Integrating powdery mildew tolerance and fungicide disease control programs to maximize economic return for pumpkin production

Industry Partner: Ohio Vegetable and Small Fruit Research Development Program

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Project Summary:

This research project evaluated the performance of a powdery mildew tolerant, Super Herc (PMT), and non-PMT pumpkin variety, Pro Gold 510, under three different disease control programs ranging from a minimally acceptable to a highly intensive program. These three disease control spray programs were compared on the basis of cost, disease resistance management, i.e., the recently developed Fungicide Resistance Action Committee (FRAC) number, as well as the environmental impact.

C. Project Description

<u>Objectives</u>

1. Establish the production efficacy of low, standard, and highly intense disease control programs on pumpkins
2. Compare the economic impact of powdery mildew tolerant varieties and susceptible varieties under different spray programs
3. Produce Environmental Impact Quotient (EIQ) for each disease control program

<u>Rationale and Significance:</u>

Pumpkins are now Ohio's third largest fresh market vegetable. Some producers report that pumpkin production may now account for twenty to forty percent of a grower's gross income. Important diseases that threaten pumpkins each year are powdery mildew, downy mildew, Microdochium Blight, and watermelon mosaic virus. Powdery mildew can be controlled by fungicide application but costs may be high and prohibitive. Powdery Mildew Tolerant (PMT) varieties have been introduced and these varieties can help lower disease control costs and the amount of fungicide entering the environment. However, precise reductions in fungicide application and cost savings are not known. Downy mildew control may require one to several applications of a high cost fungicide such as a stobiluron.

Research Methods

The research was conducted at the Western Agriculture Research Station (WARS) in South Charleston, OH. Two pumpkin varieties, Super Herc (PMT) and standard Pro Gold 510 were direct seeded on May 27th into single row plots in a randomized complete design with 4 replications. Plot size was 40 feet by 15 feet. Due to excessive vertebrate seed predation, the study was replanted on June 7th, and eventually filled in with transplants for certain plots on June 23. All direct seeded plantings included Admire 2F in-furrow at a rate of 16 oz / A for early season pest control. All plots received one application of Sevin XLR (1 Q/A) for cucumber beetle control during fruit sizing, Weed control programs included Strategy (4 pt/A) immediately after planting and spot treatments of Roundup plus hand cultivation. Because the insecticides and herbicides were used in all plots, their environmental and economic costs were not figured in to any of the spray programs. All plots received trickle irrigation on a weekly basis during dry weather.

In the low cost program, spray intervals were at 7-10 days apart. This program utilized both organic and inorganic fungicides to control bacterial and fungal diseases (Table 1). The standard program utilized only synthetic organic fungicides including the Strobiluron class, which have laminar systemic activity for enhanced disease control. The standard program was also be sprayed on a 7-10 day interval. Fruit quality and yield were expected to be higher than the low cost program. The intensive fungicide program mirrored the standard program but sprayed on a 3-5 day schedule. Fruit quality and yield were expected to be excellent as a result of the most intensive and expensive program.

Table 1. The order and number of sprays in three distinct spray programs. All spray programs will begin the last week of July unless otherwise needed.

Spray number	**Low Cost**	**Standard Program**	**Intensive Program**
	7-10 day interval	7-10 day interval	3-5 day interval
1 (ca. July 30th)	Manex + Copper + Sulfur	Bravo + Nova	Manex + Nova
2	Manex + Copper + Sulfur	Tanos	Tanos
3	Manex + Copper + Sulfur	Bravo + Nova	Manex + Nova
4	Manex + Copper + Sulfur	Tanos	Tanos
5	Manex + Copper + Sulfur	Bravo + Nova	Manex + Nova
6	Manex + Copper + Sulfur	Tanos	Tanos
7			Manex + Nova
8			Tanos
9			Manex + Nova

Sprays for the intensive program began July 25th with a tank mix of Manex (1.6 Q/A) + Nova 40W (5 oz./A), alternated with Tanos (8 oz./A) every 4-5 days for a total of 13 applications. Sprays for the standard program also began July 25th with a tank mix of Bravo Weather Stik (3 pts/A) + Nova 40W (5 oz. /A), alternated with Tanos (8 oz. / A) every 7-10 days for 7 applications. The low cost program was applied at the same interval as the standard program, but consisted of a Manex (1.6 Q/A) + Kocide 2000 (2.25 lbs./A) + Micro Flo Sulfur 6L (4 GPA) tank mix. All fungicide sprays were applied at 55 GPA with cone nozzles at 65 psi.

The standard fungicide spray programdates were: Bravo + Nova was applied on: 25 Jul, 8 Aug, 22 Aug, 6 Sep alternating with Tanos applied on: 1 Aug, 16 Aug. and 6 Sep.

At the end of the season, 8 Sep, foliar evaluations were made to determine the percent severity of foliage infected with Powdery Mildew, Downy Mildew and other prominent diseases. See footnote #1 in tables 2 and 3 for details. In addition, yield data such as handle quality (the presence or absence of powdery mildew), average fruit weight, number of fruit per acre, tonnage per acre, and fruit disease susceptibility were recorded.

The fungicide spray records of each treatment were reviewed for economic feasibility and environmental impacts. Because most growers are also concerned with environmental impacts associated with their production practices, Environmental Impact Quotients (EIQ) were assessed for each pesticide used in the spray program. The EIQ values for most pesticides have already been calculated (Kovach et al, 1992) and vary according to their load and eventual fate in the environment. In general, lower EIQ scores result from materials with lower percentages of active ingredient and lower field use rates.

<u>Results and Discussion</u>

Over all fungicide and variety treatment combinations, Pro Gold produced significantly more fruit per acre than Super Herc (Table 2). However, there was no significant difference in tons per acre produced between varieties because Super Herc produces larger fruit. This is confirmed by the significantly larger fruit size of Super Herc over Pro Gold 510 (Table 2.). Over all fungicide-variety treatment combinations, there was no significant difference in the severity of powdery mildew on the bottom or top of the leaves between a PMT and a standard variety. The potential advantage of a PMT variety may not have been realized in a dry season as the summer of 2005.

Table 2. The effect of cultivar on yield characteristics and foliar infection of powdery mildew

ID#	Variety	Marketable Fruit Number/Acre	Tons/Acre	Average Fruit Size (lbs)	Foliar Powdery Mildew Rating Top[1]	Foliar Powdery Mildew Rating Bottom[1]
2	Pro Gold 510	1823a	16a	17a	0.12	18
1	Super Herc	1298b	14a	21b	0.10	13
			ns		ns	ns
	LSD 0.05%	348	3.3	1.3	0.14	10

<u>Key To Disease Ratings in Table 1.</u>

1. Powdery Mildew: Percentage of severity of leaf area infected on top and bottom of the leaf. Average of 2 rankers, each using five leaves per plot.

When the effect of spray program and variety interaction is evaluated on fruit number per acre, the standard-fungicide Pro Gold treatment had significantly more fruit than the standard fungicide Super Herc treatment (Table 3). This is due the influence of cultivar on fruit number as seen in Table 2 rather than on the influence of spray program. Again, there was no significant difference in tons per acre among spray program/variety interaction. All Super Herc fungicide treatments had significantly larger fruit than Pro Gold fungicide treatments (Table 3).

While variety and fungicide treatment interaction had no significant effect on fruit yield or quality, there were differences in percent powdery mildew severity observed on pumpkin foliage. The percent severity of powdery mildew on the top of leaves was significantly higher on the low cost Pro Gold treatment compared to the standard Pro Gold and intensive fungicide Super Herc treatment. There were no significant differeces among all other treatments. The severity of powdery mildew on the bottom of the leaves in both the low cost Pro Gold and low cost Super Herc treatments was significantly higher than all other treatment combinations (Table 3). In a wet and humid year as in 2004, this increased percentage of infection could lead to greater reduction in yield and fruit quality.

Table 3. The effect of cultivar and fungicide program on yield characteristics and percent foliar infection of powdery mildew.

ID#	Treatments: Fungicide Program | Variety	Fruit Number/ Acre	Tons/Acre	Average Fruit Size (lbs)	Foliar Powdery Mildew Rating Top[1]	Foliar Powdery Mildew Rating Bottom[1]
F1V2	Low | Pro Gold 510	1790	15	17	0.31 a	34 a
F2V2	Std | Pro Gold 510	1960a	17	17	0.01 b	16 b
F3V2	High | Pro Gold 510	1718	16	18	0.06 ab	2 b
F1V1	Low | Super Herc	1452	15	21	0.26 ab	39 a
F2V1	Std | Super Herc	1161c	13	22	0.06 ab	0.8 b
F3V1	High | Super Herc	1282	13	21	0 b	0.02 b
	LSD 0.05%	620	ns	1.3	0.2	17

Key To Disease Ratings in Table 1.

1. Powdery Mildew: Percentage of severity of leaf area infected on top and bottom of the leaf. Average of 2 rankers, each using five leaves per plot.

At the end of the season, the fungicide spray records for each program were reviewed for economic costs and environmental impacts. Fungicide costs were generated from actual retail costs with no educational or quantity discounts applied (Table 4). If two or more compounds were used in a tank mix, the cost of each component was added together and referred to as the segment cost (Table 5).

Table 4. Individual fungicides ranked by cost used in the three spray programs.

Fungicide	Rate	Cost / application
Kocide 2000	2.25 Lbs / A	$ 5.81
Manex	1.6 Q / A	$ 6.10
Tanos	8 Oz / A	$ 11.00
Bravo Weather Stik	3 Pts / A	$ 15.54
Micro Flo Sulfur 6L	4 GPA	$ 16.00
Nova 40W	5 Oz / A	$ 19.00

Table 5. The composition, cost, and frequency of three fungicide programs.

Fungicide Combinations	Segment Cost	# Applications	Segment Cost / Season	Program Cost / Season
Intensive program (Manex + Nova)	$ 25.10	7	$ 175.70	$ 241.70
Intensive program (Tanos)	$ 11.00	6	$ 66.00	
Standard program (Bravo + Nova)	$ 34.54	4	$ 138.16	$ 171.16
Standard program (Tanos)	$ 11.00	3	$ 33.00	
Low cost program (Manex + Cu + S)	$ 27.91	7	$ 195.37	$ 195.37

Aside from fungicide costs, growers are also concerned with environmental impacts associated with their production practices, specifically pesticide applications. Environmental Impact Quotients (EIQ) are a scientific means of assessing pesticide fate in the environment based on toxicological and environmental data, impacts against arthropod natural enemies, honey bees, and birds, leaching potential, and related human health issues. EIQ values for fungicides used in this study have already been calculated in the paper by Kovach et al (1992) and are presented in Table 6. In general, lower EIQ scores indicate products with overall lower environmental impact. Perhaps what is more important than the raw EIQ score is the Field Use Rating (FUR), which takes into account the EIQ score x % active ingredient x rate per acre to get an more accurate picture of environmental impact. When comparing spray programs it is important to realize that the EIQ FUR score needs to be multiplied by the number of applications made over the season to get an accurate overall understanding of environmental impact (Table 7). Thus, not always should the product with the lowest EIQ FUR score be chosen over a product with a higher value without first considering how many applications might be necessary to properly manage the pest, or in this case, the disease.

Table 6. Fungicides used in spray programs ranked by Environmental Impact Quotient Field Use Rating.

					Field Use Rating (FUR)
Fungicide	**EIQ**	**% ai***	**Label rate**	**Unit**	**EIQ x % ai x rate**
Manex	21.4	0.37	1.6	Q / A	12.7
Kocide 2000	33.3	0.54	2.25	Lbs / A	40.5
Tanos	10.22	0.5	8	Oz / A	40.9
Bravo Weather Stik	40.1	0.54	3	Pts / A	65.0
Nova 40W	33	0.4	5	Oz / A	66.0
Micro Flo Sulfur 6L	45.5	0.52	4	GPA	94.6

* ai = active ingredient

Table 7. Environmental Impact Quotient (EIQ) Field Use Ratings and total EIQ for three fungicide programs.

	EIQ FUR	# Applications	Partial Program EIQ	Program EIQ
Intensive program (Manex + Nova)	78.7	7	550.7	796.0
Intensive program (Tanos)	40.9	6	245.3	
Standard program (Bravo + Nova)	105.8	4	423.4	546.0
Standard program (Tanos)	40.9	3	122.6	
Low cost program (Manex + Cu + S)	147.8	7	NA	1034.4

Using tables 5 and 7, it is possible to determine which of these three fungicide programs might be considered "the best" based on lowest cost and lowest environmental impact (Table 8). If cost and impact are the only two parameters considered, then the standard program of Bravo + Nova alternated with Tanos is clearly the least expensive and has the lowest environmental impact in this trial. The "low cost" program is more costly than the standard program, and has the highest EIQ FUR score, due mostly to the sulfur in the tank mix. In fact, the EIQ FUR for this program is significantly lower than it could have been due to the relatively low percentage of sulfur in the product. If another sulfur product was used with a higher percentage of active ingredient, the low cost program EIQ FUR would have been dramatically higher. The intensive program was the most expensive, but intermediate in its environmental impact.

The caveat to the environmental and economic ranking assumes the rates, percentage of active ingredients, and costs as listed; if growers use different products with different percentages of active ingredients or discounted product cost, the ranking of fungicide programs may need to re-ordered. A second very important consideration is the number of applications a sprayer makes to each field, considering fuel and labor costs, and potential compaction issues. If these costs are figured in to the overall picture, the cost of the intensive program doubles by relative comparison with the other two spray programs.

Table 8. Rank of fungicide programs by environmental impact and economic factors.

	Rank Key: EIQ 1 = Highest Impact	Rank Key: Economics 1 = Most Expensive
Fungicide Program	**Total Program**	**Program Cost**
Intensive	2	1
Standard	3	3
Low Cost	1	2

Conclusions:

1. Pumpkin variety had the most significant effect on yield and fruit quality. Pro Gold 510 produced more fruit per acre. Super Herc was larger in fruit size (lbs per fruit). There was no difference in tonnage per acre.

2. Selection of a PMT variety versus a standard variety had no influence on the incidence of powdery mildew on foliage or fruit quality (handles). This was probably due to a very dry, hot season in 2005.

3. Fungicide spray programs did not affect pumpkin fruit number per acre, tonnage or average fruit size.

4. Fungicide spray programs did affect the percent severity of powdery mildew on the bottom of the pumpkin leaves. The low cost program had a significantly higher incidence of infection compared to all other treatments regardless of variety. On the top of the foliage, powdery mildew control was virtually the same among treatments. Only the low cost-Pro Gold combination had significantly more powdery mildew than the intensive-Super Herc and standard-ProGold combinations.

5. The standard fungicide program remains the best recommendation. It was the cheapest in cost and had the lowest environmental impact.

6. It is important to realize that a wet season with high disease pressure (e.g. summer of 2004) might give different results.

E. References

Kovach J. *,C. Petzoldt, J. Degni**, and J. Tette. A Method to Measure the Environmental Impact of Pesticides. 1992. IPM Program, Cornell University, New York State Agricultural Experiment Station Geneva, New York 14456.
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