BEET CURLY TOP VIRUS CONTROL PROGRAM

California Department of Food and Agriculture Grant Proposal

A. Cover Page

1. Project Title. Reduced-risk insecticides for management of beet leafhopper and curly top virus

2. Project Leaders.

- Dr. Erik J. Wenninger, Professor of Entomology, University of Idaho, Kimberly Research and Extension Center, 3806 N 3600 E, Kimberly, ID 83341-5082. Phone 208-423-6677. erikw@uidaho.edu
- Dr. Alexander V. Karasev, Distinguished Professor of Virology, University of Idaho, 604 S. Rayburn St., Moscow, ID 83844. Phone 208-885-2350. akarasev@uidaho.edu
- Dr. Rajtilak Majumdar, Research Geneticist, USDA-ARS, 3793 N 3600 E, Kimberly, ID 83341-5076. Phone 208-423-6517. raj.majumdar@usda.gov

3. Cooperators. None.

4. CDFA Funding Request Amount/Other Funding. CDFA request: Year 1 $39,238.89; Year 2 $39,238.89; total $78,477.78. Extra-mural or in-kind funding committed: Year 1 and Year 2 $37,995.10 (USDA-ARS, Richard Kimball [agency administrative point of contact], 800 Buchanan St, Room 2017, Albany, CA 94710, richard.kimball@usda.gov, 510-559-6019)

5. Agreement Manager. University of Idaho, Office of Sponsored Programs, Sarah Martonick, 875 Perimeter Drive MS 3020, Moscow, ID 83843-3020. Phone 208-885-6651. osp@uidaho.edu

B. Executive Summary

1. Problem

Beet curly top virus (BCTV) causes curly top disease, which stunts and can kill sugar beet, tomato, pepper, bean, melon, spinach, hemp, and other crops across the Western United States. Infection early in the season can mean total crop loss, and infected plants cannot be cured. The virus is spread only by the beet leafhopper (BLH), a small sap-feeding insect that picks up the virus from weeds and other hosts in rangeland and foothills and carries it into fields. Control therefore depends on suppressing leafhoppers. California's Beet Curly Top Virus Control Program (BCTVCP) relies mainly on malathion, a broad-spectrum insecticide (one that kills many kinds of insects, not just leafhoppers), applied to non-cultivated lands. Broad-spectrum insecticides face growing regulatory constraints, worker safety issues, public concern, and harm to non-target insects, including beneficial insects such as predators and parasitoids that attack beet leafhoppers and other insect pests. Alternative options are needed that can manage BLH and BCTV without these negative effects.

2. Objectives, Approach, and Evaluation

Objectives. We will compare reduced-risk insecticides (products with lower toxicity to people, wildlife, and non-target insects) with conventional insecticides on: (1) curly top severity, yield, and sugar quality in sugar beet; (2) densities of BLH and other select arthropod pests; and (3) abundance and richness (number of kinds) of beneficial predatory and parasitoid insects. A fourth, outreach objective is to deliver the results to growers, pest control advisors, and CDFA.

Approach. The reduced-risk products to be evaluated are Applaud (buprofezin, an insect growth regulator that disrupts insect development), SpearT (a biopesticide made from spider-venom peptides), and jasmonates (plant hormones that trigger plant defenses and can attract beneficial insects). They will be tested alone and in combination against malathion, esfenvalerate (Asana, a pyrethroid insecticide with proven efficacy in our previous work), and a non-treated control. These treatments were selected through our preliminary screening (Majumdar et al. 2025; Strausbaugh et al. 2024b). Trials will use sugar beet, a crop highly susceptible to curly top, at the USDA-ARS farm in Kimberly, Idaho, in a randomized complete block design (treatments randomly assigned within replicate blocks) with eight replicates per treatment. Plots will sit next to a separate study in which viruliferous (virus-carrying) BLH are released; this will ensure that the study outlined in the current proposal will have enough virus pressure to elicit BCTV symptoms, but not so much that plants are decimated by the virus. We will measure BLH and other pests from vacuum samples (using a leaf blower with an insect net affixed to the intake tube), rate curly top symptoms using a standardized 0-9 rating scale, and confirm infection with laboratory tests; moreover, we will count and identify beneficial insects, and measure yield and sugar content at harvest.

Evaluation. Treatments will be evaluated on (a) efficacy against BLH and curly top relative to the malathion and esfenvalerate standards; (b) compatibility with beneficial and other non-target insects; and (c) practicality, including ease of use and cost compared with current standards. Results will be reported annually to the BCTVCP.

3. Audience

California growers of curly-top-susceptible crops, pest control advisors, CDFA and BCTVCP staff and Board members, extension personnel, researchers, and policymakers will use the results. The public also benefits from lower pesticide risk to people and the environment. The project supports the program's long-term resilience to regulatory change affecting broad-spectrum insecticides.

C. Justification

1. BCTVCP Mission and Research Priorities

This project supports the BCTVCP mission of advancing the environmentally safe and agronomically sound use of insecticides, and its priority of identifying less toxic alternatives to the broad-spectrum products used against BLH. The program relies heavily on malathion applied to non-cultivated lands next to susceptible crops. That approach has reduced curly top, but safety, non-target, and regulatory concerns call for alternatives. This proposal describes work that evaluates commercially available products that are already registered with the Department of Pesticide Regulation (DPR) for use in California (Applaud on cucurbits, snap bean, and tomato; SpearT on cucurbits, tomato, and several beans and peas) and a plant-hormone treatment to generate field-validated data on efficacy and non-target effects.

2. Impact

Curly top causes serious losses in sugar beet (Strausbaugh et al. 2007), tomato (Chen et al. 2016), basil (Chen et al. 2014), hemp (Melgarejo et al. 2022), chile pepper (Creamer et al. 2007), and melon, where losses of up to 66% have been reported (Flock et al. 1960). Unusual outbreaks in northern California processing tomatoes in 2021–2022 underscore the continuing statewide risk (Melgarejo et al. 2024). *Agronomic and economic:* effective, affordable alternatives protect yield and grower income. *Environmental:* the tested products are expected to better conserve and

even promote natural enemies while reducing pest prevalence, lowering risk to pollinators, beneficial insects, and nearby natural areas. *Local to statewide:* findings apply to foothill source habitats, in-crop use in the San Joaquin and Sacramento Valleys, and any California region with high BLH pressure.

3. Long-Term Solutions

The long-term goal is a management framework that keeps BCTV in check while reducing reliance on broad-spectrum insecticides and building resilience to regulatory change, insecticide resistance, and potential negative public perception. Effective reduced-risk products—alone or combined with conventional chemistries—offer a path to durable management. Jasmonates may add plant resistance and natural enemy recruitment (Thaler 1999; Bruce et al. 2003), and pairing them with selective products such as Applaud and SpearT could meaningfully lower the environmental footprint of BCTV management. Results could allow CDFA and growers to phase out high-toxicity, broad-spectrum products.

4. Related Research

Curly top has threatened irrigated Western crops for over a century (Bennett 1971; Strausbaugh et al. 2008), and climate change may worsen its impact (Melgarejo et al. 2024). Management has relied on insecticide applications targeting BLH in crops and rangeland (Creamer 2020), mainly with neonicotinoid, pyrethroid, and organophosphate products (Kaffka et al. 2002; Strausbaugh et al. 2016). Optimal timing of insecticide application is challenging because leafhopper emergence, prevalence, and dispersal vary among years (Murphy et al. 2012; Strausbaugh et al. 2024a).

For more than a decade, our group has been running sugar beet trials seeking reduced-risk alternatives that match efficacy of conventional insecticides. SpearT and Applaud showed efficacy approaching conventional insecticides, and jasmonates combined with conventional insecticides reduced curly top and increased sugar yield (Fugate et al. 2016; Strausbaugh et al. 2024b; Majumdar et al. 2025). Insect growth regulators (Echegaray et al. 2012; Van Driesche et al. 2001) and spider-venom biopesticides (Miranda et al. 2024; Powell et al. 2020) have shown compatibility with preserving beneficial insects, though effects on predators in our system need clarification. Insect growth regulators can affect development of immature insects as well as negatively affect the physiology and biology of adult insects, which might explain the effects observed in our previous studies. Jasmonates can enhance plant resistance to many pests and stressors (Bruce et al. 2003; Dar et al. 2015; Thaler et al. 2004), may recruit natural enemies (Mrazova et al. 2018; Thaler 2002), and reduce viral disease while improving yield in other crops (Awang et al. 2015; Cao et al. 2008).

5. Contribution to Knowledge Base

Gaps remain in how reduced-risk products perform in the field against BLH and BCTV. Their effects on beneficial insects are expected to be small but are largely untested in the field, and little is known about how non-BLH pests respond to more targeted treatments, which creates uncertainty about secondary pest outbreaks if the program moves away from broad-spectrum products. This project will (a) provide a well-replicated field comparison of several reduced-risk insecticide classes in a BCTV system; (b) quantify trade-offs among virus suppression, pest control, and impacts on beneficial arthropods and other pests; and (c) test jasmonates alone and in combination, including their effect on natural enemy abundance in sugar beet, which has not

been studied. New information will include treatment effects on BCTV strain composition, a topic poorly understood for these compounds.

6. Grower Use

Growers and pest control advisors want effective tools that fit sustainability goals, economic constraints, and evolving regulations. Because the products are already registered in California for other crops, a demonstrated record of efficacy and non-target safety can support use decisions and future label amendments for foothill and other non-crop BLH habitats. Field days and reports will show comparative performance, cost, and fit with standard practices. Adoption incentives include lower regulatory and public-perception risk, lower risk of secondary pest outbreaks, and protection of beneficial insects.

D. Objectives

The goal is to evaluate reduced-risk insecticides as alternatives and supplements to conventional chemistries for managing BLH, preventing spread of BCTV, and preserving beneficial insects. Field plots will be established adjacent to a study in which viruliferous BLH are released, ensuring BCTV pressure in the plots used here.

We will compare reduced-risk and conventional insecticides with respect to:

1. Severity of beet curly top virus, yield, and quality in sugar beet
2. Densities of beet leafhoppers and other select arthropod pests
3. Abundance and richness of beneficial, predatory and parasitoid insects

Moreover, we will carry out a robust outreach program that will:

4. Communicate results to growers, pest control advisors, CDFA, and the scientific community through field days, extension deliverables (publications, website updates, presentations at commodity schools), and peer-reviewed publications.

E. Work Plans and Methods

1. Work Plan (to be repeated each of two years)

Task 1.1./2.1 Project startup (January–March). Hire and train the research aide and technician; finalize protocols, treatment rates, and application timing; order supplies. *Milestone:* approved plot plan and protocols by March.

Task 1.2./2.2 Establish Season 1 trial (April–June; Objectives 1–3). Prepare the field site, plant a commercial sugar beet cultivar with low to moderate curly top resistance, and take baseline arthropod counts in May. Site management follows the 2025 Sugar Beet Grower's Guide Book (Amalgamated Sugar Co. LLC, Boise, ID). *Milestone:* uniform stand and baseline arthropod counts by June.

Task 1.3./2.3 Apply treatments (June–September; Objectives 1–3). Apply foliar treatments at least once, timed to precede or coincide with release of viruliferous BLH in the adjacent study. Continue insect sampling. Rate plots for curly top virus symptoms at least once. Collect late-season leaf samples for virus testing and strain typing. *Milestone:* all treatments applied by late June. Post-treatment vacuum samples collected, and preliminary sorting and counting of arthropods underway. Plots rated for curly top. Leaf samples collected.

Task 1.4./2.4 Harvest, sample processing, and reporting (September–December). The center two rows of each plot will be defoliated and harvested in September or October using a small-

plot harvester. Two eight-beet subsamples from each plot will be collected and submitted to the Amalgamated Sugar Co. Tare Lab (Paul, ID) for sucrose and estimated recoverable sucrose (ERS) analysis. Data will be analyzed and a report prepared. *Milestone:* plots harvested, sucrose data obtained, report prepared and submitted to BCTVCP.

Task 1.5/2.5. Outreach. Present plots at the Snake River Pest Management Tour and at the curly top WERA, Idaho Association of Plant Protection, and/or Pacific Branch Entomological Society of America meetings; prepare extension presentations after each season.

2. Methods

Design. Treatments will be arranged in a randomized complete block design with eight replicates. Plots will be at least 25 ft long and 12 rows wide (22-in row spacing); the width accounts for mobility of beneficial arthropods among plots and lessens the potential for edge effects to influence results. Plots will be placed adjacent to a separate, independently funded study in which viruliferous BLH from a greenhouse colony are released onto sugar beet at the eight-leaf stage. Blocks will be oriented so each is comparably exposed to dispersing BLH.

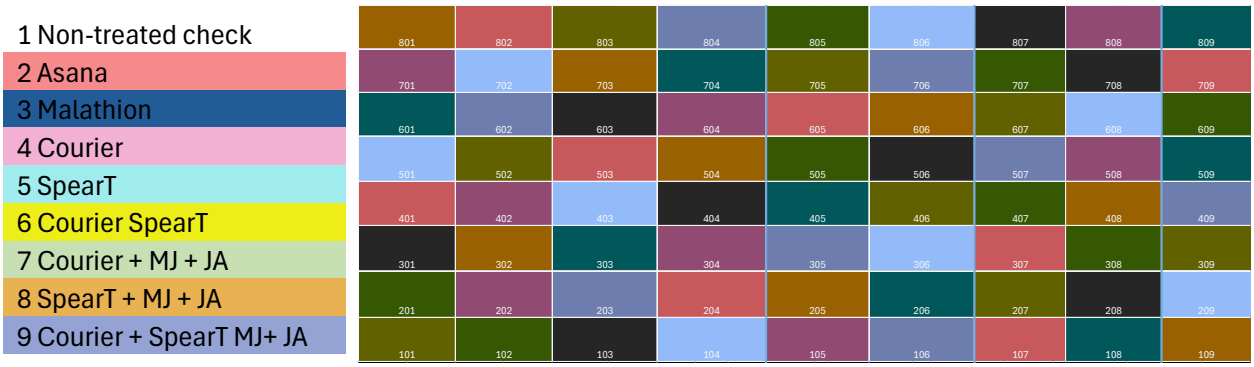
Treatments. (1) Non-treated check; (2) esfenvalerate (Asana, pyrethroid standard); (3) malathion (organophosphate standard in California); (4) Applaud; (5) SpearT; (6) Applaud + SpearT; (7) jasmonates + Applaud; (8) jasmonates + SpearT; (9) jasmonates + Applaud + SpearT. Products are applied as foliar sprays at the highest label rate; jasmonate doses follow Strausbaugh et al. (2024b).

Data gathered. (a) BLH and other pests: weekly vacuum samples after treatment (Wenninger et al. 2020, 2025), plus beet leafminer flies, black bean aphids, sugar beet root aphids, and Lygus bugs as in Wenninger et al. (2019). (b) Beneficials: predators and parasitoids from at least two post-application vacuum samples, identified to the lowest taxonomic level possible; abundance and richness are the response variables. (c) Disease: foliar curly top ratings in August (Strausbaugh et al. 2007; Wenninger et al. 2019); leaves from 10 randomly selected plants per plot tested for BCTV by ELISA/RT-PCR (Durrin et al. 2010), with positives typed to strain (Strausbaugh et al. 2008, 2017), prioritizing the check, standards, and a subset of reduced-risk treatments if resources require. (d) Yield: center two rows harvested in September or October with a small-plot harvester; two eight-beet subsamples per plot analyzed for sucrose and estimated recoverable sucrose at the Amalgamated Sugar Co. Tare Lab (Paul, ID). Ratings and yield serve as proxies for efficacy against BLH and virus transmission.

Analysis. Data will be analyzed with generalized linear models and Fisher's protected LSD ($\alpha = 0.05$), with repeated-measures or nonparametric methods and community-level multivariate analyses of arthropod richness as needed.

3. Experimental Site

The USDA-ARS farm near Kimberly, Idaho, has hosted large sugar beet trials for decades, has uniform silt loam soils typical of the Snake River Plain, and is a representative environment for curly top outbreaks with reliable populations of common sugar beet pests and natural enemies. The figure shows the plot layout (schematic, not to scale); treatment positions will be re-randomized in Season 2. A separately funded study featuring inoculation of viruliferous BLH will be positioned upwind of this study.



F. Project Management, Evaluation, and Outreach

1. Management

Dr. Wenninger is Project Director and primary liaison to the BCTVCP. He is responsible for experimental design, field operations, treatment applications, sample collection and processing, compliance with grant terms, pesticide safety rules, and for all reporting and outreach. Dr. Karasev oversees molecular testing and strain typing, performed by a part-time technician. Dr. Majumdar contributes plant physiology expertise, including jasmonate use, and helps with design, analysis, and interpretation. A research aide performs sampling, sorting, identification, spraying, and data collection under Dr. Wenninger. The team will regularly during the field season and hold quarterly updates otherwise.

2. Evaluation

- *Progress:* milestones in Section E will be tracked against schedules from more than 10 years of similar trials.
- *Success:* complete data collection and analysis for all objectives. Each treatment will be compared with malathion and esfenvalerate to determine whether it meets or exceeds benchmarks for BLH suppression and curly top control, and with the non-treated check for beneficial and non-target effects.
- *Cost/benefit:* product and application costs per acre will be compared with the standards and set against sugar yield and recoverable sucrose, combined with the non-target results.
- *Barriers to adoption:* we will assess registration status for BLH and rangeland use, changes in timing or frequency, possible secondary pest resurgence, and cost and logistics relative to malathion-based operations.
- *Outreach:* evaluated by attendance at field days and meetings plus short post-event surveys of knowledge change on BCTV management, and views and downloads of online materials.

At the end of each season, data will be reviewed against objectives and preliminary findings shared with stakeholders.

3. Outreach

Outreach will be coordinated with University Extension, industry, and CDFA. Both CDFA (non-crop control) and growers (in-crop control) could use these chemistries, so both are audiences. Activities: annual field days at the trial site; presentations at regional meetings, including the curly top WERA, the Idaho Association of Plant Protection, and the Pacific Branch of the

Entomological Society of America; summaries distributed through extension newsletters and University and CDFA websites; and final recommendations and data provided to the BCTVCP Board for program planning.

G. Budget Narrative

A. Personnel Expenses (Year 1: $25,496; Year 2: $25,496; Total: $50,993)

Research Aide, 0.25 FTE (Wenninger). Funds are requested for 0.20 FTE of a research aide's time each year. Base pay rate is $24.58/hr. Years 1 and 2 $10,225 salary and $4,079 fringe (39.9%). The Research Aide will assist the Graduate Student (funded separately) with the labor-intensive work of insect sampling, insect identification, and plot spraying.

Research Technician, 0.20 FTE (Karasev). Funds are requested for 0.20 FTE of a Research Technician's time each year. Base pay rate is $19.23/hr. Year 1 and 2 $7,999 salary and $3,191 fringe (39.9%). The Research Technician will conduct molecular work under the guidance of Karasev.

B. Operating Expenses. (Year 1 and 2: $10,175; Total: $20,350)

Supplies. (Year 1 and 2: $10,000; Total: $20,000).

Wenninger. (Year 1 and 2: $2,000). Field charges for running field trials, insect collection and curation supplies, including nets, vials, ethanol, pins, collection boxes).

Karasev. (Year 1 and 2: $8,000). Year 1 and 2: Materials and kits for virus detection using molecular techniques, including ELISA kits ($2,000), kits for nucleic acid extractions ($3,000), and RT-PCR ($1,000). Miscellaneous supplies (reverse transcriptase and Taq-polymerase enzymes, primers, plasticware, and sequencing kits), RNase and DNase free agarose and reagents for cloning ($1,000). General laboratory supplies, disposable Petri dishes, agar, antibiotics, chemical and laboratory supplies for analysis, and miscellaneous supplies ($1,000).

Equipment. Not requested.

Travel. (Year 1 and 2: $175; Total: $350).

Funds are requested in Years 1 and 2 for Wenninger team travel to the field site at the USDA-ARS south farm, which is a ten-mile round trip. Estimate 25 trips per year x 10 miles x $0.70/mile = $175/year. Total $350.

C. Indirect Costs. (Year 1 and 2: $3,567; Total: $7,134).

Indirect costs were calculated using the funder limit of 10% of Total Costs.

D. Other Funding Sources. (Year 1 and 2: $37,995; Total: $75,990).

The United States Department of Agriculture, Agricultural Research Service is providing $37,995 per year for two years for complementary studies through a Research Service Agreement.

Total Project Budget (Year 1 and 2: $77,233.99; Total project: $154,467.98)

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H. Budget Template

See attached.

I. Appendices

Submitted separately: (1) two-page resumes, recent publication lists, and current/pending activity descriptions for each project leader; (2) cooperator letters (none; no cooperators are named); (3) supporter letter from Amalgamated Sugar.

J. CEQA

Not applicable. The project is a small-plot field trial of registered products on a USDA-ARS research farm; the project lead will comply with all applicable State and federal requirements.