

Cabbage Research and Development Program

2022-2023 Proposal

Funding Period April 1, 2022-March 31, 2023

Project Title:

Evaluating Pyridate and Acetochlor efficacy and Safety in Cabbage

Principal Investigator:

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Amount Requested: \$5,416

Is this a duplicate submission to another entity Yes No

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Project Summary:

Weed management remains one of the highest research priorities for the CRDP. Weeds that escape control can compete, directly, with the cabbage crop for water and nutrients, resulting in yield loss. Weeds can also interfere with production operations, indirectly, by impeding harvest. Additionally, weed seeds can contaminate cabbage heads reducing their quality and increasing the labor required to clean them up. Furthermore, weeds of the mustard family, such as Shepherd's purse, field pennycress and wormseed mustard, can serve as alternate hosts for the pathogens that cause Alternaria leaf spot, bacterial black rot, and club root diseases. While herbicides are significant components of cabbage production programs, the limited number of registered products and their narrow spectrums of control can result in significant in-season escapes and require the need for costly hand-weeding.

The number of companies involved in the discovery and registration of new crop protection chemicals has decreased by more than 70% over the last 40 years. **Consequently, it is imperative that to investigate the suitability of all potential herbicide options for use in cabbage as future releases of active ingredients are not assured.**

The 2022 proposed research will primarily focus on the evaluation of two active ingredients for weed control efficacy and crop safety in cabbage: pyriproxyfen and acetochlor.

Pyriproxyfen (WSSA Group 6), a photosystem II-inhibitor, was previously labelled for use in cabbage in the US, although registrations were cancelled in 2004. The active ingredient is currently labelled as Tough EC (emulsifiable concentrate) for use in field corn, chickpea, and mint in some US states. Pyriproxyfen injury, which occurs as a blotchy chlorosis, has been observed in cole crops, particularly when using EC products (Figure 1). A new dry formulation (Lentagran, from Belchim Crop Protection, currently registered in the US) is being evaluated in cabbage, Brussels sprouts, and bulb onions for because of enhanced safety potential. Results from 2021 Geneva field trials found less injury was recorded in the Lentagran (16.7 and 22 dry oz/A) treatments (up to 5%) as compared to the Tough EC (12 and 16 fl oz/A) applications (up to 23%) when applied within two weeks of transplanting (Figure 2). Observed injury in the Lentagran treated plots was also lower than the injury caused by both GoalTender (up to 13%) and Stinger (up to 12%). Averaged over crops and application rates, Lentagran did not reduce yields relative to the checks; mean head weights were 98% of the controls. Specific weed targets of the pyriproxyfen include Galinsoga, nightshades, lady's thumb, lambsquarters, pigweeds, and purslane among other broadleaf weed species (including members of the mustard family). **One proposed project in 2022 will evaluate the new pyriproxyfen formulation to describe best use scenarios and provide additional data in support of a label registration.**

Because of crop injury potential, tank-mixes of S-metolachlor (Dual Magnum), a WSSA Group 15 herbicide, and oxyfluorfen (GoalTender) are not advised. There are also recommendations to avoid applying oxyfluorfen in cabbage in the same season as Group 15 products. In 2021 trials, mixes of Dual Magnum and GoalTender injured cabbage and broccoli, on average, 30% two weeks after treatment



Figure 1. Pyriproxyfen injury resulting from an application of the EC formulation to cabbage.

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(Figure 3). Conversely, combined applications of a micro-encapsulated formulation of acetochlor (Warrant), which is also a WSSA 15 herbicide, and GoalTender resulted in only 6% injury. A mix of GoalTender with a non-encapsulated acetochlor product (Harness) caused severe injury to cabbage and broccoli (approximately 60%), highlighting how formulation can significantly affect crop responses. Currently, Warrant is registered for use in corn in New York for the pre-emergence control of grass and broadleaf (including lambsquarters, pigweeds, nightshades, and ragweed) weed species. A 2022 field trial will look at the efficacy and safety of Warrant alone and in combination with GoalTender to determine if the microencapsulated formulation of acetochlor is safe and effective under field conditions.

| Treatment | Crop | Percent (%) Crop Injury (0 = No Injury, 100 = Complete Plant Death) | | | | | |
|--------------------------------|----------|---|----------|----------|-----------|-----------|------------------------|
| | | 5/27/2021 | 6/1/2021 | 6/7/2021 | 6/16/2021 | 6/20/2021 | Max Percent (%) Injury |
| GoalTender 8 oz/A POST | Broccoli | 0.0 | 0.0 | 8.3 | 13.3 | 8.3 | 13.3 |
| | Cabbage | 0.0 | 0.0 | 11.7 | 10.0 | 6.7 | 11.7 |
| Stinger 8 oz/A POST | Broccoli | 0.0 | 0.0 | 11.7 | 6.7 | 3.3 | 11.7 |
| | Cabbage | 0.0 | 0.0 | 11.7 | 5.0 | 3.3 | 11.7 |
| Lentagran 16.7 (dry) oz/A POST | Broccoli | 0.0 | 0.0 | 3.3 | 3.3 | 3.3 | 3.3 |
| | Cabbage | 0.0 | 0.0 | 5.0 | 1.7 | 0.0 | 5.0 |
| Lentagran 22 (dry) oz/A POST | Broccoli | 0.0 | 0.0 | 5.0 | 1.7 | 0.0 | 5.0 |
| | Cabbage | 0.0 | 0.0 | 5.0 | 1.7 | 0.0 | 5.0 |
| Tough 12 oz/A POST | Broccoli | 0.0 | 0.0 | 15.0 | 8.3 | 8.3 | 15.0 |
| | Cabbage | 0.0 | 0.0 | 15.0 | 10.0 | 6.7 | 15.0 |
| Tough 16 oz/A POST | Broccoli | 0.0 | 0.0 | 15.0 | 16.7 | 15.0 | 18.3 |
| | Cabbage | 0.0 | 0.0 | 23.3 | 16.7 | 10.0 | 23.3 |

Figure 2. Early-season cabbage and broccoli injury ratings in response to two rates and formulations of pyridate (Lentagran and Tough EC) compared to two currently registered herbicides. Applications were made on May 27, 2021.

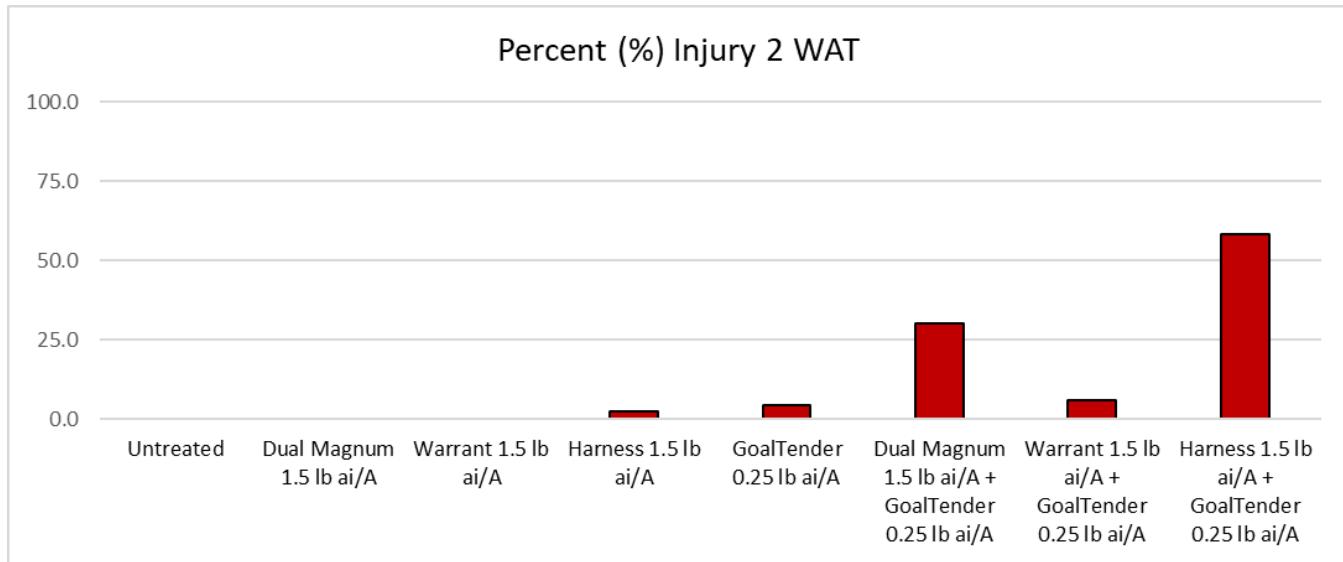


Figure 3. Mean injury to cabbage and broccoli (combined) in response to S-metolachlor, Warrant, and Harness with and without GoalTender. Ratings were collected at 2 weeks after treatment (WAT). Warrant, a microencapsulated formulation of acetochlor (WSSA 15) produced less crop injury when tank-mixed with GoalTender as compared to Harness (also acetochlor, but not microencapsulated) or Dual Magnum (S-metolachlor, WSSA 15).

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Overall Goals: To describe the weed control efficacy and crop injury potential of:

- 1) a novel formulation of pyridate (Lentagran), alone and in combination with grass herbicide tank-mix partners, and***
- 2) a micro-encapsulated formulation of acetochlor (Warrant) with and without oxyfluorfen, as compared to S-metolachlor.***

Desired Outcomes: The desired outcomes of these studies are to identify safe and effective “new” active ingredients/herbicide formulations for use in New York in the production of cabbage and other cole crops. These studies will determine the utility of these products when applied singly, but also describe if applications with tank-mix partners. The data derived from the project will be used to support Section 3 labelling efforts and provide data to the IR-4 program for federal support of efficacy and residue testing

Organizational Capacity:

Sosnoskie received in PhD in Weed Science from Ohio State University in 2005. For the last 16 years she has worked, extensively, in annual specialty crop systems in Georgia and California. Much of her research has focused on identifying strategies to maximize weed management within and across cropping seasons to build more resilient and sustainable production environments. Sosnoskie contributes extensive experience working with the herbicides included in this trial (with respect to both weed control efficacy and crop safety concerns). At Cornell AgriTech in Geneva, Dr. Sosnoskie has conducted two years of research activities, both in the field and in the greenhouse to evaluate weed control and crop safety in cole crops. This includes trials that have been conducted in support of renewing 24c labels and facilitating the registration of new chemistries. In addition to cabbage and broccoli studies, Dr. Sosnoskie and her team also conduct research on other fresh market and processing vegetables including sweet corn, pumpkins, snap beans, carrots, and beets.

At Cornell AgriTech, Sosnoskie has access to a minimum of 7 acres of annual crop land for weed control research. The research farm in Geneva is equipped with the necessary tractors, transplanters, and spray rigs to establish and maintain trials; Sosnoskie’s program owns CO₂-pressurized backpack sprayers to apply treatments to individual plots. Weather stations supported by the Northeast Weather Association (NEWA) are located on the AgriTech farms to generate real-time weather data summaries and IPM forecasts.

With respect to staffing, more than 20 technical personnel are employed by AgriTech during the summer, all of whom are available to assist with greenhouse and large-scale field activities. Currently, Sosnoskie’s lab consists of a full-time technician, a technical research assistant, and three graduate students. Last summer, four temporary summer hires assisted with summer studies and a similar amount are expected to be hired in 2022. All staff at Cornell receive training regarding best worker safety practices when participating in research activities. This includes responses to inclement weather and avoiding heat-related illnesses. All safety-related training is updated yearly.

With respect to COVID, All employees, working on the Cornell campus, even if only occasionally, are required to adhere to all CDC, NYS, local health department, and Cornell University orders, guidelines, policies and procedures at all times; currently this includes being fully vaccinated and masking while indoors. All employees working on campus are required to complete EHS 2021-HERO Act Designation of

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COVID-19 as an Airborne Infectious Disease Compliance Training. Employees are required to complete a Daily Check health assessment each day before arriving on campus. Surveillance testing is also available.

Cornell is an Equal Opportunity Employer and is committed to inclusion. As such, all employees are required to take anti-discrimination and workplace diversity training.

Objective 1:

Describe the weed control efficacy and crop injury potential of postemergence treatments of Lentagran, a novel formulation of pyridate, 1) applied alone, 2) applied as a tank-mix partner, and 3) applied sequentially with currently registered products

Task 1.1

Herbicide options are limited in cabbage production and available products have limited spectrums of control. The discovery and release of novel chemistries has slowed across all cropping systems even though growers remain heavily reliant of the technology for suppressing unwanted vegetation. The active ingredient pyridate is a WSSA Group 6 herbicide (photosystem II inhibitor) that was registered for use in cabbage in the 1990's and then cancelled in the early 2000's. Previously published research has demonstrated its effectiveness for the post-emergence control of broadleaf weeds in cabbage, especially when used with a residual herbicide program (Al-Khatib et al. 1995. HortSci. 30:1211-1214; Henderson and Cairns. 2002. Aus. J. Exp. Agr. 42:1113-1117).

Recent research out of Delaware and Michigan indicates that a new dry formulation of pyridate (Lentagran) can improve crop safety (compared to older EC formulations) in both cabbage and cauliflower while suppressing weeds like lambsquarters, common ragweeds, purslane, pigweed, mustards, and ladysthumb. 2021 trials in NY saw similar results; the dry formulation (which is not currently registered in the US) was less injurious to cabbage and broccoli than an EC formulation (Tough EC, which registered in the US, but not in cabbage), Stinger, and GoalTender applied post-emergence. Belchim Crop Protection is evaluating the novel dry formulation for possible registration.

2022 Lentagran trials will be conducted Cornell's AgriTech facility in Geneva, NY in May 2021; soil at the station is a Honeoye loam with a lower clay surface. The Honeoye series is the state soil of New York, covering 500,000 acres in the state. Field selection will focus on existing infestations of problematic weed species including ragweed, lambsquarters, and pigweeds. Treatments (below) will be arranged as a randomized complete block design with 3-4 replications and applied with a CO₂-pressurized backpack sprayer. Individual plots will be 2 rows of cabbage wide (~5 feet) and 25 to 30 feet long. Cabbage transplants will be placed in rows using a C&M UniTrium transplanter and then set with overhead sprinkler irrigation to reduce shock. Crop production (e.g. fertility) and pest management practices, except for weed control, will adhere to guidelines established by Cornell University for commercial systems.

Specific postemergence Lentagran treatments to evaluate in the study include;

- 1) Untreated check
- 2) Lentagran at 16.7 dry oz/A postemergence (2-6 leaf stage)
- 3) Lentagran at 22 dry oz/A postemergence (2-6 leaf stage)

Lentagran labels from Europe specifically advise against applications with or following products that could de-wax leaves, such as COCs. Similar observations were made by Bellinder et al. (1997. Weed

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Technol. 11:81-87) when exploring earlier formulations of pyridate. Consequently, a set of treatments will also include Lentagran tank-mixed with registered rates of:

- 4/5) GoalTender (plus their recommended adjuvants)
- 6/7) Stinger (plus their recommended adjuvants)
- 8/9) Poast (plus their recommended adjuvants)

Another set of treatments will feature Lentagran applied following treatments of:

- 10/11) GoalTender (plus their recommended adjuvants)
- 12/13) Stinger (plus their recommended adjuvants)
- 14/15) Poast (plus their recommended adjuvants)

These additional treatments will allow us to identify potential safe combinations of products. All postemergence applications will be made between the 2 and 6 leaf stage of crop development.

Performance Measure 1.1.1

Late-May, 2022. Set up cabbage herbicide trial in commercial cabbage field.

Performance Measure 1.1.2

June-August, 2022. Weed control: Weed cover will be rated on a scale of 0% (no weeds) to 100% (complete weed cover) at 7, 14, 21, and 28 days after each herbicide application. Weed density counts will also be taken at the same time. Weed biomass estimates will be collected at harvest.

Performance Measure 1.1.3

June-August, 2022. Crop safety and yield: Crop injury will be rated on a scale of 0% (no injury) to 100% (complete crop death) at 7, 14, 21, and 28 days after each herbicide application. The weights and diameters of individual cabbage heads will be collected at harvest.

Performance Measure 1.1.4

September-November, 2022. Data entry, analysis, and summary.

Performance Measure 1.1.4

December, 2022-March, 2023. Write final report. Report to CRDP. Communicate results to chemical companies and discuss label potential. Submit data to USDA IR-4 Program for consideration for evaluation and residue testing via the Food Use Workshop. Presentations at winter meetings. Write newsletter article, if appropriate.

Objective 2:

Describe the weed control efficacy and crop injury potential of Warrant, a microencapsulated formulation of acetochlor, as compared to Dual Magnum, 1) applied alone, 2) applied as a tank-mixture with GoalTender, and 3) applied in advance of GoalTender.

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Figure 4. Injury to broccoli from Dual Magnum tank-mixed with GoalTender (left) as compared to Warrant tank-mixed with GoalTender (right)

investigated the injury potential of Warrant versus Dual Magnum applied alone and tank-mixed with GoalTender in greenhouse grown cabbage and broccoli transplants. Early results suggest that Warrant plus GoalTender is safer than Dual Magnum plus GoalTender (Figure 4) 2022 trials will evaluate the combined efficacy and safety of the products under field conditions.

trials will be conducted Cornell's AgriTech facility in Geneva, NY in May 2021; soil at the station is a Honeoye loam with a lower clay surface. The Honeoye series is the state soil of New York, covering 500,000 acres in the state. Field selection will focus on existing infestations of problematic weed species including ragweed, lambsquarters, and pigweeds. Treatments (below) will be arranged as a randomized complete block design with 3-4 replications and applied with a CO₂-pressurized backpack sprayer. Individual plots will be 2 rows of cabbage wide (~5 feet) and 25 to 30 feet long. Cabbage transplants will be placed in rows using a C&M UniTrium transplanter and then set with overhead sprinkler irrigation to reduce shock. Crop production (e.g. fertility) and pest management practices, except for weed control, will adhere to guidelines established by Cornell university for commercial systems.

Specific treatments will include:

- 1) Untreated check
- 2) GoalTender at 0.25 lb ai/A pre-transplant
- 3) Dual Magnum at 1.5 lb ai/A 1 day post-transplant
- 4) Warrant at 1.5 lb ai/A 1 day post-transplant
- 5) GoalTender at 0.25 lb ai/A pre-transplant followed by Dual Magnum at 1.5 lb ai/A 1 day post-transplant

Task 2.1

GoalTender is an important chemical in cabbage production for the suppression of broadleaved weeds, especially when used with Treflan and Prowl H2O. However, GoalTender can't/shouldn't be used in combination with all herbicides. Applications of GoalTender with Dual Magnum or in the same season with other acetanilide herbicides (WSSA 15) may cause severe injury to cabbage.

Acetochlor is an acetanilide herbicide with significant residual activity against small-seeded broadleaved weeds, velvetleaf, and grasses like foxtails (Jhala et al. 2015. Can. J. Plant Sci. 95:973-981). A micro-encapsulated formulation of acetochlor is reported to improve crop safety in corn when applied over-the-top.

Preliminary Cornell trials in 2021

GoalTender is an important chemical in cabbage production for the suppression of broadleaved weeds,

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- 6) GoalTender at 0.25 lb ai/A pre-transplant followed by Warrant at 1.5 lb ai/A 1 day post-transplant
- 7) Dual Magnum at 1.5 lb ai/A plus GoalTender at 0.25 lb ai/A 1 day post-transplant
- 8) Warrant at 1.5 lb ai/A plus GoalTender at 0.25 lb ai/A 1 day post-transplant
- 9) Dual Magnum at 1.5 lb ai/A post-transplant followed by GoalTender at 0.25 lb ai/A 14 days after transplanting
- 10) Warrant at 1.5 lb ai/A post-transplant followed by GoalTender at 0.25 lb ai/A 14 days after transplanting
- 11) Dual Magnum at 1.5 lb ai/A plus GoalTender at 0.25 lb ai/A 14 days after transplanting
- 12) Warrant at 1.5 lb ai/A plus GoalTender at 0.25 lb ai/A 14 days after transplanting

The treatments for this trial will allow us to evaluate the performance and safety of Warrant as compared to Dual Magnum when tank-mixed with or applied sequentially with GoalTender.

Performance Measure 1.1.1

Late-May, 2022. Set up cabbage herbicide trial in commercial cabbage field.

Performance Measure 1.1.2

June-August, 2022. Weed control: Weed cover will be rated on a scale of 0% (no weeds) to 100% (complete weed cover) at 7, 14, 21, and 28 days after each herbicide application. Weed density counts will also be taken at the same time. Weed biomass estimates will be collected at harvest.

Performance Measure 1.1.3

June-August, 2022. Crop safety and yield: Crop injury will be rated on a scale of 0% (no injury) to 100% (complete crop death) at 7, 14, 21, and 28 days after each herbicide application. The weights and diameters of individual cabbage heads will be collected at harvest.

Performance Measure 1.1.4

September-November, 2022. Data entry, analysis, and summary.

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December, 2022-March, 2023. Write final report. Report to CRDP. Communicate results to chemical companies and discuss label potential. Submit data to USDA IR-4 Program for consideration for evaluation and residue testing via the Food Use Workshop. Presentations at winter meetings, Write newsletter article, if appropriate.

Outcome and Benefits Expected:

Outcomes Objective 1:

1. Describe Lentagran efficacy and safety in New York cabbage
2. Determine if Lentagran can be safely tank-mixed with currently registered postemergence herbicides and their recommended adjuvants
3. Determine if Lentagran can be safely applied following treatments of registered postemergence herbicides and their recommended adjuvants
3. Develop a report in support of a potential Section 3 label

Outcomes Objective 2:

1. Describe Warrant efficacy and safety in New York cabbage
2. Determine if Warrant can be safely tank-mixed with GoalTender as compared to Dual Magnum

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3. Determine if GoalTender can be safely applied following post-transplant applications of Warrant as compared to Dual Magnum
3. Determine if tank-mixes of Warrant and GoalTender applied 14 days after application can safely extend residual weed control as compared to Dual Magnum
4. Submit data to IR-4 program in support of federal funding for efficacy testing and residue screening to facilitate label changes.
5. Discuss potential of a Special Local Needs with registrant.

Accomplishments/Benefits to Date:

In 2020, NuFarm acquired marketing rights in 2020 to the Goal 2XL and GoalTender brands that had previously been held by Corteva. As part of the transition of the Goal brands, supplemental labels needed to be renewed, including the post-emergence 24c registration. Dr. Sosnoskie used data from 2020 research trials to generate a document in support NuFarm's submission to the DEC.

In 2021, Dr. Sosnoskie had conversations with the weed scientist in the USDA's Office of Pest Management Policy to discuss potential label changes for numerous herbicide active ingredients, including oxyfluorfen, according to the EPA's recently released Preliminary Interim Decisions (PIDs). Data generated in 2020 Field trials confirming the safety and efficacy of the oxyfluorfen were included in the talks, as well as impressions collected from CCE specialists about the possible impacts of label changes for cabbage growers in New York.

Belchim Crop Protection is evaluating the possible registration of new formulations of pyridate in multiple crops, including cabbage. Data from the 2021 trials are being shared with the company to support these efforts. 2022 data will be used to develop best use scenarios in New York in advance of a potential label.

Dr. Sosnoskie has received additional grant support (USDA-SCRI) to investigate the potential for adopting novel weed control technology in specialty crops, including cabbage. Producers in New York have actively expressed interest in these new weed management tools and strategies because of 1) widespread herbicide resistance, 2) a slowdown in the registration and release of new active ingredients, 3) concerns about crop safety and worker health, and 4) changes in public perception regarding the sustainability of local, regional and national agriculture. From this work, trials will be integrated into future projects to develop diversified weed management programs.

Research Experience Relevant to the Proposal:

Sosnoskie received in PhD in Weed Science from Ohio State University in 2005. For the last 16 years she has worked, extensively, in annual specialty crop systems in Georgia and California. Much of her research has focused on identifying strategies to maximize weed management within and across cropping seasons to build more resilient and sustainable production environments. Sosnoskie contributes extensive experience working with the herbicides included in this trial (with respect to both weed control efficacy and crop safety concerns). At Cornell AgriTech in Geneva, Dr. Sosnoskie has conducted two years of research activities, both in the field and in the greenhouse to evaluate weed control and crop safety in cole crops. This includes trials that have been conducted in support of renewing 24c labels and facilitating the registration of new chemistries. In addition to cabbage and broccoli studies, Dr. Sosnoskie and her team also conduct research on other fresh market and processing vegetables including sweet corn, pumpkins, snap beans, carrots, and beets.

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Budget: –

| SALARY | | | | |
|--|------------------------------|------------------------------|------------------------|--|
| POSITION TITLE (non-Exempt) | HOURLY PAY RATE PER POSITION | STANDARD WORK HOURS PER WEEK | NUMBER OF WEEKS FUNDED | TOTAL |
| Temporary Service Technician, Unbanded 10986 (Sosnoskie Program) | \$12.50 | 15 | 12 | \$2,250.00 |
| | | | | Subtotal \$2,250.00 |
| TOTAL SALARY | | | | SALARY TOTAL \$2,250.00 |
| OPERATING EXPENSES - TYPE/DESCRIPTION | | | | |
| Materials & Supplies (Sosnoskie Program) | | | | TOTAL \$1,000.00 |
| Services: | | | | |
| Fuel (Cornell Pumps) (Program Vehicle) 3 trips x 60 miles x \$.56/mile (Sosnoskie Program) | | | | \$100.00 |
| Geneva Farm Crew Services - \$37 per hour (20 hrs) (Sosnoskie Program) | | | | \$740.00 |
| FRU Land Use - 1 Acre(Sosnoskie Program) | | | | \$500.00 |
| | | | | OPERATING EXPENSES - TOTAL \$2,340.00 |
| OTHER EXPENSES - TYPE/DESCRIPTION | | | | |
| Indirect Costs - Direct Costs x 18% | | | | \$826.00 |
| | | | | OTHER EXPENSES - TOTAL \$826.00 |
| | | | | \$5,416.00 |

Objective 1: \$2,708

Objective 2: \$2,708

Budget Justification:

Salaries and Wages - \$2,250

Temporary Summer Technician: These funds will be used to support trial design, treatment application, data collection, data analysis, and outreach (Sosnoskie Program)

Operating Expenses - \$2,340

Materials and Supplies:

Seeds and transplants, stakes, flags (Sosnoskie Program)

Services:

Fuel Cornell Pumps (Program Vehicle): To pick up transplants, to and from field site (Sosnoskie Program)

FRU Land Use: 1 acre (Sosnoskie Program)

Geneva Farm Service Fees: Service preparing land, transplanting, pest management (Sosnoskie Program)

Other Expenses: \$826

Indirect Costs 18%