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Pumpkin Powdery Mildew Fungicide Demonstration Trial Report - 2021

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Introduction

A powdery mildew (PM) fungicide evaluation trial was conducted on pumpkin at the Western Ag Research Station in South Charleston, OH at 39.857672, -83.667513. All treatments were applied to a powdery mildew susceptible hybrid (Hybrid Pam, Rupp Seeds) to determine the efficacy of compounds on foliage health. No yield data was taken.

This goal of this powdery mildew demonstration trial is to evaluate the contribution and effectiveness of a primary fungicide when used in combination with rotational fungicides such as Procure, Manzate Pro Stick, Vivando or Quintec to determine leaf and canopy health, ostensibly to maximize marketable fruit and handle quality.

These fungicide programs have been designed to primarily manage powdery mildew and may have inherent weaknesses against specific diseases such as downy mildew and bacterial diseases.

The upper leaf surface and upper canopy is easier to protect with fungicides, and therefore typically has lower levels of powdery mildew infestation. The lower leaf surface and mid to lower canopy is more difficult to protect due in part to known limitations in spray application technology and complex plant architecture, but can reveal the extent to which materials are mobile or locally systemic. **Using that criteria, this report focuses primarily on how well the lower leaf surface is protected.** All products in the trial are known to have some level of systemic activity.

The scouting threshold for PM is conservative and uses initial detection to determine the onset of fungicide applications. In terms of relative product comparisons, lower percent infestation is considered better. When leaves become colonized by PM in the 70+% range, they quickly begin to show symptoms of chlorosis, necrosis, and disintegrate, losing the ability to photosynthesize and leaving fruit exposed to possible sunburn and marketable loss.

The pumpkin hybrid **intentionally** used in this trial is **PM susceptible**, which helps to separate any genetic resistance the plant may offer from the efficacy of the fungicide program. As part of our IPM program standard recommendations, we strongly recommend growers select a PM tolerant or resistant hybrid when possible to maximize foliage and handle quality throughout the

season. Even marginal spray programs provide much better control when used in combination with tolerant or resistant hybrids.

In the 2021 trial, the weather was more like a "normal" summer with periods over 90F occurring mid-June, late June, early July, early and late August. From June 1 - September 17, the station recorded just over 13" of rain. There was also a cool wet period in mid-August which lead to minor downy mildew infections in the plots due to the use of protective fungicides in most of the treatments.

Methods

The trial was direct seeded June 1 using a Monosem vacuum planter. Each plot consisted of one 80' long row of Hybrid Pam pumpkin (PM susceptible) with a final stand 4' within the row. Fifteen feet on the east side of each plot was not sprayed and served as an "untreated check" section to confirm the presence of PM and reflect the condition of untreated foliage.

Treated plots were separated by a 15' drive lane on each side with a 20' fallow buffer between the header and end of each plot. These spacing measures were designed to minimize spray drift between plots. The seeds were treated with FarMore (thiamethoxam) to limit striped cucumber beetle feeding and minimize transmission of bacterial wilt.

Weeds were managed by spraying Strategy (4.5 pints/A) plus Dual Magnum (1.3 pints/A) plus Liberty (32 oz/A) pre-emerge June 1, followed by a shielded post application of Sandea (1oz/A) and glyphosate (32oz/A) between the rows on June 21. Any weed escapes in the row or between the plots were hand pulled or hoed out. The prior crop was soybean, and no cover crop was planted in the field.

Based on soil test results, no P or K was added to the field. On June 15, 75 pounds of nitrogen in the form of liquid 28-0-0 was side dressed six inches away from the row, approximately two inches deep in the soil.

In 2021, downy mildew was confirmed at the station on pumpkin August 13. Regardless, the plots were protected by alternating Ranman (2.75 oz/A) and Zampro (14 oz/A) as a part of the treatment from spray #4 (8/16) through #6 (8/30). None of the downy specific products should impact PM development. Bacterial Leaf Spot was not detected on the foliage or fruit in any of the treatments, therefore copper protectant sprays were not applied.

Powdery mildew was first detected in the trial on July 20. Full scouting and data collection occurred between 10am and noon on July 20, July 29; August 9, 16, 23, 30; September 9. Fungicide treatments were applied between 1-4pm on July 20, 31; August 9, 16, 23; and September 2. All treatments were applied using a hydraulic boom sprayer at 36 GPA using hollow cone nozzles at 65 PSI.

In each treatment plot, powdery mildew development was evaluated on six randomly chosen leaves. Each leaf selected was examined on the upper and lower surface for powdery mildew colonies. Prior to each rating, a pictorial guide (**Figure 1**) representing percent PM infestation was used to calibrate visual assessment to approximate the percent infestation seen on each leaf

surface. This chart was carried during the evaluation and periodically referred to for accuracy. During each evaluation period an effort was made to randomly choose leaves of a consistent age from both the middle and upper canopy that represented product efficacy fairly. These two factors, chart calibration and leaf age consistency, are key to producing a reliable powdery mildew efficacy data set. The percent powdery mildew of each leaf surface was recorded and a mean value plus its standard deviation were calculated for use in the tables below.

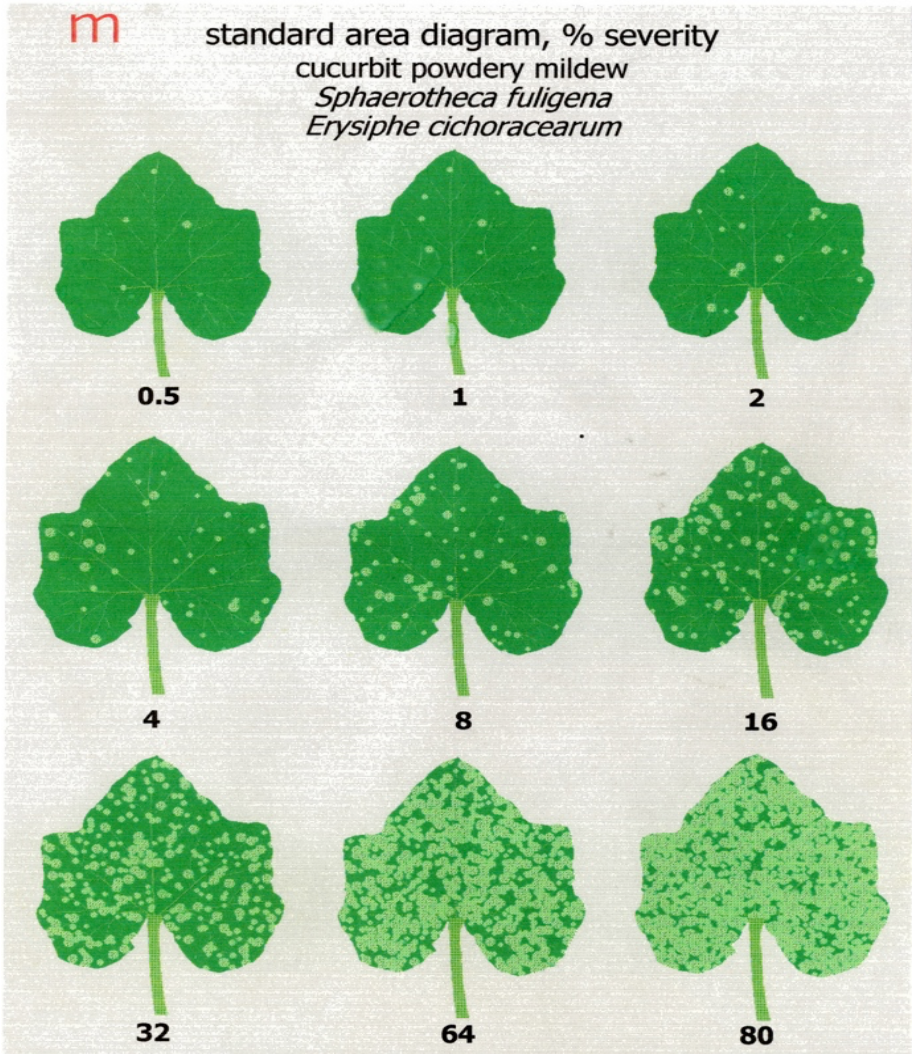


Figure 1. Percent powdery mildew infection chart.

Fungicide treatments are listed in **Table 1.** Rating data for the seven evaluations can be found in **Tables 2-7**. The "untreated check" was created by taking two leaves from each untreated plot area, for an average of 14 leaves per rating, on both the upper and lower surface.

Table 1. Powdery mildew fungicide trial treatments, rates per acre, FRAC and manufacturer.

TRT	**Product, Rate, FRAC Sprays 1, 3, and 5**	**Product, Rate, FRAC Sprays 2, 4, and 6**
1*	Cevya 5 fl oz + Manzate Pro 2.5lbs + [FRAC 3 +M] (BASF, UPL)	Quintec 6oz + Manzate Pro 2.5lbs [FRAC 13 + M] (Gowan, UPL)
2*	Cevya 5 fl oz + Manzate Pro 2.5lbs +) [FRAC 3 +M] (BASF, UPL)	Merivon 4 fl oz + Manzate Pro 2.5 lbs + FRAC [7,11 + M] (BASF, UPL)
3*	Procure 8 fl oz + Manzate Pro 2.5lbs + Vacciplant 14 fl oz (FRAC 3 + M +P4) (UPL)	Vivando 15.4 fl oz + Manzate Pro 2.5 lbs + Vacciplant 14 fl oz (FRAC U8 + M + P4) (BASF, UPL)
4*	Aprovia Top 10.5-13.5 oz/A [FRAC 3,7] + Manzate Pro 2.5lbs [FRAC M] (Syngenta, UPL)	Vivando 15.4 fl oz + Manzate Pro 2.5lbs + FRAC [U8 + M] (BASF, UPL)
5*	Procure 8oz + Manzate 2.5 lb [FRAC 3 + M] (Gowan, UPL)	Quintec 6oz + Manzate Pro 2.5lbs [FRAC 13 + M] (Gowan, UPL)
6*	Gatten 6 oz [FRAC U13] Nichino	Gatten 6 oz [FRAC U13] Nichino
7*	Gatten 6 oz + Manzate Pro 2.5 lb [FRAC U13 + M] (Nichino, UPL)	Procure 8 oz + Manzate Pro 2.5 lbs + [FRAC 3 + M] (UPL)
8*	Gatten 6 oz + Manzate Pro 2.5 lb [FRAC U13 + M] (Nichino, UPL)	Merivon 4 fl oz + Manzate Pro 2.5 lbs + FRAC [7,11 + M] (BASF, UPL)

* All sprays include Chemsurf 90 NIS @ 0.125% (0.00125 v/v)

Results

The first PM evaluation was conducted on July 20 (Table 2) to provide a baseline for PM infections at very low levels on both upper and lower leaf surfaces (<0.2%). No fungicides have been applied yet.

Table 2. Percent powdery mildew and standard deviation of seven fungicide treatments plus an untreated check for July 20, sorted by lower leaf surface.

	Avg PM % Upper Leaf	St. Dev. (±)	Avg PM % Lower Leaf	St. Dev. (±)
TRT 3 - Procure1	0.0	0.0	0.0	0.0
TRT 5 - Procure2	0.0	0.0	0.0	0.0
TRT 7 - Gatten2	0.0	0.0	0.0	0.0
TRT 8 - Gatten3	0.0	0.0	0.0	0.0

TRT 9 - UTC	**0.0**	**0.0**	**0.1**	**0.2**
TRT 1 - Cevya1	0.0	0.0	0.1	0.2
TRT 6 - Gatten1	0.0	0.0	0.1	0.2
TRT 2 - Cevya2	0.0	0.0	0.2	0.3
TRT 4 - Aprovia	0.1	0.2	0.2	0.3

In the second evaluation (Table 3), the upper leaf PM infestation is < 0.7% and <2% in lower leaf colonies across all treatments. The untreated check is lower than several treatments but overall infestation remains barely detectable.

Table 3. Percent powdery mildew and standard deviation of seven fungicide treatments plus an untreated check for July 29, sorted by lower leaf surface.

	Avg PM % Upper Leaf	St. Dev. (±)	Avg PM % Lower Leaf	St. Dev. (±)
TRT 3 - Procure1	0.2	0.4	0.3	0.4
TRT 8 - Gatten3	0.1	0.2	0.4	0.2
TRT 5 - Procure2	0.0	0.0	0.5	0.3
TRT 9 - UTC	**0.3**	**0.3**	**0.5**	**0.4**
TRT 7 - Gatten2	0.3	0.4	0.7	0.3
TRT 6 - Gatten1	0.4	0.2	0.8	0.3
TRT 1 - Cevya1	0.7	1.6	1.2	1.0
TRT 4 - Aprovia	0.2	0.4	1.3	1.5
TRT 2 - Cevya2	0.4	0.8	2.0	1.8

In the third evaluation (Table 4), all treatment upper and lower leaf ratings are below the UTC. The Gatten3 treatment has the fewest lower leaf PM colonies while the Gatten1 and Aprovia treatment are at 10% infestation level. Both Procure treatments are performing similarly while the Cevya2 has under half the infestation of Cevya1 on the lower leaf surface.

Table 4. Percent powdery mildew and standard deviation of seven fungicide treatments plus an untreated check for August 9, sorted by lower leaf surface.

	Avg PM % Upper Leaf	St. Dev. (±)	Avg PM % Lower Leaf	St. Dev. (±)
TRT 8 - Gatten3	0.2	0.4	1.7	1.6
TRT 3 - Procure1	0.3	0.4	3.2	1.5
TRT 5 - Procure2	1.3	2.3	3.2	1.9
TRT 2 - Cevya2	0.1	0.2	3.5	1.9
TRT 7 - Gatten2	0.3	0.4	4.3	2.6

TRT 1 - Cevya1	2.9	6.0	7.5	9.1
TRT 6 - Gatten1	0.4	0.4	10.0	7.7
TRT 4 - Aprovia	0.7	1.2	10.3	8.6
TRT 9 - UTC	**11.0**	**9.9**	**13.9**	**10.5**

In the fourth evaluation (Table 5), PM infestation on the UTC is clearly increasing on both the lower and upper leaf surface at just under 60%, meaning there is significant pressure on all treatments at this point in the season. All three Gatten and Procure1 treatments have <10% infestation on the lower leaf surface, followed by both Cevya and Procure2 treatments at <15%. On August 13 downy mildew was observed on neighboring unprotected pumpkin trials. To prevent defoliation, Ranman and Zampro were alternated on all treatments for the last three applications. Every treatment except Gatten1 had been sprayed with Manzate Pro as part of the treatment which is generally protective against downy mildew. Some downy mildew damage was seen on the Gatten1 treatment.

Table 5. Percent powdery mildew and standard deviation of seven fungicide treatments plus an untreated check for August 16, sorted by lower leaf surface.

	Avg PM % Upper Leaf	St. Dev. (±)	Avg PM % Lower Leaf	St. Dev. (±)
TRT 8 - Gatten3	0.4	0.5	4.7	5.4
TRT 3 - Procure1	0.3	0.4	8.0	5.6
TRT 7 - Gatten2	0.0	0.0	8.0	5.5
TRT 6 - Gatten1	0.8	1.0	8.3	2.3
TRT 2 - Cevya2	0.3	0.4	11.7	9.1
TRT 1 - Cevya1	0.4	0.8	14.5	14.9
TRT 5 - Procure2	4.2	6.6	14.8	12.4
TRT 4 - Aprovia	0.3	0.8	22.7	25.1
TRT 9 - UTC	**58.4**	**20.8**	**56.6**	**22.1**

In the fifth evaluation (Table 6), the untreated check continued to climb to nearly 80% for both leaf surfaces. Gatten2, Gatten3 and Procure2 were still under 10% infestation on the lower leaf surface. Cevya1 and Cevya2 both rated in the low teens for PM on the lower leaf surface, with Procure1 and Aprovia in the low 20's for PM infestation on the lower leaf surface. Gatten1 had the highest level of infestation at 34%.

Table 6. Percent powdery mildew and standard deviation of seven fungicide treatments plus an untreated check for August 23, sorted by lower leaf surface.

	Avg PM % Upper Leaf	St. Dev. (±)	Avg PM % Lower Leaf	St. Dev. (±)
TRT 8 - Gatten3	0.0	0.0	2.3	2.0

TRT 5 - Procure2	0.8	1.6	9.2	6.6
TRT 7 - Gatten2	0.2	0.4	9.8	3.3
TRT 1 - Cevya1	0.3	0.8	11.8	16.1
TRT 2 - Cevya2	0.2	0.4	13.3	8.4
TRT 3 - Procure1	0.8	1.0	20.3	9.6
TRT 4 - Aprovia	0.0	0.0	21.7	16.0
TRT 6 - Gatten1	0.0	0.0	34.2	12.4
TRT 9 - UTC	**78.8**	**18.0**	**81.6**	**17.9**

During the sixth evaluation (Table 7), the untreated check has lower PM ratings from the previous week due to downy mildew colonizing and defoliating most of the plant foliage, so only a few leaves were left to rate. Gatten3 remained as the lowest infested treatment while Gatten1 remained the highest infested treatment. Cevya2 at 41% had nearly double the infestation of Cevya1 at 23% during this rating, and the two Procure treatments remained <25% infestation, with Gatten2 and Aprovia had around 30% infestation each.

Table 7. Percent powdery mildew and standard deviation of seven fungicide treatments plus an untreated check for August 30, sorted by lower leaf surface.

	Avg PM % Upper Leaf	St. Dev. (±)	Avg PM % Lower Leaf	St. Dev. (±)
TRT 8 - Gatten3	0.0	0.0	4.7	2.1
TRT 5 - Procure2	0.7	0.5	14.0	13.7
TRT 1 - Cevya1	0.5	1.2	23.3	24.8
TRT 3 - Procure1	0.0	0.0	24.5	9.7
TRT 7 - Gatten2	0.4	0.8	27.8	18.6
TRT 4 - Aprovia	0.3	0.5	33.8	21.8
TRT 2 - Cevya2	0.0	0.0	41.3	31.1
TRT 6 - Gatten1	0.9	0.7	66.7	14.0
TRT 9 - UTC	**66.6**	**25.1**	**70.3**	**20.6**

During the final evaluation (Table 8), the untreated check PM infestation was around 80% for both leaf surfaces. Gatten3 remained near 5% for the lower leaf infestation for the season which is an extremely low level of infestation. Both Cevya treatments stabilized at just under 20% infestation for the season, and Procure2 continued to have better lower leaf surface ratings than Procure1. Aprovia finished the season nearly unchanged from the prior rating at 34% infestation, while Gatten1 and Gatten2 were around 50% infestation.

Table 8. Percent powdery mildew and standard deviation of seven fungicide treatments plus an untreated check for September 9, sorted by lower leaf surface.

	Avg PM % Upper Leaf	St. Dev. (±)	Avg PM % Lower Leaf	St. Dev. (±)
TRT 8 - Gatten3	0.7	0.8	5.2	3.5
TRT 2 - Cevya2	1.3	3.3	17.2	7.4
TRT 5 - Procure2	2.2	3.9	17.2	23.5
TRT 1 - Cevya1	0.3	0.8	18.2	13.1
TRT 4 - Aprovia	0.0	0.0	34.2	17.4
TRT 3 - Procure1	0.7	1.2	42.5	20.9
TRT 7 - Gatten2	0.0	0.0	48.3	22.3
TRT 6 - Gatten1	2.0	1.8	55.0	13.0
TRT 9 - UTC	**80.7**	**17.7**	**81.4**	**30.0**

While weekly percent disease infestation ratings are useful to consider efficacy on any particular date, to compare treatments over the season, the Area Under the Disease Progress Curve (AUDPC) is also a useful tool. In Table 9, the Gatten3 treatment clearly had the least amount of powdery mildew development compared to the other treatments. Procure2 has the next lowest disease accumulation with 406, followed by four treatments Cevya1, Gatten2, Procure1 and Cevya2 that can be lumped together in a group separated by only 110 units. Aprovia follows at nearly 200 units higher with 875 and Gatten1 had the highest accumulation at 1,238. The untreated check accumulation was around 2,100.

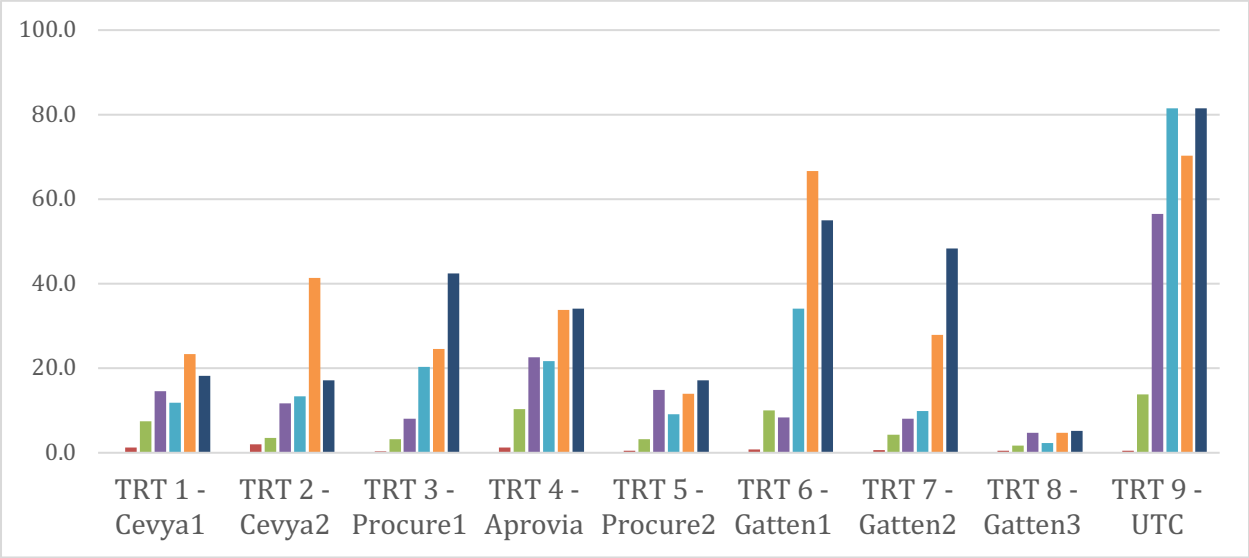
Table 9. The Area Under the Disease Progress Curve (AUDPC) for powdery mildew infestation based on lower leaf surface data only between July 20-September 9. Lower AUDPC values reflect lower overall disease accumulation.

Treatment	**AUDPC**	**Overall Efficacy**
TRT 8 - Gatten3	133.7	Excellent
TRT 5 - Procure2	406.3	Very Good
TRT 1 - Cevya1	553.0	Good
TRT 7 - Gatten2	648.8	Good
TRT 3 - Procure1	650.9	Good
TRT 2 - Cevya2	664.4	Good
TRT 4 - Aprovia	875.0	Good
TRT 6 - Gatten1	1,237.9	Fair
TRT 9 - UTC	2,101.8	NA

Individual treatment disease ratings were also graphed to give a visual perspective of their performance to control PM development over the season (Figure 2). The untreated check clearly had the highest infestation of all treatments and provided evidence that sufficient disease pressure was present in the trial to challenge the other treatments. Typically the UTC ratings top out at or very near 100% infestation but did not this year due to the downy mildew colonizing and destroying most of the foliage prior to complete PM infestation.

While most treatments incrementally build their disease ratings throughout the season, Cevya1, Cevya2 and Gatten1 treatments had lower final ratings on August 30 than the final rating but fall within the range of the standard deviation and can be considered normal fluctuation.

Figure 2. Development of powdery mildew infestation (%) on the lower leaf surface only from July 20 through September 9, across eight fungicide treatments and untreated check.



Conclusions

All treatments had three or four modes of action (MOAs) that were alternated during the season consistent with recommended FRAC rotation rules to delay the onset of resistance (Table 1). The only exception to this rule was Gatten1, which had only a single MOA applied back to back throughout the season. This would not be a recommended treatment schedule and would violate the current label but was designed to test the efficacy of only this compound against PM.

Cevya1 and Cevya2 performed similarly throughout the season with Cevya1 having slightly lower disease ratings and a smaller AUDPC value. This is likely attributable to the rotational partner of Quintec being slightly more effective than Merivon in this trial. For Cevya2, high ratings on August 30 was the only major departure in performance compared to Cevya1, otherwise they performed very similarly. In prior trials, Merivon has been considered a good to strong rotational partner.

Procure1 and Procure2 performed similarly throughout the season with Procure2 having lower disease ratings and smaller AUDPC values. Like the Cevya treatments, the Procure2 treatment alternated with Quintec performed better than the Procure1 treatment using Vivando as the rotational partner. The addition of Vacciplant to Procure1 did not seem to have an effect on PM reduction. In prior trials, Vivando has been considered a good to strong rotational partner.

The Aprovia treatment provided consistent protection from the beginning to the end of the trial with only small incremental increases in PM infestation between ratings. The rotational partner of Vivando seemed to perform well in this treatment.

The Gatten1 treatment was the lowest performing PM treatment in the trial but overall was still rated as fair and looked substantially better than the UTC at the end of the season. This level of performance should be expected for any product using only a single MOA to protect against PM for an entire season. Despite its performance alone against PM, this treatment did show some signs of protection against Downy Mildew which was detected in nearby plots on August 13. As this was the only treatment in the trial without Manzate Pro applied (a common protectant against DM) it is noteworthy that only a small loss of foliage was observed in this plot due to DM. Recall that starting with the fourth treatment application, Ranman and Zampro were alternated to provide better protection against DM. Neighboring plots that were not protected with Manzate or other DM specific products were almost completely defoliated by the end of August.

Gatten3 provided exceptional protection against PM infestation and was clearly the best performing treatment in the trial, performing significantly better than Gatten2. The only difference between these two treatments was the use of Merivon instead of Procure as the rotational partner; in this case the addition of Merivon performed very well compared to the addition of Procure. As stated earlier for other compounds, Procure is considered a good to strong rotational partner for PM control. It is interesting that Merivon did not seem to perform well with Cevya as a rotational partner but did perform well with Gatten. The interaction of these fungicides may be something to follow up on in future trials.

As you review this report remember this trial was designed as a large plot demonstration without randomization and replication, therefore no statistical analysis of these treatments is possible, but these observations may reveal a pattern of efficacy worth future exploration.

If you have any questions about the trial results, please contact me.

Respectfully,

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