Ohio Vegetable & Small Fruit Research & Development Program

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Final Report

Project Title: Incorporating On-Farm Trials to Expand the Use of Mustard Cover Crops as Biofumigants to Reduce Pumpkin Diseases.

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Introduction
This is the second year to look at the effects of planting mustard cover crops (MCC) prior to a pumpkin cash crop in order to reduce the amount of soil borne disease on both the foliage and fruit. To accomplish this we used a two prong approach: 1) a randomized, replicated research trial at the Western Agricultural Research Station and 2) an on-farm strip trial to determine the efficacy of this cultural control from a grower's perspective.

Objectives(s) of research proposal:
1. *Establish and evaluate a replicated mustard cover crop biofumigation study to reduce Plectosporium blight on pumpkin fruit and foliage at the Western Ag Research Station in South Charleston.*

In **2019**, a randomized replicated trial involving three MCC treatments to determine the effects of biofumigation on lowering soil borne diseases were conducted in a specific field range and section at Western Ag Research Station (WARS) known to be infested with this disease. The results showed very little difference between the treatments and untreated check due mostly to very dry conditions in the second half of the season which lead to poor developmental conditions for Plectosporium blight on foliage or fruit. In **2020**, this study was repeated using similar treatments (Table 1) in the same field range and section as 2019 where the disease was known to occur.

Two main differences between the trial in 2019 and 2020 are:
1. The addition of Caliente Rojo in place of the MCC mix and
2. The addition of Quintec and Procure fungicides to TRT 5 to protect the foliage from powdery mildew.

On April 22, plot preparation for drilling three MCCs began by broadcasting and lightly incorporating urea (46-0-0) and AMS (21-0-0) fertilizer at a rate of 87 lbs N / A on all plots. In addition to adding nitrogen to the plots, AMS has 24% S which is needed by the cover crop to synthesize glucosinolates, a key compound produced by the plant in the biofumigation process. Soil testing revealed no need for addition of P or K. The three cover crops were drilled on the same day as fertilizer application according to the rates in Table 1.

The three cover crops germinated and grew until flowering on June 12 at which time they were terminated by mowing, rototilling and culti-packing to maximize the biofumigation effect on soil borne pathogens. In general, the biomass of each cover crop appeared to be less than was seen in 2019, with most plants

only 18-24" tall, well short of the 3-5' that had been seen in 2019. There was some grass across the plot which likely competed with the seedlings and contributed to the short height. Pacific Gold seemed to be the most developed with Caliente 199 and C. Rojo substantially less developed and mature. This is the second year in which Pacific Gold was noted to develop quicker than other mustard cover crops. Precipitation between drilling and processing was measured at 6.1" during the seven week period.

Table 1. Description of MCC treatments and fungicide programs used in the trial. Highlighted areas show differences between 2019 and 2020 trials.

Treatment	MCC Description	Fungicide Program	MCC cost / A ($)
1-UTC	None, Untreated Check	None	NA
2 MCC	Pacific Gold (12 lb /A)	Procure 8oz alt. with Quintec 6oz	$84 ($6.97 / lb)
3-MCC	Caliente 199 (12 lb /A)	Procure 8oz alt. with Quintec 6oz	$114 ($9.50 / lb)
4-MCC	Caliente Rojo (12 lb /A)	Procure 8oz alt. with Quintec 6oz	$120 ($10.00 / lb)
5-Strobi	None, Strobiluron control	Flint 2oz + Procure 8oz alt w/ Cabrio 16oz + Quintec 6 oz	NA

On June 25, Solid Gold pumpkin, the same hybrid used in 2019 was direct seeded into each plot with a final spacing of 3.5' in row. Like 2019, each plot was 50' long. Immediately after seeding, Strategy 4.5pts/A and glyphosate 32oz/A, were applied for burndown and pre-emerge weed control. The pumpkin seedlings in each plot were sidedressed with 65 lb N / A on July 17 using liquid fertilizer (28-0-0).

To protect the pumpkin plants from powdery mildew and Plectosporium blight, fungicide applications were made according to the trial treatments starting on July 30 followed by August 7, 17, 24, 31 and September 9. For downy mildew protection, Ranman 2.75 oz/A was added to the fungicide mix on August 24 and September 9, and Zampro 14 oz/A was added to the spray program on August 31. Neither Ranman nor Zampro should effect Plectosporium blight development.

Scouting for Plectosporium blight development occurred on August 6, 17, 31 and September 14. During each sampling date, five petioles and leaves were randomly selected from each plot and inspected for signs of infestation which were estimated using percent area. Leaf injury was assessed by estimating the area of lesions on the back of the leaf veins. There were no disease lesions found on petioles or leaf veins on August 6 so that data is not shown; all other sampling data is shown (Table 2).

Results

No significant differences (NS) were found between treatments on either petioles or leaf veins for August 17 or 31. On the September 14 sampling, the petioles of treatment 1 (untreated check) had significantly higher infestation of Plectosporium blight lesions than all other treatments. In the leaf vein samples on the same date, the untreated check (treatment 1) had significantly more disease than the other treatments, and treatment 2 (Pacific Gold) had significantly more disease than treatment 5 (strobiluron fungicide).

With only small numerical differences between treatments on sampling dates August 17 and 31, we conclude there are no differences between using a MCC or a strobiluron fungicide to reduce disease pressure compared to the untreated check. With higher disease pressure on September 14, all three MCC and the strobiluron fungicide treatments controlled Plectosporium blight significantly better than the untreated check. For leaf vein infestation on the same date, the strobiluron fungicide treatment had significantly lower disease pressure than Pacific Gold treatment but the same as other MCC treatments.

In summary, for the foliage sampling part of the trial, despite having Plectosporium blight spores in the soil, there appeared to be only minor disease pressure for most of the season on the untreated check foliage. The use of MCCs and strobiluron fungicides did lower the disease pressure compared to the untreated check especially on the last sample date but the overall level of infestation was deemed relatively low. Therefore, based on these results the use of MCCs or a season long strobiluron fungicide schedule could be used to manage low levels of Plectosporium blight on foliage. In addition to the disease suppression effects of MCCs in a pumpkin rotation, growers might accrue other benefits such as soil health and pollinator utilization of blooms which may be confirmed in other research trials.

While the strobiluron fungicide combination applied back to back in treatment 5 did appear to reduce disease pressure, this mode of action rotation is not allowed by either product label. Because Flint and Cabrio are FRAC code 11 fungicides, the label requires rotating to a compound with a different FRAC code on subsequent applications in accordance with disease resistance management principles. This fungicide schedule was only used to help answer a specific research question and is not recommended to be used by growers.

Table 2. Disease ratings of Plectosporium blight symptoms on petioles and leaves (% infestation).

	17-Aug		31-Aug		14-Sep	
Treatment	**Petiole**	**Leaf**	**Petiole**	**Leaf**	**Petiole**	**Leaf**
1-UTC	1.4	0.4	4.2	1.6	19.2 a	54.0 a
2 MCC	1.2	0.8	4.5	1.8	9.5 b	12.5 b
3-MCC	2.5	1.5	4.6	2.0	6.2 b	5.3 bc
4-MCC	1.8	0.8	4.1	1.1	8.1 b	4.7 bc
5-Strobi	1.2	0.5	4.6	0.9	6.4 b	3.3 c
P-value	0.16 (NS)	0.37 (NS)	0.74 (NS)	0.53 (NS)	0.0013	<0.0001

After the foliage evaluations were complete, all mature fruit in each plot (50’ row) were harvested on September 16. Each fruit was weighed and graded for Plectosporium blight lesions on the handle or fruit rind. Complete harvest results can be found in Table 3. There were no significant differences in the number of fruit per treatment, the average fruit weight of per treatment, the percent of fruit with handle lesions (incidence) per treatment or the severity of those lesions per treatment compared to the untreated check. There were no lesions found on any of the pumpkin rinds harvested in the entire trial. Based on these results, there appeared to be no effect of the MCC or strobiluron fungicide schedule on handle or fruit quality, meaning the number of marketable fruit were not changed by using either of these cultural or chemical practices under these field and environmental conditions.

Table 3. Harvest data and Plectosporium blight lesions on pumpkin handles.

Treatment	**No. fruit**	**Wt. / fruit (lb)**	**Handle lesion incidence (%)**	**Handle lesion severity (%)**
1-UTC	17.8	22.4	19.2	1.1
2 MCC	18.8	21.3	26.5	1.2
3-MCC	19.0	22.8	25.2	0.7
4-MCC	20.5	21.8	16.2	0.6
5-Strobi	19.3	23.4	12.9	0.2
P-value	0.64 (NS)	0.23 (NS)	0.29 (NS)	0.20 (NS)

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Objectives(s) of research proposal:

2. *Recruit 4-6 growers statewide to establish a replicated mustard cover crop biofumigation on-farm study to reduce disease incidence of Plectosporium, Fusarium, or Phytophthora on pumpkin fruit and foliage.*

Two grower recruitment articles were posted to the VegNet Blog on Feb. 18 and March 12, with a total of three growers responding. After interviews, only two of the growers were suitable for the study. After visiting each on-farm site and discussing with the growers the trial design and requirements, both agreed to the terms of the project.

Instead of planting the full experiment conducted at the research station, a simple strip trial with four MCC and four non-MCC strips was designed for each location. Foliar disease ratings would be taken periodically in both MCC and non-MCC strips, and harvest data would be taken at the end of the season. Caliente Rojo cover crop seed and Solid Gold pumpkin seed were sent to each grower with a mid-April planting target, followed by a mid-June target of pumpkin seeding.

The first grower at Gorman Heritage Farm in Evandale prepared the field and drilled the cover crop on April 22. The crop emerged slowly and was damaged by two frost/freeze events in mid and late May, resulting in too low a mustard cover crop stand to conduct the second half of the study so this site was abandoned.

The second grower was located in Batavia. The grower reported not having this disease on his farm but was willing to see any beneficial effects of planting the mustard cover crop. The field was prepared for drilling by incorporating 100 lb nitrogen per acre using both urea and ammonium sulfate. The cover crop was drilled at 10 lb/ A on April 1 and had uniform emergence by mid April. This cover crop survived the two frost/freeze events in May and continued to grow normally throughout late spring.

The cover crop reached peak flowering and was ready for termination on June 9. The process included mowing the cover crop, rototilling in the plant biomass, and then running a cultipacker over the ground to seal the soil, all within 10-15 minutes per strip. This field was allowed to rest for 10 days while the biofumigation process occurred in the soil. On June 19 Solid Gold pumpkins were direct seeded into each of four MCC strips and four oat cover crop (non-MCC) strips. Each strip was approximately 250' long and planted on 8' centers. The pumpkins had excellent emergence and were thinned to a final plant spacing of 3.5' within the row.

The grower periodically applied fungicides to protect the pumpkin crop from powdery mildew using materials that should have no effect on Plectosporium blight development. Below is the growers spray schedule:
-Quintec 6oz/A on Jul 31
-Procure 8oz/A on Aug 6
-Quintec 6oz/A on Aug 14
-Procure 8oz/A + Manzate 2lb/A on Aug 20
-Previcur Flex 1.2pt/A + Bravo 2pt/A + Manzate on Aug 29.

The first foliage disease rating for Plectosporium blight occurred on August 10 (Table 4). Within the field there were pockets of heavily blighted areas with lightly bleached vines and severely damaged petioles next to areas that did not have any lesions on the foliage or vines. Interestingly the percent lesions were higher on the petioles and leaf veins in the MCC compared to the non-MCC strips.

Upon arriving at site for the second foliage disease rating on August 28, it was immediately evident that the disease had progressed to the point where approximately 95% of all plants in both the MCC and non-MCC strips were so severely infected with Plectosporium blight they had collapsed to the ground. The majority of vines were bleached white by lesions (ca. 80%), the majority of fruit handles had severe lesion

infestation (ca. 80%), and nearly a quarter of the fruit had lesions scarring their rind. There were very few marketable fruit to be found in all eight strips due to the extreme level of infestation from Plectosporium blight on their handles and rind (Figure 1).

Table 4. Percent Plectosporium lesions in MCC and non-MCC strips in Batavia, OH.

	% Infestation	
	Petiole	Leaf vein
MCC Strip	5.9	2.7
Non-MCC strip	3.9	1.1

The amount of disease in the field was very jarring to the grower who reported never having seen this disease before on his farm, especially since he had been growing pumpkins on that field for several years with a proper rotation. To support his statement, the pumpkin and squash hybrid plants immediately adjacent to both sides of this strip trial plot were generally healthy with only very few lesions on their petioles, leaves or vines (Figure 2). There is obviously a genetic host plant resistance component to this trial, meaning this particular hybrid is highly susceptible to this pathogen. The only other difference between the management of the on-farm strip trial and other pumpkin/squash fields involved the addition of Quadris on Aug. 14 and Cabrio on Aug. 20 to the spray program. These two fungicides have been shown to reduce this pathogen in other trials but how much chemical control contributed to plant protection versus host plant resistance of the other hybrids in this trial cannot be determined.

Objectives(s) of research proposal:

3. Obtain grower feedback about value of using biofumigation as a tool to combat soil borne diseases.

Below are the unfiltered and unedited observations and comments by the Batavia grower who participated in the on-farm MCC strip trial.

“Growing the mustard was a challenge I wanted to try, hoping that it would benefit the pumpkins first and the soil next. I don't think the mustard helped control the PB by itself with only spraying for Powdery Mildew. Maybe it was the variety of pumpkin that was used in the test, Solid Gold. I still have some mustard seed left over. Maybe next year I might try a few short rows with the varieties I normally plant.

I do believe tilling in the mustard helped build on the organic matter as the soil seemed easier to work. The benefit to the pollinators was great. To stand there and watch them work the flowers is always satisfying. The mustard would be a good crop to plant for a quick cover crop and pollinator refuge.

The quality of the pumpkin handles were bad. Most all of the handles were soft when picked and fell apart when dried. The fruit themselves were of top quality weighing 25-35 pounds. The average was around 30 lbs. The pumpkins that I did sell of the test crop were at a discount because of the bad handles.

I don't think planting the mustard and expecting it to control the PB by itself is a good plan. It might be an extra "tool" in the tool box when trying to control PB. I still had the blight in some of my other pumpkins but not to the extent of the test plot. I learned alot about diseases this year working with you. I'm glad I helped with the project. If somebody doesn't take a chance once in a while nothing will be learned”.

If I were to attempt summarize the on-farm trial results from my perspective, I would say he discovered that he did have substantial Plectosporium blight inoculum in several of his farm fields which were being masked by the hybrids he chose to plant and to some degree the occasional strobiluron fungicides that were sprayed on the crop.

Figure 1. Pictures taken on August 28 of (A) Plectosporium lesions and development in MCC plot, (B) Plectosporium lesions and development in non-MCC strip, (C) bleached vines, collapsed foliage and infected fruit handles, and (D) closeup of lesions on unmarketable fruit handle and blighted vine.

The investment of time and resources to prepare the field, apply fertilizer, drill and terminate the cover crop was considerable only to return a lower than average yield is likely a process most growers wouldn't repeat. On the positive side, his experience with the mustard cover crop strip trial included seeing abundant honey bees and bumble bees on his farm attracted and sustained by the flowering crop for several weeks prior to termination was a joy. The grower also learned how to identify and manage Plectosporium blight using recommended fungicides in case this disease flares up again in future years.

Project Summary

The goal of mustard cover crop research project was to find a non-chemical cultural means to control Plectosporium blight, a soil borne pathogen, that exists on many Ohio farms causing minor to substantial loss of marketable pumpkin fruit.

After two years of rigorous research and evaluation at the Western Ag Research Station in fields that were known to have this disease, the MCC treatments seem to control the foliar phase of this disease about as good as strobiluron fungicide sprays, meaning both approaches had fewer lesions than the untreated check. It is important to remember that strobiluron fungicides (FRAC 11) cannot be applied back to back as was done in this study due to resistance management guidelines spelled out on the label.

Although these results are encouraging, there is evidence the research field we used likely had a relatively low level of soil borne inoculum, and under higher Plectosporium blight inoculum loads, these two approaches may not have controlled this disease to the same extent. The vast majority of fruit from these research trials had zero lesions on the rind and only a few percent of lesions on the handle and were therefore fully marketable. The reduced disease effects of either MCC or strobiluron fungicides seemed most noticeable at the end of the season.

Figure 2. Pictures taken August 28 of (A) unaffected grower pumpkin field (L side) next to edge of collapsed pumpkin MCC strip trial (R side) and (B) edge of collapsed pumpkin MCC strip trial (L side) next to another unaffected pumpkin field (R side). Orange fruit can be seen in both photos where foliage has collapsed.

In the on-farm MCC strip trial, it was very clear that high Plectosporium blight disease pressure combined with a susceptible pumpkin hybrid could result in a near total loss of the crop. With the addition of a few well timed strobiluron fungicide sprays or a hybrid with more genetic resistance, perhaps a more normal marketable crop could be expected.

Commercial seed companies do not formally breed for enhanced Plectosporium blight resistance as they do for powdery mildew, so it appears this resistance information will only be generated by word of mouth or specific screening trials designed to measure their relative resistance to this pathogen. Based on prior research trials, cucurbits that are more squash like (*C. maxima*) or moschata like (*C. moschata*) tend to have naturally higher resistance levels than pumpkin (*C. pepo*).

When evaluating time, effort and expense to seed and fertilize a MCC strictly for disease management purposes, the return on investment in terms of marketable fruit is essential. The input costs alone in the on-farm MCC strip trials was nearly $140 per acre which needs to show dividends preferably in fruit production but may show up in some other capacity such as soil health or pollinator health.

Given these overall results, the practice of using a mustard cover crop cannot be universally recommended for purposes of managing soil borne diseases such as Plectosporium blight because of not knowing initial inoculum loads or hybrid susceptibility. This recommendation is further backed up with the single on-farm trial in 2020 that clearly demonstrated a near total loss of susceptible pumpkin plants and marketable fruit in a field where this disease was not even known to exist.

Planting a MCC may be worthwhile to growers from the perspective of attracting and sustaining a wide array of pollinators and other beneficial insects on their farm or by improving overall soil health conditions. Both of these aspects may be the focus of future research.