Onion Research and Development Program
2022-2023 Proposal

Funding Period April 1, 2022-March 31, 2023

Project Title:

Maintaining efficacy of FRAC 3 fungicides for control of Stemphylium leaf blight (SLB) in onion.

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Amount Requested: $ 29,651

Project Summary:

Stemphylium leaf blight (SLB) is now considered to be the most important foliar disease of onion in NY, being of widespread occurrence and capable of causing severe defoliation to onion crops in disease conducive years. Over the last five years, SLB has developed resistance to several fungicides with different modes of action including the FRAC 2, 7, 9 and 11 groups. Some fungicides, such as the FRAC 7 boscalid (Endura) and fluxapyroxad (in Merivon) and FRAC 11 azoxystrobin (Quadris) have been rendered almost completely ineffective, and can no longer be used alone for SLB control. Other fungicides, such as the FRAC 7, fluopyram (in Luna Tranquility) have shown a substantial reduction in field efficacy over the years, but still provide some level of control. At present the FRAC 3 fungicide active ingredients tebuconazole (a component of Viathon and Luna Experience), propiconazole (the active ingredient of Tilt) and difenoconazole (a component of Quadris Top and Inspire Super) are the most effective fungicides against SLB in NY onion crops. However, it appears the FRAC 3 group is also under threat as disease control can now be achieved, only by the use of higher rates, through applying combinations of FRAC 3 (e.g. Viathon + Tilt). **Resistance of SLB to fungicides was listed in the ORDP priorities for 2022-2023.**

There is an urgent need to develop strategies that best preserve the efficacy of FRAC 3 fungicides for control of SLB. This project aims to:

1. Determine if there is cross-resistance among active ingredients within FRAC 3 group.
2. Determine the effect of increasing the rate of FRAC 3 on efficacy of SLB control, and development of fungicide resistance. This includes increasing rates of single active ingredients and tank mixing FRAC 3 fungicides with different active ingredients.
3. Determine the effect of co-applying FRAC 3 with another FRAC group (9, 11 and P07) on the efficacy of SLB control, and development of fungicide resistance.
4. Determine the effect of rotating FRAC 3 with another effective mode(s) of action on the development of fungicide resistance.

Organizational Capacity:

Frank Hay is a Senior Extension Associate at Cornell AgriTech, Cornell University, Geneva. He has been leading research into the fungal diseases of onion and garlic in NY since 2015. He has extensive experience in a broad range of diseases caused by fungi and nematodes, and specifically working with Stemphylium leaf blight of onion. He has conducted the fungicide resistance laboratory screening of NY *S. vesicarium* isolates, and conducted multiple trials evaluating overwintering inoculum and spore release to optimize forecasting systems. Prior to Cornell, Hay worked as a vegetable plant pathologist for 17 years with University of Tasmania, Australia, researching fungal, viral and nematode pathogens of several crops including carrot and potato, and in extractive crops e.g. hops, pyrethrum and opium poppy.

Christy Hoepting is a Senior Extension Associate in the Cornell Vegetable Program and is responsible for onion research and extension in the Elba muck and other regions. Each year, her team undertakes an intensive scouting program in NY onion fields, and undertakes replicated on-farm trials examining pest disease and weed control, including screening fungicides for efficacy against SLB. She will be integrally involved in the project conducting on-farm fungicide trials, and extension activities to maximize impact.

Sarah Pethybridge is a vegetable pathologist (Associate Professor) at Cornell AgriTech, Cornell University, Geneva. She is also the Program Leader for the Plant Pathology & Plant-Microbe Biology Section at Geneva. Her program focuses on supporting the broadacre vegetable industries through research and extension focusing on disease epidemiology, fungicide resistance and management. Prior to appointment at Cornell University in 2014, she was a Senior Extension Plant Pathologist for 10 years at the University of Tasmania, Australia; Agricultural Research and Development Manager for the Australian Pyrethrum Industry (4 years); and Science Group Leader in Field and Vegetable Crop Research for the New Zealand Government (2 years).

Objective 1:
To determine best practices for managing SLB fungicide resistance in onion to preserve the efficacy of FRAC 3 fungicides to sustain SLB management.

Task 1.1
We decided to focus on tebuconazole (FRAC 3c) and Viathon (3c + P07) for this project, because Viathon has been the most effective of the FRAC products for keeping onion foliage healthy in recent fungicide trials, and it is also one of the more affordable FRAC products. For these reasons, we anticipate that it will be a popular product used to manage SLB in the near future in NY onion production. An on-farm small-plot fungicide trial will be established in Elba utilizing a late-season onion variety that will be exposed to highest SLB pressure in August (e.g. c.v. Hamilton). The trial will be a randomized complete block design with 4 replicates and 15 treatments including a nontreated control (Table 1). Individual plots will be 5 ft wide (= 4 onion rows) x 15 ft long. Fungicide treatments will be applied on a 7-10 day interval for total of 8 applications (A to H, Table 1) using a CO_2 backpack sprayer with 40 pa, 32 psi and Teejet 8005 flat fan nozzles. Applications will start pre-bulbing/early bulb swell about one week after SLB disease is first detected. Dyne-Amic 0.125% v/v will be included with each treatment, as well as appropriate insecticides to control onion thrips and mancozeb or Orondis Ultra to protect against downy mildew (these fungicide have no activity on SLB).

SLB assessments:

- One week after spray B (2 sprays), D (4 sprays) and F (6 sprays): the outer 3 leaves will be collected from 10 plants per plot. The following will be recorded: % SLB severity of spore colonization of tips (or presence/absence if disease pressure is low), presence/absence of target spots, color of target spots, whether there are more than 3 target spots per 3-leaf plant sample, and whether SLB appears to be primary or secondary. SLB will be considered primary when copious *S. vesicarium* conidia (asexual spores) and numerous black and purple target lesions occur, and when lesions occur on green leaf tissue.
- One week after spray F (6 sprays): % green foliage per plot will be visually estimated.
- One week after spray H (8 sprays): 10 randomly selected plants per plot will be collected. The following will be recorded – visual assessment per plant of % tip dieback and % SLB severity of leaf tip colonization, SLB target spots will be characterized (tan, black or purple and on necrotic or green tissue), whether a plant has more than 3 target spots and if SLB appears to be primary.
- One week after spray H (8 sprays): % green foliage per plot will be visually estimated.
- Two to three weeks after spray H: % of onions that failed to lodge (= dying standing up) per plot will be estimated visually.

Fungicide sensitivity testing:

- ***Baseline fungicide sensitivity:*** To establish a baseline sensitivity to FRAC 3 prior to the application of fungicides, 50 leaves will be collected from the trial area prior to the first application of treatments. *S. vesicarium* will be isolated from leaves, stored and then tested in the laboratory against difenoconazole and tebuconazole. Isolates (n=30) will be grown on V8 agar and used for sensitivity testing. A 5 mm diameter plug of each *S. vesicarium* isolate will be taken from an actively growing colony and placed in the center of agar plates amended with fungicide at (0, 0.2, 1.0, 5.0, and 10.0 µg a.i./ml). Each isolate will be placed on three replicate plates of each concentration. Plates will be incubated for 5 days at room temperature and the diameter of fungal colonies will be recorded. The concentration of fungicide required to reduce fungal diameter by 50% (EC_{50}) will be calculated by probit analysis.
- ***Post treatment fungicide sensitivity:*** One week after the final fungicide application (H) (Table 1), 20 diseased leaves will be collected from each plot. *S. vesicarium* will be isolated from leaves, stored and 15 isolates from each plot will be tested for fungicide sensitivity in the laboratory as described above. Isolates will also be collected after spray D in treatments 14 and 15 (see below).

Effect of these factors on SLB fungicide resistance

- ***Co-application of FRAC 3b (difenaconazole) with FRAC 9 and 11:*** Given that SLB has developed resistance to FRAC 9 and FRAC 11, we need to determine whether applying mixtures of FRAC 3b + 9 (Inspire Super) and FRAC 3b + 11 (Quadris Top) provides reduction in the development of resistance compared to applying FRAC 3b alone (Inspire) or to the nontreated control. The EC_{50} of *S. vesicarium* isolates against difenaconazole will be compared among these treatments (1, 3, 4, and 5 in Table 1).
- **Co-application of FRAC 3c (tebuconazole) with FRAC P07:** To determine whether the P07 component of Viathon reduces the development of SLB resistance to the FRAC 3c component, we will compare the EC_{50} of *S. vesicarium* isolates against tebuconazole among Folicur 5.9 fl oz (FRAC 3c alone), Viathon (3c + P07) and the nontreated (treatments 1, 6 and 8 in Table 1). Note reatment 9 (Table 1) of P07 alone (as Rampart) will be included in the trial to assess the level of efficacy of the P07 component against SLB.
- **Rate of FRAC 3 active ingredient:** To determine whether increasing the rate of FRAC 3c reduces the development of resistance, Folicur @ 5.9 fl oz, 11.8 fl oz (2x rate), 17.7 fl oz (3x rate) and the nontreated will be compared for SLB control in the field. Isolates will be collected and the EC_{50} of *S. vesicarium* isolates against tebuconazole will be compared among these treatments (1, 10, 11 in Table 1).
- **Co-application of multiple FRAC 3 active ingredients:** To determine whether combining two and three FRAC 3 active ingredients in a tank mix reduces the development of SLB resistance compared to applying a single FRAC 3 and increasing the rate of FRAC 3 active ingredient. We will compare FRAC 3a + 3c (Folicur + Tilt) and FRAC 3a + 3b + 3c (Tilt + Folicur + Inspire) to FRAC 3a applied alone (Tilt), FRAC 3b applied alone (Inspire), 1x, 2x and 3x rates of FRAC 3c applied alone (Folicur). The EC_{50} of *S. vesicarium* isolates tested against respective active ingredients tebuconazole, propiconazole and difenaconazole will be compared from treatments 1, 2, 5, 6, 10-13 (Table 1).
- **Rotating FRAC 3c + P07 with other FRAC groups:** We will compare the most effective FRAC 3 product, Viathon (FRAC 3c + P07) applied weekly A-H to FRAC 3c + P07 alternated weekly with

an effective SLB tank mix FRAC 7(4) + 12 + 2 (Miravis Prime + Rovral) and to applying Viathon only every other week (which may allow SLB population to build up and mutate) on development of SLB resistance to FRAC 3c. This will involve a comparison of EC_{50} against tebuconazole of *S. vesicarium* isolates from treatments 8, and 14-15 (Table 1), collected after the fourth (D) and eighth spray (H).

- **Cross resistance between FRAC 3 components**: To check for the level of cross resistance between subclasses of FRAC 3's, 30 *S. vesicarium* isolates which exhibit a range of sensitivities from the tests described above will be retested against propiconazole (FRAC 3a), difenaconazole (3b), tebuconazole (3c) and mefentrifluconazole (3d). The association between the EC_{50} values of specific isolates against particular FRAC 3 subgroups will be evaluated. Cevya, which has a new FRAC 3 active ingredient (3d) will also be included in the field trial to evaluate SLB control.

Table 1. List of proposed treatments:

Number	**FRAC Group**	**Product and Rate (/A)**	**Application time**
1**		Nontreated control	
2	3a[1]	Tilt 8 fl oz	A-H
3	3b	Inspire 7 fl oz	A-H
4	3b + 11 (co-apply)	Quadris Top 14 fl oz	A-H
5	3b + 9 (co-apply	Inspire Super 20 fl oz	A-H
6	3c	Folicur 432F **5.9** fl oz	A-H
7*	3d	Cevya 5 fl oz	A-H
8	3c + P07 (co-apply)	Viathon 3 pt	A-H
9*	P07	Rampart 3qt	A-H
10	3c (2x rate)	Folicur 432F **11.8** fl oz	A-H
11	3c (3x rate)	Folicur 432F **17.7** fl oz	A-H
12	3c + 3a	Folicur 432F 5.9 fl oz + Tilt 8 fl oz	A-H
13	3c + 3a + 3b	Folicur 432F 5.9 fl oz + Tilt 8 fl oz + Inspire 7 fl oz	A-H
14**	Rotate FRAC 3c with FRAC 7(4) + 12 + 2	Viathon 3 pt Alt. Miravis Prime 11.4 fl oz + Rovral 1 pt	ACEG BDFH
15**	Rotate FRAC 3c with nothing	Viathon 3 pt bi-weekly	ACEG

[1]3a: propiconazole; 3b: difenaconazole; 3c: tebuconazole; 3d: mefentrifluconazole.
**S. vesicarium* isolates will be collected and tested for sensitivity after the final application in all treatments except 7 and 9. **In addition *S. vesicarium* isolates will also be collected after the 4th (D) spray for treatments 14 and 15.

Performance Measure 1.1.1
Early July, 2022. Field trial established and *S. vesicarium* isolates collected (pre-fungicide).

Performance Measure 1.1.2
Late-July through August, 2022. Treatments applied. Fungicide efficacy data collected after sprays B, D and F.

Performance Measure 1.1.3
Late-August/Early-September, 2022. Fungicide sprays completed and *S. vesicarium* isolates collected and stored. Trial tour for growers and allied industry representatives to showcase results.

Performance Measure 1.1.4
Late-September, 2022. Failure to lodge (dying standing up) data is collected and the trial is harvested, graded and evaluated for yield.

Performance Measure 1.1.5
December 30, 2022. Presentation of preliminary results to ORDP.

Performance Measure 1.1.4
March 31 2023. Plate testing of fungicide sensitivity and statistical analysis completed. Final report submitted to ORDP. Results incorporated into fungicide recommendations for upcoming season, Cornell Onion Fungicide Cheat Sheet for Leaf Diseases updated. Grower outreach via winter educational meetings such as Empire Expo and Orange County Onion School, and newsletter articles.

Outcome and Benefits Expected:
Objective 1.
Stemphylium leaf blight causes leaf death in onion leading to smaller bulbs and lower yield. The disease occurs in almost all fields in NY and can be severe in wet and warm seasons. Trials by C. Hoepting in NY have demonstrated a 30-40% increase in yield where SLB is effectively controlled with fungicide. Our team has documented the rapid and widespread development of fungicide resistance in SLB over the last five years, which threatens the ability to control this disease. At this point the SLB fungicide program is leaning heavily on FRAC 3 fungicides for effective SLB control. It is imperative that we understand how to effectively manage SLB resistance to FRAC 3 fungicides to ensure their useful longevity, as losing them to fungicide resistance would be devastating.

The proposal has one objective, to develop strategies which maintain control of SLB while minimizing selection pressure for resistance in FRAC 3 fungicides. We will do this by examining a) cross-resistance among FRAC 3's, b) the effect of increasing the rate of FRAC 3 via tank-mixing multiple FRAC 3 products, and c) the effect of co-applying and rotating FRAC 3 with other effective FRAC groups, on SLB control and development of fungicide resistance.

This information will better inform the NY onion industry on the best way of preserving their most effective FRAC group (3) for sustained control of SLB.

Research Experience Relevant to the Proposal:
Hay, Hoepting and Pethybridge have formed a highly effective team over the last five years to study the SLB issue in NY onion. They have identified fungicide resistance in FRAC 2, 7, 9 and 11 fungicides, and this information, along with Hoepting's annual screening of fungicides in field trials, has been used each year to recommend fungicide programs that maintain control of SLB in the face of rapid resistance development. Basic research in SLB is on-going through our other projects (AFRI-CARE, Federal Capacity Fund and NIFA CPPM). These projects aim to a) understand the host-range and lifecycle of the *Stemphylium vesicarium* in an effort to develop an integrated management strategy which reduces reliance on fungicides, b) assess the accuracy of disease forecasters for predicting infection periods to

better time fungicide applications, and c) develop rapid molecular tools to assess fungicide resistance to FRAC 7 fungicides and variability in the NY population of *S. vesicarium*. This ORDP project will allow the investigators to determine best use practices for FRAC 3 fungicides to avoid the development of fungicide resistance in SLB to this important group.

Budget: –

SALARY				
POSITION TITLE (Exempt)	**ANNUALIZED SALARY PER POSITION**		**PERCENT OF EFFORT FUNDED**	**TOTAL**
Sr. Extension Associate, Unbanded, 11155 (Hoepting Program)	$93,933.00		6.000%	$5,636.00
			Subtotal	$5,636.00
POSITION TITLE (non-Exempt)	**HOURLY PAY RATE PER POSITION**	**STANDARD WORK HOURS PER**	**NUMBER OF WEEKS FUNDED**	**TOTAL**
Technician II, Band B, 10953 (Hay Program)	$19.00	40	19	$14,440.00
Technician I, Band A, 10952 (Hoepting Program)	$16.05	40	3	$1,926.00
Technician I, Band A, 10952 (Hoepting Program)	$16.05	40	3	$1,926.00
			Subtotal	$18,292.00
TOTAL SALARY				
			SALARY TOTAL	$23,928.00

TRAVEL - TYPE/DESCRIPTION	TOTAL
14 trips Albion to Elba x 25.56 miles x $0.56/mile (Hoepting Program)	$200.00
TRAVEL TOTAL	$200.00

OPERATING EXPENSES - TYPE/DESCRIPTION	TOTAL
Materials & Supplies - Field and lab supplies	
Petri plates and agar for fungicide sensitivity testing, fungicide active ingredients (Hay Program)	$525.00
Stakes, flags, sharpies, sample bags, PPE, CO_2 tank refill etc. (Hoepting Program)	$312.00
Services:	
Cornell Fleet Vehicle Rental Services Geneva to Elba rtn., 3 days x $12.36=$37: 3 days x 150 miles x 0.28 mi.= $126 (Hay Program)	$163.00
OPERATING EXPENSES - TOTAL	$1,000.00

OTHER EXPENSES - TYPE/DESCRIPTION	TOTAL
Indirect Costs - Direct Costs x 18%	$4,523.00
OTHER EXPENSES - TOTAL	$4,523.00
	$29,651.00

Budget Justification:

Salary: $23,928

Technical Support (Hay Program) To assist with sample collection, isolation of Stemphylium from diseased leaves, preparation of media for, and undertaking fungicide sensitivity tests.

Senior Extension Associate (Hoepting Program) To conduct all aspects of the field trial (trial set-up, fungicide applications, SLB evaluations, harvest, interpretation of results, etc.) and undertake all extension and outreach activities.

Technical Support (Hoepting Program) For two technicians to assist with trial set-up, copious amounts of data collection, entry, analysis and summary, and collecting leaf samples for fungicide sensitivity testing.

Travel: $200

To visit the field trial and gather samples. (Hoepting Program)

Materials and Supplies: $837

Laboratory supplies: petri plates, agar, and fungicide active ingredients for fungicide sensitivity testing. (Hay Program)

Field supplies: stakes, flags, sharpies, sample bags, PPE, CO_2 tank refill for sprayer. (Hoepting Program)

Services: $163

Cornell Fleet Vehicle Rental: To visit the field trial and gather samples. (Hay Program)

Other Expenses $4,521
18 % Indirect Costs

Hay Program - $2,723
Hoepting Program - $1,800