Final Report

Project Title: Expanding IPM in Potatoes by Implementing Biocontrol for Early Blight
NRCS Agreement No. 68-0211-8-155

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Project Purpose

Idaho potato growers often use three applications of fungicides each season to control early blight, a common disease in most potato-growing areas in Idaho. Growers face concerns about resistance development and the environmental impacts of older chemistries.

Bacillus mycoides isolate "J" (BmJ) is a naturally occurring soil bacterium, discovered by Dr. Barry Jacobsen at Montana State University, shown to control several plant diseases by eliciting a plant defense response. Previously, Montana Microbial Products tested BmJ for control of early blight in potatoes in research field trials in 2005, 2006 and 2007.

In this project, Montana Microbial Products and the Northwest Center for Alternatives to Pesticides conducted field demonstrations with eleven cooperating potato growers and informed 225 growers and agricultural professionals about this practice as part of an integrated pest management program.

Project Activities

➔ Conducted demonstration field trials with ten cooperating growers in 2009.

We identified potential cooperating growers in the fall of 2008 through announcements at our fall field days and a conference, visits with University of Idaho researchers and crop consultants, and at the 2009 University of Idaho Potato Conference. The project was also announced in the *Capital Press* article "Microbes target early blight." (attached)

In mid-February 2009, we confirmed with three crop consultants that they would conduct disease monitoring and yield test digs for the project. In addition, we partnered with two University of Idaho plant pathologists to conduct research field studies. An additional grant from American Farmland Trust – EPA, that we were able to secure, supported these additional research trials.

We worked with ten demonstration field sites and growers located across southern Idaho, which provided a variety of growing conditions and soil types. Seven sites were conventional potato fields and three were organic. In late May 2009, we visited all ten field sites to layout the treated strips. We also coordinated with our crop consultants, who conducted the regular monitoring of disease progression.

We treated the strips in all ten fields from June through mid-August. Most fields were treated two or three times with BmJ. The earliest maturing field in Glenns Ferry was first treated in

June, whereas the other potato fields were first treated in July. In general, early blight pressure was low in 2009.

Yield data were collected from all fields, except for one field near Shoshone which did not show any disease pressure. We decided it was not worth the time to hand dig these plots, since the field did not show any early blight. Yields were measured in hand dug sections of each strip in eight demonstration fields. In one field near Buhl, we collected potatoes for a yield analysis as the grower made passes with his harvester across each of the trial strips in the field.

We met with the crop consultants and some of the cooperating growers in early December to review the results. We reviewed how the treatments were conducted, the timing, and the yield results. We also shared a preliminary draft of the results from all ten fields. In addition, we discussed plans for the cooperating grower to participate in demonstration trials in 2010.

Montana Microbial Products had expected to have full registration by fall 2009, but the economic situation made it difficult to raise the funds to complete the registration process with the Environmental Protection Agency. Since the microbial control agent was not available for commercial scale trials in 2010, we conducted additional demonstration fields again in 2010.

Also in 2009 and with support from American Farmland Trust – EPA, we conducted research trials to address grower adoptability issues. The ability to apply BmJ through the irrigation system via chemigation was tested by Miller Research in Rupert, ID. There were no difficulties using the chemigation method and sampling verified that the microbial spores were present on the leaves. This result will help to increase the adoption of the microbial control agent, as growers will be able to easily apply BmJ through their irrigation systems.

We also worked with University of Idaho plant pathologist Phil Wharton to evaluate BmJ in rotation with conventional fungicides in his trial of early blight products at the Aberdeen R&E Center. The research center experienced some early blight pressure. The trial evaluated three rates of BmJ and a combination of BmJ with Endura in comparison with grower standard treatments. For early blight, the high rate of BmJ was comparable to the older chemistries. Endura followed by BmJ provided significant control. BmJ alone or in rotation with Endura also showed very good control of white mold. Data for disease reduction and yield are in the attached summary of trial results.

➔ **Featured the biological control demonstration trials at two field days in 2009 and shared information with 155 growers and agricultural professionals.**

We held two field days that highlighted the use of the microbial control agent, BmJ, for early blight in potatoes. A field day on July 21 at the University of Idaho Kimberly R&E Center's organic research site had strong attendance with 85 people. Oliver Neher, University of Idaho plant pathologist and project partner, talked about biological controls in general and BmJ. We had 70 people attend a field day on August 13 at Nate Jones' farm near Glenns Ferry, one of our participating growers' fields. We had planned to invite key individuals to visit our field sites in the Osgood area near Idaho Falls, but early blight disease pressure was unusually low.

As a result of our field day at Nate Jones' farm, the *Capital Press* wrote an article about the microbial control agent BmJ for early blight in potatoes. The article, "Vaccination' keeps plant diseases at bay: microbial alternative to conventional fungicide tested," is attached.

➔ **Conducted demonstration field trials with three cooperating growers in 2010 and a small plot trial.**

We identified five growers to conduct further demonstration trials in 2010. Three were located in the Idaho Falls area, one near Blackfoot, and another near Glenns Ferry. The demonstration field located near Glenns Ferry had to be abandoned, though, when the applicator notified us that they no longer conducted ground applications. This was a few days before our scheduled application. We could not secure another applicator in that area in enough time to salvage the demonstration trial. Part of the difficulty was that this demonstration was on an organic farm and we did not want to work with a new applicator that was not familiar with the organic farmer's practices and requirements of the National Organic Program.

We also had a small plot trial, conducted by University of Idaho plant pathologist Oliver Neher, on the organic farm. Dr. Neher tested the use of multiple Organic Materials Review Institute (OMRI) listed microbial products for the biological control of early blight on potatoes. All of the microbial products slowed early blight disease progression, although the disease pressure was light.

The four demonstration fields were treated with at three applications of the biological control in three strips across the fields. Our crop consultants monitored for early blight in strips of potatoes treated with either the microbial control agent or the growers' conventional fungicide program. In general, early blight pressure was light again in 2010. While this was good for growers, it impacted our ability to fully demonstrate the effectiveness of and use of BmJ. Some of our crop consultants involved in this project have expressed concern about whether or not the microbial control agent can be effective during heavy early blight pressure.

Yields were measured from test strips in BmJ-treated and grower standard fungicide program-treated strips. We did not gather yield data from the field near Blackfoot, as there ended up being an overspray issue when the application through the land lines did not overlay that of the first BmJ application done by a ground rig.

➔ **Featured the biological control demonstration trials at two field days in 2010 and shared information with 70 growers and agricultural professionals.**

We held two field days in August 2010 at potato growers' fields where we gave presentations on the biological control. The first field day was held in Buhl. The hosting potato grower had participated in our demonstration trial in 2009. University of Idaho plant pathologist and project partner, Oliver Neher, talked about the biological control agent and our project. We also included a presentation by Cliff Bradley of Montana Microbial Products at our field day in Soda Springs. We were able to reach 70 additional people with information about this biological control for early blight in potatoes. We also shared results of the small-plot trial of BmJ and other OMRI

listed microbial products for the control of early blight in a newsletter distributed by mail to 430 organic producers and agricultural professionals and to 600 people through email.

Results

In general, disease pressure was light in both 2009 and 2010. However in test fields where there was disease pressure, foliage damage and yields in BmJ treated strips was statistically equal to the grower standard chemical fungicides in all but one trial. Grower trial summaries from 2009 and 2010 are attached.

Potential for Transferability

This practice has potential for transferability in both conventional and organic potato production. Once the product has full EPA registration, potato producers will be able to use this biological control agent as part of their integrated pest management program.

After conducting demonstration trials in both 2009 and 2010, it is most likely that conventional growers would use BmJ to replace one of their conventional fungicide treatments and as a tool in fungicide resistance management. Overall, there was no difference in yields in the strips treated with BmJ as part of the disease management program versus the growers' standard fungicide treatment. However, early blight pressure was not severe in any of the demonstration field sites in 2009 or 2010. Consequently, some of the growers and crop consultants we worked with do not feel completely confident in switching to the biological control agent BmJ as they were not able to see it perform under heavy early blight pressure. For those years when the fungicide program is primarily used as "insurance," the biological control agent could boost plants' natural defenses, while reducing the negative impacts that come with conventional fungicide use. While this makes sense in hind-sight, potato producers find it hard to commit to using the biological control agent when they cannot predict early blight pressure.

Another aspect which contributes to the likelihood of transferability is the cost competiveness of BmJ. Montana Microbial Products had BmJ in pilot production for the two years of the trial program. Based on the pilot data for media cost, culture time, spore yield and application rates used in tests, Montana Microbial Products believes BmJ can be priced near the low end of fungicide costs. The price of BmJ could be set to promote the "preventative" or "insurance" strategy. Depending on how retail distribution might be structured, BmJ could be delivered to growers at a cost in the range of $6.00 to $9.00 per acre per treatment. This compares to costs for chemical fungicides ranging from $5.00 to $10.00 per acre per treatment for older chemistries up to more than $20.00 per acre per treatment for new chemical fungicides.

NCAP, Montana Microbial Products, and the University of Idaho are continuing to conduct research and demonstration trials with the biological control agent, which will help to increase growers' awareness and comfort with the product. We will continue work to have the biological control agent included as a part of an integrated disease management approach in potato production. Our work is also exploring the additional benefits for managing other disease, including white mold (Sclerotinia) and potato virus Y.

Of the three demonstration trials on organic farms, only one trial showed an impact of the biological control agent on early blight. The other two trials did not show enough early blight

pressure to be able to demonstrate the effectiveness of the biological control. The organic potatoes rely upon diverse cropping systems and early blight does not appear to be a limiting production factor. The biological control will be a benefit to organic growers who regularly experience early blight, as there are no other options for direct control of this disease. Only one of the three organic potato farms may consider using BmJ, since it appears to more regularly experience early blight.

Conclusion

The ten cooperating growers reduced their use of conventional fungicides by 77 pounds on the 100 acres in the demonstration fields in 2009. The potato growers used BmJ alone or in rotation with conventional fungicides in three strips on each of the ten fields. Disease severity and yields in the BmJ strips were compared to the grower standard fungicide program in nearby sections of the remainder of the fields.

Overall, potato yields and quality did not differ in the trials with the biological control agent, BmJ, versus the growers' standard fungicide program. Early blight pressure was generally light during the last two years, so potato growers and crop consultants are hesitant to adopt the new practice.

These demonstration trials indicated that BmJ could be used as part of the potato producers' standard fungicide program and as an "insurance" treatment to boost the plants' natural defenses, in case early blight pressure increases. Later in the season, growers could then choose a conventional fungicide, if conditions favored the development of early blight.

Another approach would be for growers to follow a commonly used newer fungicide, Endura, with one or two applications of BmJ. In this use, BmJ would provide resistance management for Endura or other newer and resistance prone fungicides. Resistance management in disease control programs could be an important role for BmJ.

This project was an important step in highlighting a biological control agent for use in an integrated disease management program for potatoes. Eleven cooperating growers, two crop consultants, and four researchers increased their knowledge and experience working with a biological control agent, which must be managed differently than a conventional fungicide. In addition, 225 producers and agricultural professionals learned about use of a biological control during field days. Additional work and grower-supported trials will be needed, once the product is commercial available, to encourage growers to adopt the microbial control agent BmJ as part of their standard early blight management program.

In these field demonstrations, potato growers used BmJ as a standalone treatment or in rotation with conventional fungicides. They replaced the use of strobilurins, chlorothalonil, mancozeb, and the newer chemistry boscalid, resulting in a reduction of fungicide use by one pound per acre. Once Montana Microbial Products completes the full EPA registration process, BmJ will be available for commercial production. If potato growers used BmJ on 100,000 acres of potatoes to replace one application of mancozeb, this would displace about 40,000 to 160,000 pounds of the active ingredient.

Funding Received and Expended
Financial reports were sent separately.

Attachments
2009 Grower Trial Summary
2010 Grower Trial Summary
Newspaper clipping: Microbes target early blight, *Capital Press*
Newspaper clipping: 'Vaccination' keeps plant diseases at bay, *Capital Press*

BmJ WP
2009 Grower Trial Summary

Northwest Center for Alternatives to Pesticides and Montana Microbial Products

During the 2009 season, the Northwest Center for Alternatives to Pesticides (NCAP) and Montana Microbial Products (MMP) conducted a series of grower trials of the microbial disease control product BmJ WP for control of early blight in potatoes. The trial program included 10 sites in Idaho. MMP conducted two additional grower trials in Montana. The 2009 program also included research trials conducted with the University of Idaho and Miller Research (Rupert, ID) for early blight control and with Oregon State University evaluating control of potato virus Y.

BmJ WP is a wettable powder formulation of the bacterium *Bacillus mycoides* isolate "J" (BmJ). BmJ acts by inducing systemic disease resistance in plants. Trials were conducted under an EPA experimental use permit (EUP 82761-EUP-2). MMP produced BmJ WP at the company's facility in Butte, MT. The Idaho trial program was conducted with support from grants provided by the Idaho office of the USDA Natural Resources Conservation Service and the EPA administered by American Farmland Trust. Montana and Oregon trials were conducted in cooperation with Dr. Barry Jacobsen, Plant Sciences and Plant Pathology, Montana State University and Dr. Phil Hamm, Botany and Plant Pathology, Oregon State University.

Idaho grower trials included:

- Three sites in the Osgood Area north of Idaho Falls, managed by Kelly Hurst, Agriculture Consulting Inc.
- Three sites in the Blackfoot area, managed by John Taberna, Western Ag Research.
- One trial site near Rupert, conducted by Jeff Miller, Miller Research.
- Three sites with organic growers in south central Idaho, monitored by Oliver Neher, Extension Plant Pathologist, University of Idaho.

Montana trials were conducted with seed potato growers:

- One site near Manhattan (just west of Bozeman, MT).
- One site near Ronan (about 50 miles north of Missoula, MT). Both trials were monitored by MMP and Dr. Barry Jacobsen at Montana State University

Grower trials were conducted as strip trials, generally with three BmJ WP treated strips in a field compared to the grower standard fungicide treatment in the remainder of the field. BmJ WP was applied at two ounces per acre in one, two, or three applications at roughly two week intervals. In all but two of the trials, BmJ was applied by air in 5 gallons of water per acre. Two trials used ground application equipment with BmJ WP applied in 20 gallons of water per acre.

Early blight pressure was generally low to moderate in the 2009 trial sites. Overall, BmJ showed early blight control and yields comparable to standard chemical treatments. Greenhouse and small plot field trials showed control of potato virus Y with application of BmJ. Direct control of virus infections represents a very important result.

Idaho Grower Trial Results

Osgood Area

In these trials, BmJ WP was applied three times at two week intervals beginning just prior to row closure. BmJ was applied alone. The conventional treatment was Endura (boscalid) 2.5 oz per acre applied at row closure followed in two weeks by an application of Quadris Opti (azosystrobin + chlorothalonil) at 1.6 pints per acre. In each of the three sites, an area of 216 square feet in the field was covered with a tarp during application to provide an untreated check for comparison. Treatments were rated for disease severity and yield. Disease ratings were conducted seven times at weekly intervals and made on a scale of 1 mild to 5 severe. Yields were obtained by hand harvesting two 10 foot row sections from each of three BmJ treated strips, three of the adjoining conventional strips, and from the control section in each field.

Disease pressure was very low at these sites. There was little difference and no consistent pattern in disease ratings and overall yield between the untreated, conventional, and BmJ treatments.

BmJ Osgood Area Trials

Disease severity on last two ratings (1 mild to 5 severe)

	UTC	Conventional Endura Quadris Opti	BmJ 3 applications
Site 1			
19 Aug	1	1	1
26 Aug	2	1	2
Site 2			
19 Aug	1	0	0
27 Aug	2	0	0
Site 3			
19 Aug	1	0	0
27 Aug	1	1	1

Yield (cwt/acre)

Site 1	396 ± 4	519 ± 16	461 ± 50
Site 2	472 ± 22	508 ± 36	524 ± 33
Site 3	430 ± 1	394 ± 46	364 ± 48

Blackfoot Area

Trials were conducted at sites near Morgans Pasture, Pingree, and Wapello. At Morgans Pasture, BmJ was applied two times as a standalone compared with one application of a tank mix of Tanos (famoxadone + cymoxanil) and Penncozeb (mancozeb). At Pingree, BmJ was applied twice. The first BmJ application was alone and the second was applied with Bravo (cholorthalonil) because of concerns about early blight in the whole field. The rest of the field was treated with a tank mix of Tanos and Penncozeb at the first application and then a second application of Bravo. At Wapello, BmJ was applied once with Amistar (azoxystrobin) following an application of Ridomil Gold MZ (mefenoxam and mancozeb). The conventional treatment was Amistar following an application of Ridomil Gold MZ.

Disease severity was rated by sampling twenty-five petioles (leaflets) per each BmJ and conventional strip and counting the number of lesions on each petiole (leaflet), with results as the average number of lesions per petiole. Yields were estimated from test digs of 10 foot row sections from each strip.

Disease pressure was light at Morgans Pasture and Wapello. At Morgans Pasture and Wapello, there were no significant differences in disease severity between the BmJ and conventional programs. Yield was greater with the BmJ program in two of the comparisons at Morgans Pasture and all three of the comparisons at Wapello.

Disease pressure was heavy at the Pingree site. There were no significant differences in disease severity. Yield was greater with the BmJ program in just one of the three comparisons.

BmJ Blackfoot Area Trials

	Rep 1		Rep 2		Rep 3	
	BmJ	Conv	BmJ	Conv	BmJ	Conv
Morgans Pasture (BmJ Program = BmJ; BmJ. Conv Program = Tanos + Penncozeb.)						
Ave # lesions	2.4	2.2	1.4	2.6	2.0	1.7
SD	4.0	2.9	2.6	3.5	3.2	4.1
Yield (cwt/ac)	410	440	465	450	475	450
Pingree (BmJ Program = BmJ; BmJ + Bravo. Conv Program = Tanos + Penncozeb; Bravo.)						
Ave. # lesion	56.8	37.9	39.7	37.3	20.0	24.1
SD	27.6	16.5	13.9	22.3	11.2	14.6
Yield (cwt/ac)	365	395	388	422	410	390
Wapello (BmJ Program = Ridomil Gold MZ; BmJ + Amistar. Conv Program = Ridomil Gold MZ; Amistar.)						
Ave. # lesions	2.9	3.8	4.0	11.4	7.7	13.7
SD	2.0	2.6	3.0	4.5	5.0	6.2
Yield (cwt/ac)	522	498	540	515	500	485

Rupert Trial

The Rupert grower trial compared a treatment of Endura (boscalid) followed by one application of BmJ to the grower standard of Endura followed by an application of Tanos (famoxadone + cymoxanil), Penncozeb (mancozeb), and Echo ZN (chlorothalonil). Treatments were applied using ground equipment.

Disease pressure was low. BmJ showed less control than the chemical treatment, 11% disease incidence as compared with 4% for the chemical treatment. This was the only trial in which BmJ showed less control than a conventional treatment. Yield was not significantly different between the BmJ program and the grower program at 500 and 492 cwt/ac, respectively. The grower program did result in significantly more US#1 tubers (89% as compared to 86% for the BmJ program). The difference was small, but measurable. The percentage of large tubers (over 10 oz) and the dollar return per acre based on a mock fresh pack contract were similar for both treatments.

BmJ Rupert Trial

Description	% Early Blight		Yield (cwt/acre)
Rating Date	Aug 11	Aug 18	Sept 16
Treatment			
1 Grower program: Endura Tanos + Penncozeb + Echo Zn	2 b	4 b	492 a
2 BmJ program: Endura BmJ	8 a	11 a	500 a

Organic trials

In the trials with organic growers, BmJ WP was applied two times to treated strips. There was no fungicide treatment on the remainder of the fields, so these trials were a comparison of BmJ with no treatment for early blight. Disease pressure was low in the three trials; however, there were differences in disease severity and yield in two of the three trials. In the third trial, there were no significant differences in disease severity.

Organic site 1 used ground application and site 2 used aerial application. At site 1, the area under the disease progress curve (AUDPC) was significantly less with the BmJ treatment and yield was substantially higher. At site 2, there was no significant difference in disease severity as assessed by area under the disease progress curve, but BmJ treatment showed a small increase in yield.

Organic Site 1

	DI † 1st rat	DI 2nd rat	DI 3rd rat	DI 4th rat	AUDPC	Yield cwt /A
BmJ	38.8 a	41.4 a	44.4 a	49.4 a	2549.3 a	625.1 a
UTC	38.8 a	47.2 b	46.3 a	59.8 b	2765.2 b	514.0 b
LSD (0.05)	*0*	*1.25*	*3.81*	*3.57*	*46.9*	
P	*na*	*0.0007*	*0.2151*	*0.0026*	*0.0007*	

Organic Site 2

	DI † 1st rat	DI 2nd rat	DI 3rd rat	AUDPC	Yield cwt /A
BmJ	39.0 a	39.6 a	48.1 a	1499.5 a	298.7
UTC	38.8 a	40.0 a	48.3 a	1503.8 a	282.8
LSD (0.05)	*0.90*	*0.90*	*16.60*	*137.09*	
P	*0.54*	*0.04*	*0.39*	*.30*	

Montana Grower Trials

The Manhattan trial compared two applications of BmJ WP with the grower standard treatment of Bravo (chlorothalonil) followed by Dithane (mancozeb). The field was rated for disease incidence and severity approximately two weeks after the final application. In both the treatments, rating for disease incidence showed that about 70% of the plants had at least one visible lesion. Disease severity was about 5% and there was no difference between the BmJ and standard chemical treatment. Without treatment, disease incidence would have been sufficient to cause yield reductions.

The Ronan trial used two applications of BmJ compared to the grower standard treatment of two Bravo (chlorothalonil) applications. A similar result was seen in the Ronan trial, no differences between the BmJ and chemical treatment in early blight incidence or severity. This trial was also assessed for potato virus Y titer by ELISA test performed at Montana State University. In assays taken in the summer, BmJ treated plots showed a virus titer of 0.36% compared with 0.56% in the untreated plots. Samples taken in the winter after harvest showed much greater reductions in PVY infection with BmJ treatment, 0.74% in BmJ treated versus 4.38% in the untreated. Visual inspection of the winter samples also showed a difference with BmJ treatment, 3.25% compared with 4.5% in the untreated. Potato variety in this field was Bintje, a variety highly susceptible to PVY infection. The difference in virus titers in the winter sample would make a difference in value as certified seed potatoes.

Research trials

Miller Research, Rupert Idaho

This trial was designed to evaluate the potential for application of BmJ by chemigation using center pivot irrigation. There were no difficulties applying BmJ through the irrigation system via chemigation. Miller Research collected leaf samples and sent them to Montana Microbial Products' lab for verification that the microbial spores were present on the leaves. BmJ spores were confirmed to be on the leaf surface. This result shows that BmJ can be applied via chemigation, which will increase growers' ease of using the product.

The trial compared two BmJ chemigation applications with one ground BmJ application and a chemical treatment of three applications of Endura (boscalid) combined with Rivet, a spray adjuvant. There were no significant differences between the BmJ chemigation and ground application treatments, indicating that BmJ could potentially be applied using chemigation. However, the BmJ treatments showed less control than the three applications of Endura treament. Disease was severe in this trial.

University of Idaho

Dr. Phill Wharton, at the University of Idaho Aberdeen R&E Center, evaluated BmJ for early blight and white mold control in comparison with standard chemical fungicide treatments. BmJ treatment programs had significantly higher disease progression, as measured by the RAUDPC values, than the industry treatment of Endura (boscalid), Headline, Endura, Dithane, but the higher BmJ application rate was not significantly different than the protectant fungicides Dithane (mancozeb) and Bravo (chlorothalonil). The rotation of Endura followed by BmJ provided significant control.

Over the season, all BmJ treatment programs except the BmJ 0.33g/l program had significantly lower incidences of white mold compared to the untreated control. Phytotoxicity was not noted in any treatment.

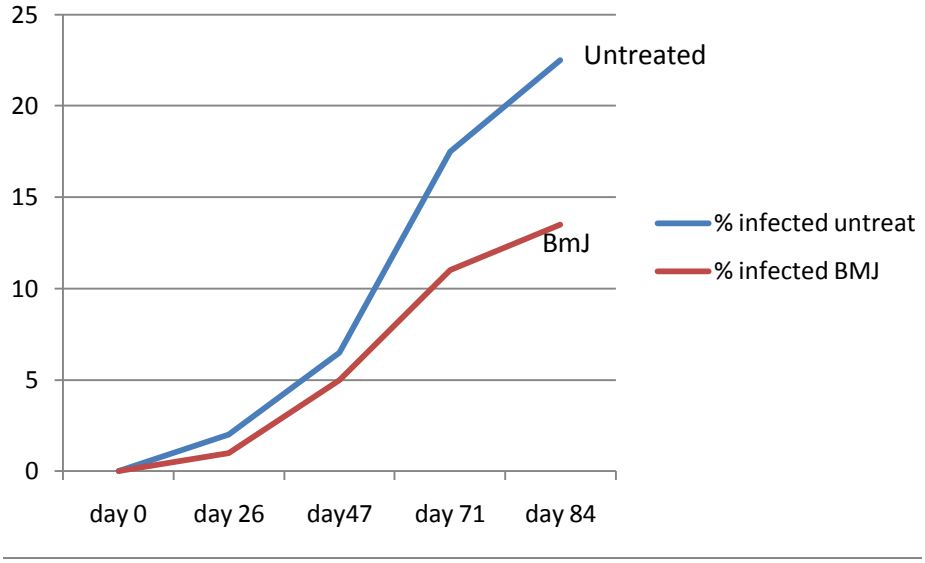
BmJ Potato Early Blight and White Mold Trial Idaho 2009

Treatment	Early Blight	White Mold	Yield
	RAUDPC	RAUDPC	(1b/plot)
Untreated	44.5 a	5.7 a	151.4 ab
Endura/Rivet Headline/Preference Endura/Rivet Dithane	1.2 e	0.1 d	173.9 a
BmJ 33g	34.9 b	3.2 ab	143 ab
BmJ 66 g	30.5 b	2.5 bcd	117.7 b
BmJ 99 g	21.3 c	0.2 cd	120.3 b
Endura, BmJ 66 g	13.2 d	0 d	134.5 ab
Dithane	17.9 cd	3.0 abc	139.4 ab
Bravo Ultrex	19.0 c	2.8 bcd	149.0 ab

Oregon State University Trial

This trial evaluated BmJ in control of potato virus Y (PVY). Previous greenhouse trials conducted at Montana State University showed that BmJ treatment prevented infection an average of 42% of the time in PVY-exposed plants, as measured by ELISA test. The 2009 virus trial program evaluated PVY control in a field replicated plot trial and control of potato virus X (PVX) and PVY in greenhouse trials. In the field trial conducted in Oregon, BmJ was applied at two week intervals over the growing season with statistically significant reduction in PVY infection in the last two sample dates. The greenhouse trial showed an average 60% reduction in PVY infection in three replications of 200 plants each. Greenhouse trials did not show significant control of PVX.

Control of Potato virus Y by BmJ, Hermiston, OR field trial 2009



Direct control of virus infection by BmJ in both greenhouse and field trials represents a very important result from the 2009 trial program.

BmJ WP
2010 Grower Trial Summary

Northwest Center for Alternatives to Pesticides and Montana Microbial Products

In 2010, the Northwest Center for Alternatives to Pesticides (NCAP) and Montana Microbial Products (MMP) conducted grower demonstration trials of the microbial disease control agent BmJ WP for control of early blight in potatoes. The 2010 program also included a research trial conducted with the University of Idaho in an organic potato field.

Idaho grower trials included:

- Two sites in the Osgood Area north of Idaho Falls, managed by Kelly Hurst, Agriculture Consulting Inc.
- One site in the Rexburg area, managed by Phillip Nolte, University of Idaho.
- One on-farm small plot research trial near Glenns Ferry, managed by Oliver Neher, University of Idaho.

Idaho Grower Trial Results

Osgood Area

In these two demonstration trials, BmJ WP was applied three times at two week intervals beginning just prior to row closure. BmJ was applied alone. The conventional treatment was Endura (boscalid) 2.5 oz per acre applied at row closure followed in two weeks by an application of Tanos (famoxadone + cymoxanil 25%) at 6 oz per acre and Manzate (mancozeb) at 1.5 lbs per acre. In each of the two sites, an area of 216 square feet in the field was covered with a tarp during application to provide an untreated check for comparison. Treatments were rated for disease severity and yield. Disease ratings were conducted six times at weekly intervals and made on a scale of 1 mild to 5 severe. Yields were obtained by hand harvesting two 10 foot row sections from each of three BmJ treated strips, three of the adjoining conventional strips, and from the control section in each field.

Disease pressure was very low at these sites, with no early blight found in the strips for any of the six monitoring dates (last two dates shown).

There were some differences in yields. Average yields were higher in the test digs from the strips treated with the grower conventional fungicide program compared to the BmJ-treated areas in both demonstration fields. While the average yield was higher in the strips under the conventional fungicide program, the average ± standard deviation did overlap with that of the strips treated with BmJ. In demonstration site 1, US#1 potatoes made up a larger percentage in the conventional strips than the BmJ-treated strips, resulting in greater net revenue per acre in the conventional strips. In field site 2, the production of US#1 potatoes was nearly identical in the conventional and BmJ-treated strips.

BmJ Osgood Area Trials 2010

Disease severity on last two ratings (1 mild to 5 severe)

		UTC	Conventional Endura Quadris Opti	BmJ 3 applications
Site 1	11 Aug	0	0	0
	19 Aug	0	0	0
Site 2	11 Aug	0	0	0
	19 Aug	0	0	0

Yield (cwt/acre)

Site 1	388 ± 33	445 ± 40	409 ± 62
Site 2	429 ± 23	499 ± 32	437 ± 36

Rexburg Area

This cooperating grower planted Russet Burbank. BmJ was applied by airplane on three 80-foot strips running the length of the field. Three strips were established next to the sprayed strips for the non-BmJ treated control. These strips were approximately 120 feet wide. BmJ was applied three times on August 10, August 23 and September 4.

Early blight was not seen in this field. Due to weather conditions, the field was planted late in the spring and was behind schedule for vine growth in August. Also, there were freezing temperatures on September 5 and 6, 2010, which killed the plants. These factors contributed to the low likelihood of early blight.

The BmJ-treated strips were harvested on October 4, 2010 and in the non-BmJ treated strips on October 5, 2010. Yield was taken in three random locations in each of the six strips using a 10-foot section across four rows. There was no significant difference in total yield or cwt/A between the two treatments.

TREATMENT	TOTAL YIELD (LBS)	CWT/A
BmJ Treated	83.59	303.45
BmJ Untreated	97.62	354.35
LSD	16.71	60.66

No significant difference in total yield or cwt/A between the two treatments.

Organic Small-Plot Trial

This small-plot trial was conducted on an organic potato grower's farm near Glenns Ferry. Oliver Neher, University of Idaho plant pathologist, tested the use of multiple Organic Materials Review Institute (OMRI) listed microbial products for the biological control of early blight (*Alternaria solani*) on potatoes.

Small plot trials were established to test *Bacillus mycoides* isolate BmJ, Serenade Max (*Bacillus subtilis* QST 713), M-Pede (potassium salts of fatty acids) and Actinovate AG (*Streptomyces*

lydicus). Products were applied starting July 10th with row closure and were repeated two times in two week intervals. Infection with early blight was first observed around the second application and progressed very slowly.

Microbial products like BmJ, Serenade, or Actinovate must be applied before disease onset. This enables the microorganisms to establish themselves and to occupy wounds, produce antimicrobial compounds or to stimulate the plant defense system. Some products that are able to stimulate the plant defense system have the potential to protect the plant against a multitude of viral, bacterial and fungal pathogens.

Potassium salts of fatty acids (M-Pede), commonly called soap salts, are mainly used as insecticides where the product penetrates and disrupts the insect's cells and consequently leads to dehydration and death. Certain soap salts also express fungicidal activity and products with multiple activities (insecticide and fungicide) could be beneficial to organic growers, since one application would protect potato plants against thrips, spider mites, white flies, aphids, etc., as well as against fungal pathogens.

At the second early blight rating, all tested products were able to slow down the development of the disease, with Actinovate AG and *B. mycoides* BmJ expressing the lowest disease ratings (Table 1).

At the last rating, an overall reduction of early blight lesions by 58% was achieved with use of the products. M-Pede showed a 65.4% reduction followed by *B. mycoides* BmJ (0.88 oz/A) with 63.4%. However, none of the treatments were significantly different from each other when compared to the untreated control. There was also no significant difference between the individual treatments when compared over time (AUDPC), but M-Pede and *B. mycoide*s BmJ (2.64 oz/A) where able to reduce early blight lesions by 63.4% and 62% respectively.

Yield data were not collected, since disease was not severe enough and a negative effect on yield was not expected.

Table 1: Early blight ratings for individual treatments expressed as percent leaf area covered with fungal lesions.

Treatments	rate/A	1. rating	2. rating		3. rating		4. rating		5. rating		AUDPC [z]	
Untreated control		0	2.61	a [y]	5.17	a	25.41	a	60.25	a	583.65	a
B. mycoides BmJ	0.88 oz	0	1.06	b	3.62	b	9.82	bc	22.02	b	247.77	b
	1.76 oz	0	0.86	bc	3.10	bc	12.17	b	29.47	b	284.63	b
	2.64 oz	0	0.62	c	2.01	d	9.41	bc	25.87	b	222.59	b
Serenade Max	3 lb	0	0.76	bc	2.60	bcd	9.50	bc	23.81	b	228.81	b
M-Pede	2% v/v	0	0.81	bc	2.74	bcd	8.66	c	20.85	b	213.63	b
Actinovate AG	9 oz	0	0.57	c	1.62	d	9.42	bc	29.25	b	226.00	b
LSD $_{(0.05)}$		NA	0.31		1.15		3.23		8.75		149.39	
P> F [x]		NA	< 0.0001		< 0.0001		< 0.0001		< 0.0001		0.0006	

[z] AUDPC = Area under disease progress curve is a quantitative summary of disease intensity over time. It was calculated based on five individual ratings using the formula $\sum [(i + j) / 2 * (\text{day } j - \text{day } i)] + [(j + k) / 2 * (\text{day } k - \text{day } j)]$

[y] Means followed by the same letter were not significantly different based on Fisher's protected least significant difference (P=0.05)

[x] *Pr > F* was the probability associated with the F value. LSD = Fisher's protected least significant difference value.

White mold (Sclerotinia) Montana Trial

Montana State University included a BmJ treatment in trials for white mold (Sclerotinia) control. Results shown below are consistent with other trials showing BmJ provides very effective control of white mold. Controlling multiple diseases will provide added commercial advantages for BmJ, resulting in further use of biological rather than chemical disease control products.

Potato Sclerotinia Trial – Montana 2010

Treatment	Lesions/10ft row	Yield cwt/acre
Untreated	38.3 a	190.8 a
EchoZN, Luna Tranquility	2.8 c	218.3 b
Endura	3.0 c	219.4 b
BAS 700 04F	4.5 c	230.8 b
Bas 703 AG F	16.8 b	216.5 b
BmJ	10.3 bc	232.8 b
Proline	10.0 bc	228.9 b

Each product was applied at label rate in 2 applications, at 10%bloom and at 10 days post bloom

Potatoes

Microbes target early blight

Distributor looks for Idaho farmers to test fungicide

By DAVE WILKINS
Capital Press

Dave Wilkins/Capital Press

Fred Brossy, left, digs a hill of spuds during an organic potato field day Sept. 19 near Shoshone, Idaho. New microbial fungicides may provide organic and conventional potato growers with another option for control of early blight.

A Montana company is looking for a few Idaho farmers willing to field-test a new microbial fungicide on potatoes.

The new fungicide, called BmJ, contains microscopic spores that trigger a biochemical response in plants that helps control pathogens, according to distributor Montana Microbial Products of Missoula, Mont.

Combined with standard fungicides, the new product improves control of early blight in potatoes and helps manage fungicide resistance, company representatives said.

The Montana company plans to test the fungicide next year in farmers' fields in Idaho.

"We're trying to find about 10 cooperators in the state to begin field trials next growing season," Cliff Bradley, a representative for the company, told people attending an organic potato field day near Shoshone, Idaho, in September.

Potato early blight is caused by the fungus *Alternaria solani*. It poses a significant risk to crop productivity in the field and to tuber quality in storage.

Early blight can be very destructive, sometimes resulting in complete defoliation of plants. The fungus can be found in all potato-growing regions and is a major disease in hot climates, especially where crops are irrigated.

BmJ activates the plants' natural defenses against the fungus, representatives for Montana Microbials said.

The new product is a dry powder that suspends readily in water for spray applications. It controls plant diseases by inducing systemic resistance, the company said.

BmJ was first developed by scientists at Montana State University. Montana Microbials licensed the product for commercial development.

The new product has been formulated to comply with organic standards, and Montana Microbials expects to gain approval for use on organic crops.

But the company isn't focusing exclusively on the organic market. BmJ is intended for conventional fields, too, Bradley said.

"We see this as a good resistance management tool," he said.

BmJ will be priced comparable to some of the low-end standard fungicides on the market and much less than some of the high-end treatments, Bradley said.

Three years of university field trials have shown that BmJ provides a safe, effective new tool for managing early blight, company representatives said.

The company expects to gain Environmental Protection Agency approval of the product for large-scale commercial trials in 2009 and to have full EPA registration for the 2010 season.

Toxicity studies have shown no adverse affects, the company said.

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Dave Wilkins/Capital Press

Oliver Neher, right, a University of Idaho Extension plant pathologist, and Jennifer Miller, with the Northwest Coalition for Alternatives to Pesticides, discuss a new microbial fungicide during a field day Aug. 13 at Kings Crown Organic Farm near Glenns Ferry, Idaho.

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'Vaccination' keeps plant diseases at bay

Microbial alternative to conventional fungicide tested

By DAVE WILKINS
Capital Press

A new microbial fungicide is showing promise against potato early blight and other plant diseases.

The product, called BmJ, is a naturally occurring bacterium that activates plants' defenses. The active ingredient is a microscopic spore derived from the bacterium *Bacillus mycoides*, isolate J.

The product was tested in Idaho this summer on three organic farms.

"It's more or less a vaccination for your plant," Oliver Neher, a University of Idaho Extension plant pathologist, said Thursday, Aug. 13, during a tour of Kings Crown Organic Farm near Glenns Ferry, Idaho.

Unlike conventional fungicides, BmJ protects plants against multiple diseases, Neher said.

"It's not only active against fungi, but viral diseases and bacterial diseases," he said.

Plants sprayed with BmJ are protected against fungal diseases, bacterial diseases and viral diseases for up to 14 days, Neher said.

First developed by a team of researchers at Montana State University, BmJ has been licensed for commercial development by Montana Microbial Products of Missoula, Mont.

The product performed well against a variety of plant diseases during testing at MSU, said Neher, who worked on the project as a graduate student.

It helped protect potatoes against early blight, greenhouse tomatoes against gray mold, sugar beets against cercospora leaf spot and cucumbers and melons against angular leaf spot and anthracnose.

An experimental-use permit from the Environmental Protection Agency allowed large-scale commercial trials this year. The company expects to have full EPA registration for the 2011 season.

BmJ was developed to comply with national organic standards, and Montana Microbial Products plans to seek approval for its use on organic crops.

The company worked with the Northwest Coalition for Alternatives to Pesticides to arrange for field testing in Idaho this year.

BmJ comes in a dry powder that suspends readily in water for applications using standard commercial spray equipment, according to the company.

While BmJ shows promise, it's not a silver bullet, Neher said.

"You have to apply it before the disease comes into your field," he said. "It's not curative."

If a farmer already has early blight in his field, BmJ isn't going to get rid of it.