fern height compared to the untreated control. Another combination of Topsin M with Ridomil Gold gave a significant increase in the fern count compared to the untreated control. The combination treatments in this study give a broad range of control for both pathogens. Cannonball and Topsin M will target the Fusarium infections while Ridomil and Presidio will give control of Phytophthora species. Only Cannonball is registered for use as a crown soak and Ridomil Gold is registered as a broadcast application to production fields but not as a crown soak. Additional studies are needed on the other effective products before additional crop registrations for their labels can be pursued.

Table 2. Asparagus crown soak study from Oceana County, 2008.

| Treatment (rate/100 gal) | Fern height (in.) | | Fern count (20 ft) |
|---|---|---|---|
| | 25 Jun | 30 Jul | 30 Jul |
| Untreated check | 30.2 bc* | 31.2 b | 66.7 b |
| Cannonball 50WP 0.5 oz | 31.7 ab | 32.4 ab | 69.0 ab |
| Topsin M 70WP 1 lb | 31.5 ab | 32.0 ab | 74.0 ab |
| Ridomil Gold SL 1 fl oz | 30.5 abc | 30.9 b | 71.7 ab |
| Presidio SC 4 fl oz | 29.1 c | 28.8 b | 73.2 ab |
| Cannonball 50WP 0.5 oz + Ridomil Gold SL 1 fl oz | 30.9 abc | 31.6 ab | 71.2 ab |
| Topsin M 70WP 1 lb + Ridomil Gold SL 1 fl oz | 30.9 abc | 30.1 b | 79.2 a |
| Cannonball 50WP 0.5 oz + Presidio SC 4 fl oz | 31.8 ab | 30.9 b | 75.5 ab |
| Topsin M 70WP 1 lb + Presidio SC 4 fl oz | 32.8 a | 43.4 a | 78.0 ab |

*Treatments with the same or no letter are not significantly different (Fisher protected LSD; *P*=0.05).

**Planning a cropping system for profitable asparagus.** Planting crowns grown in fumigated soil and that have also been soaked in a fungicide solution**,** are the two most important steps a grower can take to ensure a healthy field establishment. These two steps are the foundation upon which other practices can be built to help prolong the length of a production asparagus field.

Some replant fields may need to be fumigated before planting to reduce the level of disease populations. This type of fumigation will have to cover the entire field and should be viewed as a long term investment with the initial cost being spread over the years the field stays productive.

After the soil pathogens have been reduced via fumigation and crown soaks, each year's fern growth must be protected from both foliar pathogens and insects that can defoliate the plants. Asparagus miner larva tunnels can also allow the colonization of fern by the soilborne pathogen *Fusarium*. Long term crop rotation in combination with fumigation can help keep pathogen populations below economic threshold. Maintaining adequate soil moisture with a proper pH level allows the asparagus plant to thrive and resist infection. Herbicide applications and nitrogen sources are other production practices that may have an impact on asparagus health. Preliminary greenhouse studies are being conducted to determine the safety of commonly used herbicides on asparagus growth in both clean and infested soil.

# IRRIGATION and RYE LIVING-MULCH IN ASPARAGUS PRODUCTION

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**ABSTRACT.** Irrigation and living mulches are potentially valuable tools for improving the resilience of asparagus to stress from extreme weather and pests. Research was initiated in 2008 with the following long-term objectives: 1) to evaluate the effects of irrigation on asparagus yields and weed management under two cropping systems; and 2) to determine the effect of summer-sown rye on soil moisture, asparagus yield and weed management. Following asparagus harvest, overhead irrigation was compared to no-irrigation in each of two management systems: typical grower practices (no till with residual herbicides) versus a "living mulch" system in which shallow tillage was used in combination with summer-sown winter rye. Irrigation had no effect on fern weight in October in the living-mulch system, but reduced fern weight in the herbicide system. Weed density increased under irrigation in both systems. Rye living mulch reduced soil moisture content in un-irrigated plots by up 2-3% during July, but had no effect on asparagus fern weight compared to the herbicide system. The density and dry weight of weeds at the end of the season was higher in the living mulch system.

## INTRODUCTION

**Why irrigate?** Drought stress may be an important factor contributing to the decline in asparagus fern health and yield in recent years. Although asparagus is deep rooted and relatively drought tolerant, soil water content during fern growth is an important determinant of crop yields (Drost and Wilcox-Lee, 1997; Drost 2005; Hartman 1981; Roth and Gardner 1990). Drought stress during fern growth can limit the capacity of plants to produce the soluble carbohydrates in roots necessary for high yields in subsequent seasons (Drost 1997). Stressed plants may also be more susceptible to fungal diseases which increasingly plague the asparagus industry (Hausbeck, personal communication; Nigh 1990). Warmer temperatures and more variable rainfall patterns observed in MI in recent years are predicted by climate models to continue, making irrigation an increasingly important tool for reducing risks of yield loss in asparagus production.

**Irrigation and cover crops.** Irrigation may also open opportunities for greater integration of cover crops into asparagus production systems. In irrigated systems, cover crops growing below the fern canopy may be more reliably established with reduced risk of competition for water with the asparagus crop. These "living mulches" may provide several important benefits. Living mulches, in combination with irrigation have the potential to buffer the crop from weather extremes. During extreme rainfall events, they can protect the soil from degradation, reduce the risks of nutrient and pesticide run-off, and take up excess moisture that can be as damaging to the asparagus crop as drought (e.g. Wilson et al 1996; Hartmann 1990). Living mulches may also provide a range of other benefits including mitigation of soil compaction, increases in soil organic matter, improved nutrient cycling, and reductions in the incidence of insect pests (Andow et al 1996; Vandermeer 1989).

**Living mulches and weeds.** The impact of living mulches on weeds and asparagus is unclear. On the one hand, if poorly managed, living mulches are themselves weeds: competing with the crop for nutrients, water or light, and acting as potential hosts for diseases and insect pests. The presence of rye also complicates weed management since several herbicides commonly used for suppression of weeds are not compatible with rye. On the other hand, carefully selected and managed living mulches may suppress weeds without suppressing the crop. Rye living mulches, sown following asparagus harvest have been recommended (e.g. Kuepper and Thomas, 2001) and tried by growers, but few studies have been conducted to evaluate their impact on asparagus or weeds (Paine et al. 1995). When sown in the summer, winter rye can emerge rapidly and suppress weeds, but does not shade crops due to its short growth habit in the absence of vernalization (Robinson and Dunham, 1954; Brainard and Bellinder, 2004).

**Objectives.** With these issues in mind, field studies were initiated last summer with the following long-term objectives: 1) To evaluate the effects of irrigation on asparagus yields and weed management under two cropping systems and 2) To determine the effect of rye living mulch on soil moisture, asparagus yield, and weed management.

**METHODS**

A field trial was initiated in 2008 at the Asparagus Research Farm in Hart, MI in an 8 year old stand of Jersey Giant asparagus. Following the final asparagus harvest on 26 June, four experimental treatments were established consisting of two different management systems (herbicide vs living mulch/tillage), each with two levels of irrigation (no irrigation vs irrigation) (Table 1).

**Table 1. Summary of treatments examined**

| | Irrigation | Cover | Tillage | PRE herbicides |
|---|---|---|---|---|
| 1. Herbicide/No irrigation | No | None | No | Dual/Spartan/Karmex |
| 2. Herbicide/Irrigation | Yes | None | No | Dual/Spartan/Karmex |
| 3. Living Mulch/No irrigation | No | Rye | Yes | None |
| 4. Living Mulch/Irrigation | Yes | Rye | Yes | None |

Six replicates of each treatment were included in plots measuring 25’ x 13.5’, with 3 rows of asparagus spaced 4.5’ apart in each plot. The herbicide system consisted of no-tillage with application of a tank-mix of Roundup (1 Q/A), Dual (1.5 pt/A), Spartan (4 oz/A) and Karmex (1.2 lbs/A). In the living-mulch system, winter rye (*Secale cereale*) was broadcast at 3 bu/A and a roto-tiller was used to simultaneously kill weeds and incorporate rye to a depth of 1-2”. No residual herbicides were used in the living-mulch system, and no post emergence herbicides were used in either system. Irrigation was accomplished using 7 micro-sprinklers per plot to simulate overhead irrigation. Soil moisture sensors (EC-5 sensors, Decagon Devices) were installed at 6” and 24” in 4 replicates of each treatment to monitor soil volumetric water content (VWC). In the irrigated living mulch system, 2 out of 4 sensors failed, so data was excluded from analysis. Irrigation was used initially to establish rye, and then to maintain VWC above 15% through the middle of August (Figure 1).

Weed density, rye dry weight, rye number and fern stem number were assessed in early September. Weed density was evaluated by counting the number of weeds greater than 1 foot in height or diameter in the entire plot. Additional weed evaluations were made by sowing seeds of pigweed (*Amaranthus powellii*), common lambsquarters (*Chenopodium album*) and large crabgrass (*Digitaria sanguinalis*) in 0.25$m^2$ quadrats in each plot on 6/25 and monitoring emergence, final density and final dry weight. Fern fresh weight was determined on 10 October from 30 stems clipped from the center row of each plot. Total fern fresh weight per meter of row was calculated by multiplying stem number per meter and fresh weight per stem.

## PRELIMINARY RESULTS

**Irrigation, rainfall and soil water content.** In irrigated treatments, 0.5-0.75 in of water was applied on each of the following dates: 6/25, 6/30, 7/25, 7/31 and 8/12, for a total of approximately 2.75 in. Total rainfall during this period was 4.24 in and rPET was 7.33 in. Soil volumetric water content was maintained at approximately 15% in the irrigated treatments until mid August when irrigation was stopped (Figure 1). During the last week of July and the last three weeks of August, soil volumetric water content in the irrigated plots was 2-3% higher than the non-irrigated plots. In non-irrigated plots, rye reduced volumetric soil water content in the top 6" by approximately 2% by the end of July. However, following rains in early August, soil moisture was restored in living-mulch plots, and rye had little effect on soil moisture for the remainder of the season.

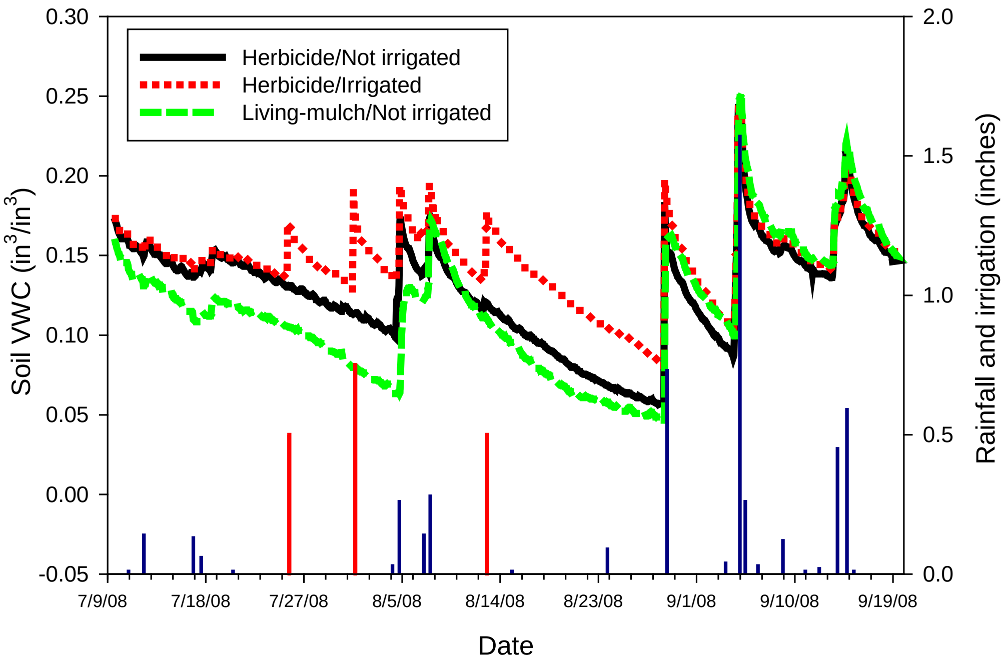


**Figure 1**: Rainfall (blue bars), irrigation (red bars) and soil volumetric water content (VWC) in three management systems, 2008.

**Asparagus fern.** Irrigation resulted in a reduction in asparagus fern fresh weight in the herbicide management system (Table 2). In contrast, asparagus fern weight was slightly higher under irrigation, but this effect was not statistically significant. There was no measureable difference between fern weight in conventionally managed plots and living mulch plots. Reduced fern weight in irrigated herbicide plots may have been partly due to herbicide injury from Dual which can be a problem under excessive moisture conditions. The 0.5 inches of irrigation water applied after herbicide application on 6/25, was followed by 0.33 inches of rain within 3 days, and almost 2 inches of rainfall within one week. Late season weed pressure in the irrigated treatments may also have contributed to reduced fern weight.

**Rye.** Rye emerged slightly earlier in irrigated plots. However, after two weeks, no differences in rye density were evident. Sufficient early rainfall occurred to establish rye in the non-irrigated treatments. Rye dry weight in September was also not affected by irrigation (Table 2). Interestingly, rye dry weight in the crop row was more than twice that between crop rows. More compacted soil between-rows due to historic tractor-traffic may explain this effect.

**Table 2. Effects of irrigation and living-mulch on asparagus fern, weeds, and rye, 2008**

| | Asparagus fern | | | Weed density at harvest[a] | | | Rye dry weight | |
|---|---|---|---|---|---|---|---|---|
| | Fresh wt. total | Fresh wt. per stem | Density | Total | Pigweed | Sandbur | Between row | In row |
| | ---kg/m--- | ---g/stem--- | --stems/m-- | --------------Plants/m$^2$-------------- | | | -----------g/m$^2$----------- | |
| Herbicide/no-till | | | | | | | | |
| Not irrigated | 2.1 a | 115 a | 19.9 a | 0.14 b | 0.08 b | 0.03 b | NA | NA |
| Irrigated | 1.4 b | 81 a | 16.8 a | 0.48 ab | 0.29 ab | 0.10 b | NA | NA |
| Living-mulch/till | | | | | | | | |
| Not irrigated | 1.7 ab | 100 a | 18.0 a | 0.58 ab | 0.11 b | 0.47 a | 20.8 a | 58.6 a |
| Irrigated | 1.9 ab | 111 a | 18.2 a | 0.73 a | 0.53 a | 0.20 ab | 21.2 a | 47.5 a |

[a] Weeds greater than 1' in height or diameter were included; Pigweed = *Amaranthus powellii*
Column means with a letter in common are not significantly different (Fisher LSD Method; *P=0.05* )

**Weeds.** The dominant weed species were pigweed (*Amaranthus powellii*) and sandbur (*Cenchrus longispinus*). Plots with herbicides had lower final weed density, particularly in the non-irrigated treatments (Table 2). Irrigation resulted in increased final density of pigweed, but not sandbur. In living mulch treatments, pigweed density was 5 times greater in irrigated compared to non-irrigated treatments (Table 2). Among weed species that were sown in microplots, irrigation led to an increase in both the density and dry weight of pigweed and large crabgrass, but not lambsquarters (data not shown).

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