Vine Crops

Wednesday morning 9:00 am

Where: Grand Gallery (main level) Room E & F
MI Recertification credits: 2 (1B, COMM CORE, PRIV CORE)
CCA Credits: SW(0.5) PM(1.0) CM(0.5)
Moderator: Phil Tocco, Extension Educator, MSU Extension, Jackson, MI

9:00 am — Cover Crop and Tillage Practices for Irrigation Management in Butternut Squash: Year One Observations
- Ben Phillips, Vegetable Extension Educator, MSU Extension, Saginaw, MI

9:30 am — Advances Made in Grafting Methods
- Richard Hassell, Environmental Horticulture Dept., Clemson Univ.

10:00 am — The Effect of Floral Strips on Beneficial Insects in Vine Crops
- Zsofia Szendrei, Entomology Dept., MSU
- Nicole Quinn, Entomology Dept., MSU

10:30 am — Managing Pumpkin Powdery Mildew with Host Resistance and Fungicides
- Beth Gugino, Vegetable Pathology, Penn State Univ.

11:00 am — Session Ends

Cover Crop and Tillage Practices for Irrigation Management in Butternut Squash: Year One Observations

Ben Phillips Michigan State University Extension
One Tuscola St Saginaw, MI 48607
Office: 989.758.2502 Email: phill406@msu.edu

A cover cropping trial in butternut squash was planted at the Forgotten Harvest Ore Creek Farm (9153 Major Rd, Fenton, MI 438430). The objective was to determine how water and yields were conserved by six cropping systems: Bare ground disced rye without irrigation, no-tilled rye without irrigation, no-tilled rye with irrigation, strip-tilled rye without irrigation, strip-tilled rye with irrigation, and plastic beds with irrigation. The bare ground and plastic treatments served as negative and positive controls, respectively, as the grower-cooperator was most familiar with these growing methods. All irrigation was supplied through pressure compensating drip lines at a rate of 0.25gpm/100 ft.

On 15 October 2014 cereal rye was drilled into the two-acre experimental area at a rate of ~ 73 lbs/ac. Three replicated plots (150 ft x 150 ft) of all six subplots (150 ft x 25 ft) were measured on 26 November. A 12 ft drive lane separated each replicated plot, and a 12 ft drive lane for a sprayer bisected all plots into two 69 ft sections. The soil type was a Miami loam with a 6-11% grade. Pre-plant fertilizer was broadcast at a rate of 80 lbs N, 20 lbs P, 105 lbs K.

Between 20 May and 25 June 2015, each subplot treatment was created. The entire area was sprayed with glyphosate (1qt/ac) before all of the rye was rolled perpendicular to the direction it was planted with a roller-crimper (I & J Manufacturing, 5302 Amish Rd, Gap, PA 17527). A custom-made one-row strip-tiller was borrowed for the strip-tilled subplots, bare ground subplots were created with two-passes of a chisel plow and 10 ft disc implement, and a one-row plastic and drip tape layer was used to create beds in the plastic subplots. Dual Magnum was used as a pre-emergent herbicide (1.33 pt/ac), and a commercial push-style deck mower was rented to cut back between-row weeds on 5 Aug. Drip tape was later added to one of the two no-till and strip-till subplots in replicate plots.

On 1 and 2 July all butternut squash (Betternut cultivar) were hand-planted with tube seeders (Stand 'N Plant, 95 Rose Rd, Saltsburg, PA 15681). Plastic subplots contained four bedded rows 6.25 ft apart seeded with two staggered rows with an in row spacing of 39 inches (379 plants per plastic subplot). All other treatment subplots contained five flat rows 5 ft apart seeded with in row spacing of 24 inches (375 plants per subplot). Seeds were coated in the Farmore F1400 chemical treatment consisting of thiamethoxam, mefenoxam, fludioxonil, and azoxystrobin. The only other pesticide applied was Kocide 3000 (copper hydroxide) on 18 August at a rate of 1.25 lb/ac.

On 25 June all moisture-monitoring tubes were installed to a depth of 15.75 inches, and weekly moisture monitoring with the Sentek Diviner 2000 (Sentek Sensor Technologies, 77 Magill Road, Stepney SA 5069, Australia) occurred between 8 July and 2 Oct. By 11 Aug all irrigation tubing was installed in irrigated plots. Rainfall accumulation was logged by the Runyan Lake Road weather station 3.6 miles NE of the plot.

On 8 Oct (day 100), harvest transects were measured 20 ft on either side of the center drive lane. Weed pressure was assessed in each treatment subplot on a 1-9 scale (1 = no weeds visible, and 9 = no crop plants visible), the number of plants were counted, and fruit were tallied as "good and clean", "good and dirty", and "cull". All good fruit was combined and weighed.

Pollination was provided by four bumble bee quads from Koppert Biological Supply (1502 Old US-23, Howell, MI 48843), and three nearby honey bee hives.

Moisture monitoring

The Sentek Diviner 2000 measures moisture within 10 cm surrounding the monitoring tube, and takes samples every 10 cm of depth. Though the Sentek moisture units are not in cubic inches, we were able to generate relative comparisons of "volumetric moisture content" at different depths, between treatments. For analysis, moisture readings for all depths were integrated within each treatment subplot, creating one average volumetric moisture content reading for each date.

What establishment, yield and quality performance did we expect?

- Our positive control, plastic with drip irrigation, would establish faster, and produce the cleanest fruit.
- No-till yields would be the slowest to establish, yet cleanest because of the mat of cereal rye blocking sunlight and heat from the seedbed.
- Similar yields between plastic subplots and conservation tillage subplots with equal plant populations.
- Similar yields between strip-till plots and bare ground plots, because of the tilled soil more exposed to the thermal energy of the sun.
- Higher yields in irrigated subplots.

What moisture dynamics did we expect?

- No-till and plastic subplots would maintain higher soil moisture levels within the top 40 cm of soil over time.
- Irrigated subplots would maintain higher soil moisture levels within the top 40 cm of soil over time.

Results

Establishment

Soil hardness, row markings, and walkability were key factors in ranking the ease of hand seeding. Plastic beds required an additional step of running a dibbler to place holes in the plastic before seeding. Once holes were established, it was problematic to walk on the plastic beds to seed. No-till and bare ground subplots were hard to maintain straight rows, and required an additional step of marking with string. No-till subplots had noticeably harder soil that challenged the seeding tools. Rankings of the ease to plant are in Table 1.

Yield

Weed pressure (broadleaf complex of lambsquarters, velvetleaf, nightshade, pigweed, and jimson weed) was high across the research area, but it is difficult to determine whether weeds where the cause or effect of the number of squash plants per acre (Table 1). Weed pressure was highest in no-till treatments, which took at least five full days longer to emerge than plastic and bare ground subplots. Irrigated strip-tilled subplots had lower weed pressure than un-irrigated subplots, and had similar pressure to bare ground subplots. Weed pressure in plastic subplots was the lowest. Bare ground plots and plastic plots maintained the highest number of plants per acre, and were the first to emerge.

The hard surface of the no-till treatments made hand seeding more difficult, and could have caused more skips and gaps in emergence and resulted in fewer plants per acre and weed proliferation. However, three factors may have allowed heavier broadleaf weed pressure overall: 1) the seed drill was not calibrated, and actually seeded 2/3 of the rate required for the recommended population of 110 lb/ac of rye; 2) the sprayer booms appeared to deliver inconsistent active ingredients to the far ends of the booms; and 3) we forewent the typical addition of Command 3ME to the pre-emergent herbicide tank mix, which has good efficacy on some of the prevalent broadleaf weeds in the plots. Therefore, weed competition could have been a real effect.

The number of fruit, and tonnage produced in each treatment was also varied (Figure 1). No-till plots had the least amount of fruit, and there was no significant difference between irrigated and unirrigated no-till treatments. The irrigated strip-till treatment produced significantly more fruit per plant than the unirrigated treatment, and both strip-till treatments produced more fruit than no-till treatments. The bare ground treatment produced significantly more fruit per acre than any conservation tillage treatment, and the plastic treatment significantly out-produced all other treatments. The fruit from the irrigated strip-till treatments were heavier than all other treatments. As a result, the bare ground treatment did not produce a significantly higher tonnage of fruit than the irrigated strip-tilled treatment when weight was considered.

Quality

Despite lower yields, a higher percentage of fruit harvested from no-till subplots were free of dirt (Table 1). Plastic rows had also had cleaner fruit. Bare ground subplots had the second lowest percentage of clean fruit. Interestingly, the treatment with the lowest percentage of clean fruit was the unirrigated strip-till subplots. This could have been a result of poor rye stand and bare soil in strip-tilled plots.

Moisture dynamics

Unirrigated bare ground, no-tilled, and strip-tilled subplots received a total of 9.74 inches of rain throughout the study, averaging 0.65 inches per week. Irrigated no-till, strip-till, and plastic subplots were irrigated three times on top of that. On 12 Aug, and 3 Sept the irrigation was run for 4 hrs, and 0.39 inches of water was applied per row (1.56 inches per plastic subplot, and 1.59 inches per no-till and strip-till subplots). On 23 Sept the irrigation was run for 6 hrs, and 0.58 inches of water was applied per row (2.32 inches per plastic subplot, and 2.9 inches per no-till and strip-till subplots). In total, irrigated plastic subplots received 15.18 inches of water throughout the study, averaging 1.01 inches per week. Irrigated no-till and strip-till subplots received 15.82 inches, averaging 1.06 inches per week

Analysis comparing each treatment was performed separately for each week of sampling to determine how each treatment handled soil moisture through the season. There were no significant differences in moisture concentration between cover treatments or irrigation treatments at any point in time through the sampling period in the top combined 40 cm, even before and after rain and irrigation events.

However, interesting patterns can be seen in the data (Figure 3). Between 26 July and 2 Aug the weather station logged 1.33" of rain that is reflected in all subplots except the plastic treatment, which was protected from this rain. When the irrigation was run on 12 Aug, the moisture levels in the plastic subplots and irrigated no-till subplots also showed an increased water concentration, but the 0.48" of rain logged that week seemed to affect the unirrigated no-till subplots disproportionately. From the beginning of August through the end of the study period, the higher moisture retention of irrigated no-till subplots could have been a indication of low squash population, as healthy squash plants remove a lot of water. From 23 Aug through 20 Sept 20, neither rainfall or irrigation events were effective at raising the moisture concentration of the soil. Because all treatments failed to respond, I suspect that flower and fruit set demand of squash plants and weeds was responsible for efficiently removing excess water inputs at this point in time. By the time of the last rain event on 18 Sept and irrigation event on 23 Sept, squash plants were dying back in all subplots, and water inputs were more easily measured in irrigated strip-till and plastic subplots. Also at this point in the season, weed proliferation was at its maximum level in no-till subplots, and it is likely that these weeds intercepted any rain or irrigation inputs during this period.

Special thanks to Mike Yancho Jr. and Anne Ginn, of Forgotten Harvest, and Dr. Dan Brainard & Lab, of Michigan State University.

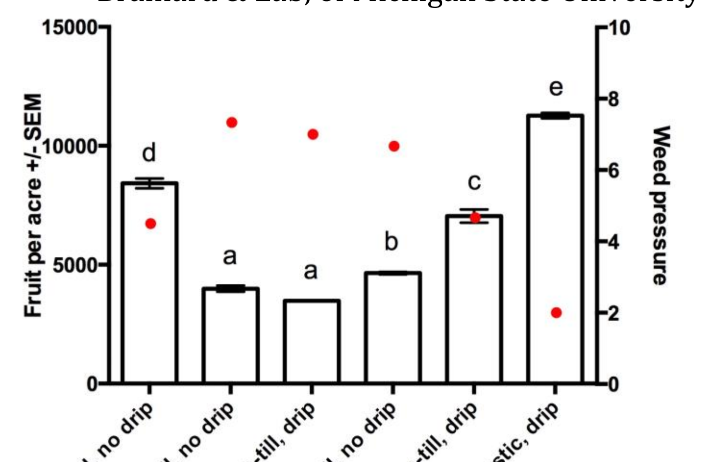


Figure 2. Fruit per acre (left axis; bars), and weed pressure (right axis; red dots) measured in six cover crop, tillage, and irrigation treatments used to grow butternut squash at the Forgotten Harvest Ore Creek Farm, Fenton, MI. Plastic subplots contained four bedded rows 6.25 ft apart seeded in two staggered rows with an in row spacing of 39 inches (379 plants per plastic subplot). All other treatment subplots contained five flat rows 5 ft apart seeded with in row spacing of 24 inches (375 plants per subplot). All subplots were harvested at 100 days after planting.

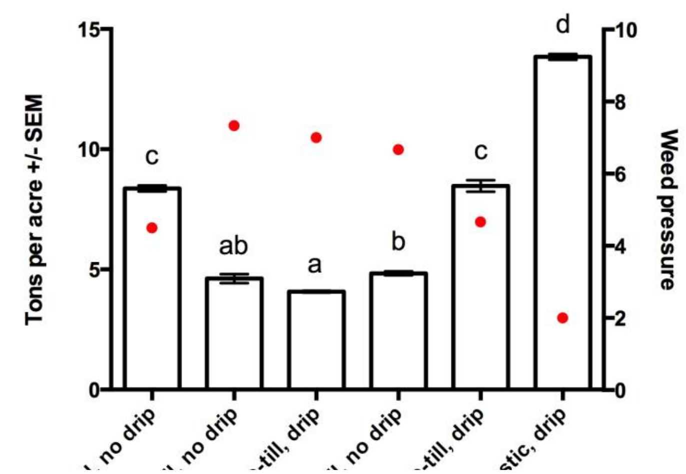


Figure 1. Tons per acre (left axis; bars), and weed pressure (right axis; red dots) measured in six cover crop, tillage, and irrigation treatments used to grow butternut squash at the Forgotten Harvest Ore Creek Farm, Fenton, MI. Plastic subplots contained four bedded rows 6.25 ft apart seeded in two staggered rows with an in row spacing of 39 inches (379 plants per plastic subplot). All other treatment subplots contained five flat rows 5 ft apart seeded with in row spacing of 24 inches (375 plants per subplot). All subplots were harvested at 100 days after planting.

Table 1. Measured characteristics of six cover crop, tillage, and irrigation treatments used to grow butternut squash at the Forgotten Harvest Ore Creek Farm, Fenton, MI. Plastic subplots contained four bedded rows 6.25 ft apart seeded in two staggered rows with an in row spacing of 39 inches (379 plants per plastic subplot). All other treatment subplots contained five flat rows 5 ft apart seeded with in row spacing of 24 inches (375 plants per subplot). All subplots were harvested at 100 days after planting.[1] Ease of planting was ranked; 1=easiest, and 4=hardest. [2] Weed pressure was assessed on a 1-9 scale in each subplot (1 = no weeds visible, and 9 = no crop plants visible).

Treatment	Ease of seeding[1]	Weed pressure[2]	% Clean fruit	Fruit/plant	Plants/acre	Fruit/acre	Tons/acre
Bare ground, no drip	3	4.50	22.41	2.21	3775.25	8421.72	8.37
No-till, no drip	4	7.33	30.91	1.14	3412.25	3993.06	4.62
No-till, drip	4	7.00	35.42	1.30	2758.84	3484.85	4.07
Strip-till, no drip	1	6.67	12.50	1.30	3702.65	4646.46	4.84
Strip-till, drip	1	4.67	27.84	1.96	3630.05	7042.30	8.47
Plastic, drip	2	2.00	30.41	2.66	4239.90	11267.68	13.84

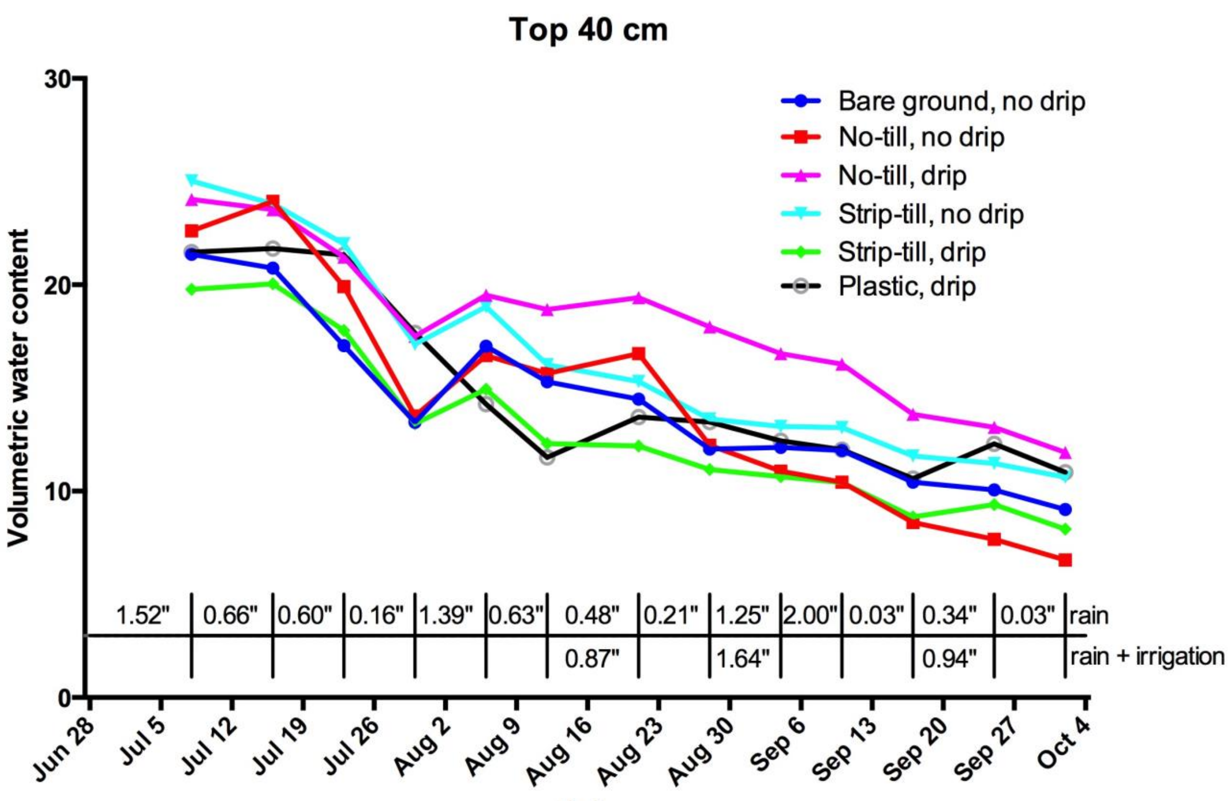


Figure 3. Volumetric moisture content over time measured in six cover crop, tillage, and irrigation treatments used to grow butternut squash at the Forgotten Harvest Ore Creek Farm, Fenton, MI. Rainfall and irrigation accumulation in inches is shown for each week between samples. Plastic subplots contained four bedded rows 6.25 ft apart seeded in two staggered rows with an in row spacing of 39 inches (379 plants per plastic subplot). All other treatment subplots contained five flat rows 5 ft apart seeded with in row spacing of 24 inches (375 plants per subplot). All subplots were harvested at 100 days after planting.

Fatty Alcohol Rootstock Treatment:
A New Approach to Cucurbit Grafting

Dr. Richard L. Hassell
Clemson University CREC
Charleston, South Carolina
rhassel@clemson.edu

Grafting has been used to manage serious soilborne pathogens, including Fusarium, Verticillium, Pseudomonas, Monosporascus root rot and vine decline, Macrophomina, other fungi, oomycete and bacterial pathogens, nematodes, and viruses (Lee and Oda, 2003; Koren and Edelstein, 2004; Louws et al. 2010). 'Fusarium wilt' is one of the most serious watermelon diseases, causing a great deal of damage and loss in the United States and worldwide; however, watermelon grafting has not been incorporated in United States production because of the increased cost of grafting. As a contributer to the cost of grafting, rootstock re-growth is a major concern (Guan, 2011). Occasionally termed "suckers," the rootstock re-growth can decrease yield by robbing the scion of water and nutrients, and could result in scion abortion and graft failure. Treating rootstocks with a fatty alcohol helps eliminate re-growth

Fatty Alcohol Treatment

'Carnivor' rootstocks treated with 7.5% Fair 85 and 6.25% Off-Shoot T exhibited unacceptable amounts of damage (13.6% and 19.0%, respectively) (Table 1). Damage increased with increasing rates of the fatty alcohol, reaching 69.1% and 55.1% at the highest rate of Fair 85 and Off-Shoot T, respectively. Similarly, regrowth in the 'Carnivor' rootstocks was successfully prevented (6.8% and 8.1%) at 6.25% and 5.00% Fair 85 and Off-Shoot T, respectively (Table 2). Damage reached 17.2% in 'Emphasis' rootstocks treated with 6.25% Fair 85 and 13.1% when treated with 5.00% Off-Shoot T. In 'Emphasis' rootstocks, regrowth was sufficiently controlled (2.0% and 0.0%) at 6.25% Fair 85 and 7.50% Off-Shoot T, respectively.

Although the labels of each compound indicate identical amounts of active and inert ingredients, significant differences in damage and regrowth control occurred. As sources of fatty alcohol vary in availability and purity (Frank Grainger, Fair Products, personal communication), variations in product purity and the resulting burn quality. In addition, the two rootstocks differed significantly in their response to the application, with 'Emphasis' rootstocks showing a higher incidence of damage than the interspecific hybrid rootstocks. We expect that this is possibly a result of physiological differences.

Rootstock Size and Carbohydrate Content

For both rootstock types, no significant differences were observed between the water-treated rootstocks and the day 1 rootstocks. 'Carnivor' rootstock hypocotyl dry weight increased from 0.0234 g on day 1 to 0.1345 g on day 21 after treatment, and width increased from 2.84 mm on day 1 to 4.48 mm on day 21 (Table 3). 'Emphasis' rootstock hypocotyl dry weight increased significantly, from 0.0131 g to 0.0563 g, and width increased from 2.53 mm to 4.99 mm (Table 3). Total soluble sugars and starch in interspecific hybrid squash rootstock hypocotyls increased 6.7-fold and 193-fold, respectively (Table 4). 'Emphasis' rootstock hypocotyls increased in total soluble sugars by 2.5-fold, and in starch by 31.5-fold.

The size increases in both rootstocks indicates that the rootstocks are expanding to accommodate the accumulating starch. It is not surprising that starch content increased greater than other sugars in both rootstocks, as starch is the storage sugar of the plant. The two rootstock types responded differently, however, in carbohydrate storage location, with the 'Carnivor' rootstock storing greater amounts of starch in the hypocotyl, and the 'Emphasis' rootstock storing greater amounts of starch in the cotyledon. As the two rootstocks are from different genera within the *Cucurbitaceae* family, this difference may be due to the adaptive differences between the two rootstock types. This starch accumulation could be harnessed by the plant to increase grafting success.

Graft Survival

Using the 1-cotyledon graft method, graft survival on 'Carnivor' rootstocks remained between 94% and 98% on days 1, 7, and 14 after treatment (Figure 1). Survival decreased significantly to 85% on day 21 after treatment. Graft survival on 'Macis' rootstocks with the 1-cotyledon method increased significantly from 88% to 98% on days 1 and 7, and did not significantly change on days 14 and 21 after treatment. In both 'Carnivor' and 'Macis' rootstocks, root fresh weight did not change significantly, and root dry weight significantly increased from days 1 to 7 after treatment (Figures 2A and 2B). Root dry weight did not significantly change on the following days.

Using the new, hypocotyl-only graft method, zero grafts survived on untreated rootstocks and on rootstocks 1 day after treatment (Figure 3). In both 'Carnivor' and 'Macis' rootstocks, survival increased significantly on day 7 to 92% and 48%, respectively. On day 14 after treatment, graft survival on interspecific hybrid squash rootstock did not change significantly, while graft survival on bottle gourd rootstocks increased significantly to 89%. On day 21 after treatment, graft survival on interspecific hybrid squash rootstock decreased significantly to 68%, and bottle gourd survival did not change.

Fatty alcohol applications can successfully control rootstock meristem growth, and by decreasing the labor required, would alleviate the high cost of grafted transplant production. The optimal treatment rate, providing a 95% control of regrowth with less than 10% damage to rootstocks, is between 5.00% when using Off-Shoot T, and 6.25% using Fair 85 fatty alcohol treatment.

There were no significant differences between water-only treatments and day 1 after fatty alcohol treatments in rootstock development, or in total soluble sugars or starch content of rootstock hypocotyls and cotyledons. Based on these data, we conclude that fatty alcohol application itself does not affect baseline rootstock development or carbohydrate storage, and that rootstocks continue to develop and expand over 21 days. Over this time, rootstocks also increase in carbohydrate content, most notably starch. These carbohydrates can be used by the plant to provide energy for graft healing and rooting, and can overcome the need for a cotyledon by grafting using the hypocotyl-only method. This new graft method could increase graft efficiency by allowing for the use of a smaller cell size in production, and could decrease disease incidences by removing the large rootstock cotyledons.

Using fatty alcohol as a rootstock treatment can improve the efficiency of grafting by decreasing the labor required in producing grafted watermelon, as well as increasing graft survivability and making a new grafting method available.

Tables

Table 1. Effect of fatty alcohol concentration on mean percent damage[2] using two C_6-0.5%, C_8-42%, C_{12}-1.5% fatty alcohol compounds, pooled over three consecutive experiments.

	'Emphasis' Damage		'Carnivor' Damage	
Fatty alcohol concentration (%)	Fair 85®[y] (%)	Off-Shoot T®[x] (%)	Fair 85® (%)	Off-Shoot T® (%)
0.00	0.0 g[w]	0.0 g	0.0 g	0.0 g
3.75	0.0 g	3.1 fg	0.0 g	1.4 g
5.00	9.8 efg	13.1 ef	4.9 fg	8.7 efg
6.25	17.2 e	43.2 cd	5.4 fg	19.0 cde
7.50	33.3 d	49.3 c	13.6 def	25.8 c
8.75	34.4 d	78.3 b	17.3 cde	43.6 b
10.00	78.4 b	91.8 a	23.7 cd	49.3 b
12.50	84.8 ab	76.6 b	48.9 b	52.2 b
15.00	92.3 ab	94.2 a	69.1 a	55.1 b

[2]18 seedlings per replication

[y]Fair Products, Inc., USA Cary, NC.

[x]Chemtura Corporation Middlebury, CT.

[w]Values within the two rootstock columns (across compound type) that are not followed by the same letter are significantly different according to Fisher's Protected Least Significant Difference test at $P \leq 0.05$.

Table 2. Effect of fatty alcohol concentration on rootstock seedling mean percent regrowthz using two C6-0.5%, Cg-42%, C10-56%, C12-1.5%) fatty alcohol compounds, pooled over three consecutive experiments.

	'Emphasis' Regrowth		'Carnivor' Regrowth	
Fatty alcohol concentration (%)	Fair 85®[y] (%)	Off-Shoot T®[x] (%)	Fair 85® (%)	Off-Shoot T® (%)
0.00	100.0 a[w]	100.0 a	100.0 a	100.0 a
3.75	32.7 b	14.9 c	47.1 b	35.9 c
5.00	16.2 c	7.7 d	26.6 d	8.1 e
6.25	2.0 de	2.1 d	6.8 e	0.7 e
7.50	1.3 de	0.0 e	1.4 e	0.0 e
8.75	0.0 e	0.0e	1.4 e	0.0 e
10.00	0.0 e	0.0 e	0.7 e	0.0 e
12.50	0.0 e	0.0 e	0.0 e	0.1 e
15.00	0.0 e	0.0 e	0.0 e	0.0 e

[2]18 seedlings per replication

[y]Fair Products, Inc., USA Cary, NC.

[x]Chemtura Corporation Middlebury, CT.

[w]Values within the two rootstock columns (across compound type) that are not followed by the same letter are significantly different according to Fisher's Protected Least Significant Difference test at $P \leq 0.05$.

Table 3. Hypocotyl[y] development

Rootstock	Days After Treatment	Hypocotyl Fresh Weight (g)	Dry Weight (g)	Length (mm)	Width (mm)
Emphasis	1 (Water)	0.2343 c[x]	0.0127 d	36.87 a	2.63 c
	1	0.2278 c	0.0131 d	36.41 a	2.53 c
	7	0.2953 c	0.0234 c	34.97 a	3.06 c
	14	0.4805 b	0.0399 b	35.82 a	4.18 b
	21	0.6191 a	0.0563 a	37.48 a	4.99 a
Carnivor	1 (Water)	0.3725 c	0.0253 c	54.20 a	2.80 c
	1	0.3493 c	0.0234 c	51.65 a	2.84 c
	7	0.4373 bc	0.0549 c	42.95 b	3.55 b
	14	0.5888 ab	0.0896 b	41.55 b	4.22 a
	21	0.7515 a	0.1345 a	41.39 b	4.48 a

[z]All rootstocks, except the water control treatments, were treated with a 6.25% fatty alcohol emulsion
[y]Single hypocotyl measurements
[x]Different letters within each column represent significantly different means based on Fisher's Protected Least Significant Difference test ($P \leq 0.05$)

Table 4. Effects of time after water and fatty alcohol treatment[z] on 'Emphasis' and 'Carnivor' rootstock total soluble solids[y] (TSS) and starch[x] content per hypocotyl and cotyledon.

Rootstock	DAT[v]	Hypocotyl[w] TSS ($\mu g \times g^{-1}$)[u]		Starch ($\mu g \times g^{-1}$)	
Emphasis	1 (Water)	1.017	bc[t]	0.023	
	1	0.841	c	0.027	
	7	1.021	bc	0.185	
	14	1.932	ab	0.469	
	21	2.521	a	0.724	
P value		*		NS	
Carnivor	1 (Water)	1.625	c	0.040	d
	1	1.546	c	0.047	d
	7	4.035	bc	2.440	c
	14	7.763	ab	4.906	b
	21	10.824	a	7.742	a
P value		**		**	

[z] All rootstocks, except the water control treatments, were treated with a 6.25% fatty alcohol emulsion.
[y] TSS per hypocotyl = (total soluble solids) / (g dry tissue) × (mean hypocotyl dry weight).
[x] µg starch · g^{-1} dry tissue · mean cotyledon dry weight (g).
[w] Mean of 12 samples, each consisting of 5 individual hypocotyls.
[v] Days after fatty alcohol treatment.
[u] µg × g-1 = 1 ppm.
[t] Means within cultivar and column having the same or no letters are not significantly different by Fishers' protected least significant difference test; NS, *, ** (not significant or significant at $P \leq 0.05$ and 0.01).

FIGURES

Fig. 1.

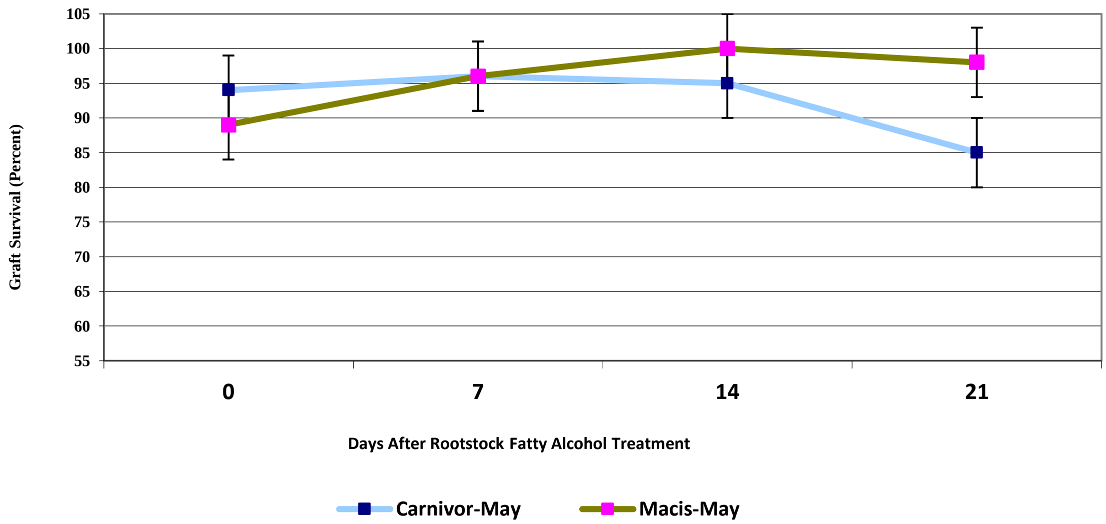
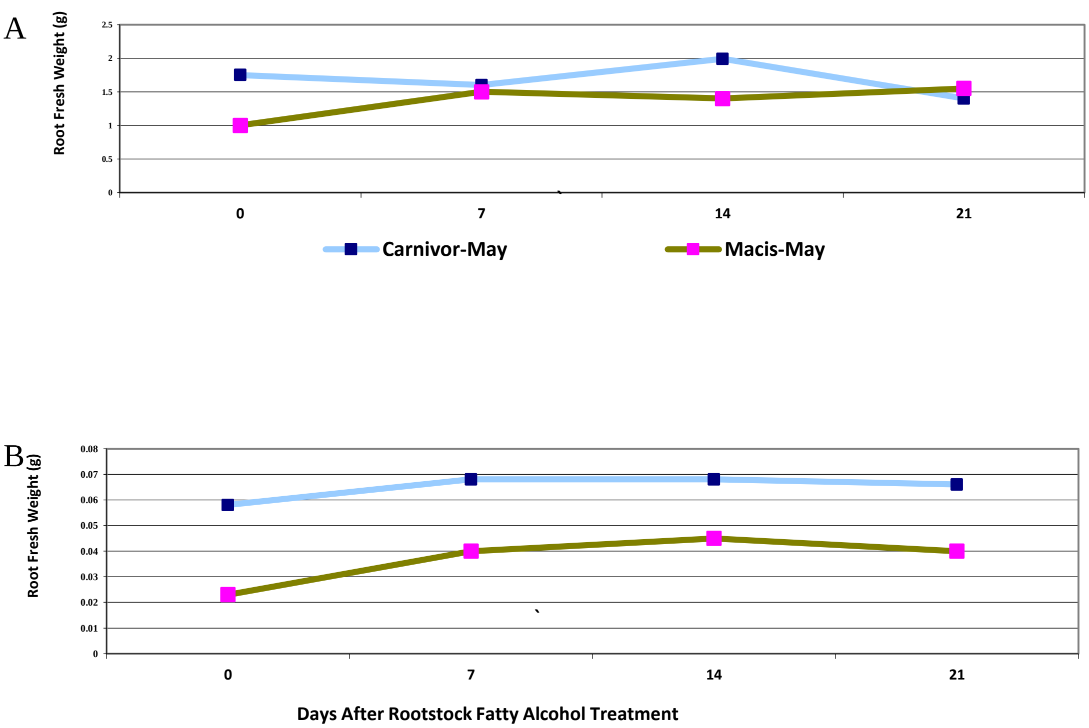


Figure 1. Graft survival using the one-cotyledon method evaluated as a percent graft healing and rootstock re-rooting. 'Carnivor' and 'Macis' rootstocks were grated at 1, 7, 14 and 21 days after fatty alcohol treatment.

A

B



Figures 2A and 2B. Root fresh (A) and dry (B) weights of 'Carnivor' and 'Macis' rootstocks grafted at 1, 7, 14 and 21 days after fatty alcohol treatment using the one-cotyledon grafting method.

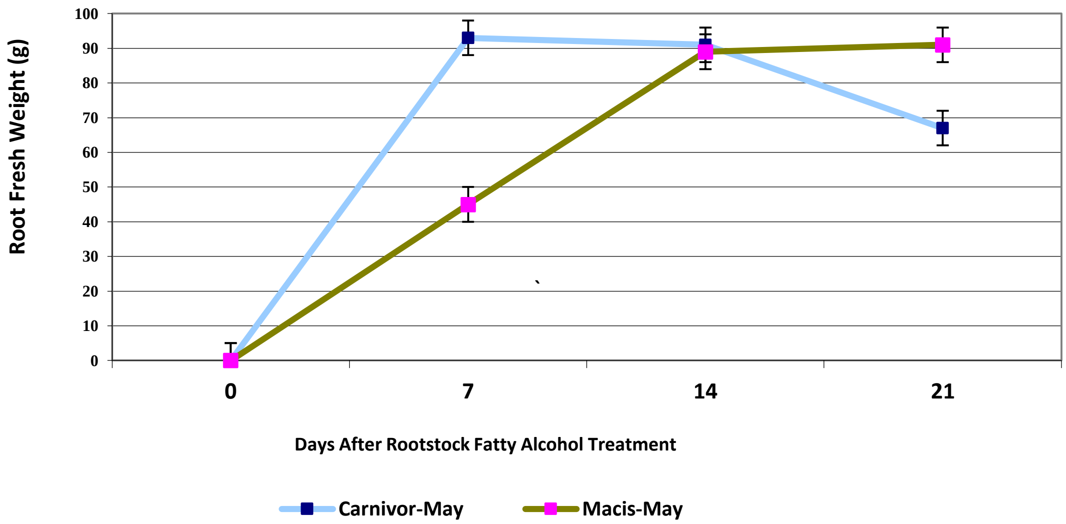


Figure 3. Graft survival using the hypocotyl only method evaluated as percent graft healing and rootstock re-rooting. Untreated 'Carnivor' and 'Macis' rootstocks (day 0) are used as a control

MANAGING PUMPKIN POWDERY MILDEW WITH HOST RESISTANCE AND FUNGICIDES

Beth K. Gugino
Department of Plant Pathology and Environmental Microbiology, The Pennsylvania State University
219 Buckhout Lab, University Park, PA 16802; bkgugino@psu.edu

Powdery mildew continues to be an annual concern for pumpkin production. Since the pathogen does not overwinter in the Great Lakes, Northeast and mid-Atlantic regions, the asexsually produced spores move into our production fields from other nearby sources typically from the southeast moving up along the east coast or in some cases from more northern sources.

The first signs of powdery mildew are small white powdery spots most commonly seen on the underside of the leaves or within the plant canopy on the petioles. When scouting, it is important to thoroughly look over the entire plant. If protectant fungicides are being used, sometimes the spots on the upper leaf surface are yellow or chlorotic and then white powdery lesions on the corresponding underside of the leaf. Accurate diagnosis is important because the targeted fungicides applied for managing powdery mildew have a completely different mode of action (FRAC code) than those used for downy mildew. Powdery mildew symptoms usually develop with the onset of fruiting starting in mid- to late July or the beginning of August. Powdery mildew is unusual because infection can still take place at a relative humidity as low as 50% and dryness over leaf wetness favors colonization, sporulation and dispersal of pathogen spores. Temperatures between 68 and 80°F are most favorable for disease development. Disease development stops at temperatures over 100°F.

Host resistance is an important tool for disease management and fortunately, there is a wide array of pumpkin cultivars that have been conventionally bred with resistance. This genetic resistance can often both delay the onset of powdery mildew and reduce overall disease severity thus reducing the number of fungicide applications needed during the season. As a result, it is important to scout for powdery mildew by cultivar. Powdery mildew resistance is designated differently in the catalogues depending on the seed source and can be categorized as highly resistant or intermediately resistant/tolerant. Highly resistant typically indicates that resistance is from both parents (homozygous) compared to intermediate resistance/tolerance which is from one parent (heterozygous). For example in the Pennsylvania Commercial Vegetable Recommendations for pumpkin, PMR (i.e. WeeeeeOne and Magician) indicates powdery mildew resistant and obtained a copy of the resistance allele from each parent versus those designated PMT (i.e. Iron Man and Magic Lantern) which indicates tolerance and contain only one resistance allele from one parent. For pumpkins, the resistance is most effective when it is from both parents (homozygous resistance) compared to one parent (heterozygous resistance).

When powdery mildew occurs early in the season and is left unmanaged it can severely reduce the photosynthetic area of the leaves needed to produce high quality marketable fruit. It can also severely damage the handles leaving them weak thus reducing marketability. Fungicides are an important tool for managing powdery mildew in-season however, there is considerable concern over the development of fungicide resistance. For resistance management, it is best to start applying the most effective products when you first start seeing symptoms (1 lesion on 50 leaves) and then later in the season switch to a protectant spray program rather than the reverse. In the long-run this will reduce the selection pressure for powdery mildew spores that are resistant to the fungicide because fewer spores are exposed to the active ingredient when disease severity is low. Fortunately for organic growers, there are also a number of organic options for effectively helping manage powdery mildew on cucurbits including copper, sulfur, oils like Eco E-rase (jojoba oil), JMS Stylet oil (paraffinic oil), Trilogy (neem oil) and Organocide (sesame oil), as well as potassium bicarbonate based products (Kaligreen and MilStop) to name a few.

Table 1. Efficacy of select fungicides and fungicide programs for managing powdery mildew on pumpin cv. Howden in a replicated field trial conducted at the Russell E. Larson Agricultural Research and Extension Center in PA in 2015. Area under the disease progress curve (AUDPC) is a measure of disease across the entire season (lower number = less disease) and were calculated separately for disease development on the upper and lower leaf surface.

Fungicide(s) and rate/A	Application timing [z]	AUDPC			
		Upper[y]		Lower[y]	
Quintec 2.08SC 6.0 oz + Bravo Weather Stik 6SC 2.0 pt + Induce 0.25% v/v	1,3				
Procure 480SC 8.0 oz + Bravo Weather Stik 6SC 2.0 pt + Induce 0.25% v/v	2,4				
Vivando 2.5SC 15.4 oz + Bravo Weather Stik 6SC 2.0 pt + Silwet L-77 0.25%v/v	3,6	0.00	--	112.36	c
Vivando 2.5SC 15.4 oz + Silwet L-77 0.25%v/v	1-6	0.08	d	13.80	f
Procure 480SC 8.0 oz	1-6	0.11	d	21.68	ef
Torino 0.85SC 3.4 oz + Bravo Weather Stik 6SC 2.0 pt + Induce 0.25% v/v	1,3				
Quintec 2.08SC 6.0 oz + Bravo Weather Stik 6SC 2.0 pt + Induce 0.25% v/v	2,4				
Procure 480SC 8.0 oz + Bravo Weather Stik 6SC 2.0 pt	3,6	0.16	d	43.19	cdef
Torino 0.85SC 3.4 oz + Bravo Weather Stik 6SC 2.0 pt + Induce 0.25% v/v	1,3				
Mettle 125ME 8.0 oz (NL)+ Bravo Weather Stik 6SC 2.0 pt + Induce 0.25% v/v	2,4				
Vivando 2.5SC 15.0 oz + Bravo Weather Stik 6SC 2.0 pt + Silwet L-77 0.25%v/v	3,6	0.20	d	51.31	cdef
Quintec 2.08SC 6.0 oz + Bravo Weather Stik 6SC 2.0 pt + Induce 0.25% v/v	1,3				
Procure 480SC 8.0 oz + Bravo Weather Stik 6SC 2.0 pt	2,4				
Pristine 38WG 18.5 oz	3,6	0.28	d	84.75	cd
Quintec 2.08SC 6.0 oz + Induce 0.25% v/v	1-6	0.76	d	59.58	cdef
Procure 480SC 8.0 oz + Induce 0.25% v/v	1-6	0.78	d	34.86	def
Mettle 125ME 8.0 oz (NL) + Induce 0.25% v/v	1-6	0.83	d	90.65	cd
Fontelis 1.67SC 1.0 pt	1,3,5				
Quintec 2.08SC 4.0 fl oz	2,4,6	2.31	d	33.40	def
Torino 0.85SC 3.4 oz + Induce 0.25% v/v	1-6	8.88	cd	68.92	cde
Pristine 38WG 18.5 oz	1-6	29.84	c	577.15	b
K-Phite 7LP 4.0 qt	1-6	661.47	b	1228.29	a
Untreated control	--	1178.48	a	1433.98	a

[z] Application dates were: 1 = 22 Jul; 2 = 29 Jul; 3 = 5 Aug; 4 = 12 Aug; 5 = 19 Aug; and 6 = 26 Aug.
[y] Powdery mildew AUPDC values on the upper and lower leaf surface were square root +0.5 and square root transformed prior to analysis, respectively. Tables contain de-transformed values. Values within each column followed by the same letter are not significantly different (*P*=0.05) according to Fisher's Least Significant Difference test (SAS v. 9.2, Cary, NC).

In Pennsylvania, pumpkin powdery mildew fungicide trials have been conducted at the Russell E. Larson Research and Extension Center in Centre Co., PA annually since 2009. Results of the most recent 2015 pumpkin powdery mildew fungicide trial conducted on cv. Howden can be found in Table 1 above. Products that continue to be the most consistently effective in these trials include Torino 0.85SC (FRAC code U6), Quintec 2.08SC (FRAC 13) and Vivando 2.5SC (FRAC U8). These are best used when alternated with products such as Fontelis 1.67SC (7), or FRAC code 3 fungicides like Procure 480SC, tebuconazole, Rally, Inspire Super 2.8F (3 + 9), Rally 40WSP, Pristine 40WSP (11 + 7) or with micronized wettable sulfur (FRAC M2). A new section 3 registration for this upcoming season is Aprovia Top (11 +3) from Syngenta Crop Protection. Keep in mind that the most effective powdery mildew programs rotate among different FRAC codes and tank mix with a protectant for fungicide resistance management. There has been increasing concerns about pollinator health and the use of fungicides such as chlorothalonil and potential synergistic interactions between pesticides, when possible time fungicide applications when fewer pollinators are foraging and visiting flowers.