Investment Agriculture Foundation

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Project Title: Development of an Integrated Pest Management Program for Insect and Mite Pests of Grapes.

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Executive Summary:

The goals outlined in the original proposal were largely met and additional areas of research were initiated based on preliminary findings. We were able to accurately map the presence of the western grape leafhopper, *Erythroneura elegantula*, and develop effective management strategies for this new pest of grapes in B.C. The economic status of other grape pests was determined by intensive monitoring of many area vineyards throughout the season, and by correlating grower practices and pesticide applications with numbers of pests and beneficial arthropods.

The primary or major pests of grapes grown in B.C. are grape phylloxera, *Daktulosphaira vitifoliae*, cutworm larvae and leafhoppers. Adult click beetles (wireworm) were previously thought to be important pests of grapes, but our studies have shown them to be of only minor importance. Outbreaks of thrips, grape mealybug, *Pseudococcus maritimus*, and spider mites were shown to be related largely to applications of broad-spectrum insecticides applied for the control of the major pests outlined above. Future research efforts should focus on sustainable, economically-viable methods to control the primary pests that help conserve or enhance populations of beneficial arthropods.

There are no effective means for controlling grape phylloxera other than the use of resistant rootstocks. Chemical applications usually result in increased phylloxera numbers; most likely due to reductions in populations of beneficial insects. In the Okanagan Valley, damaging grape phylloxera infestations are limited to a few areas with heavier clay soils that are prone to cracking. Grapes produced in these sites should be grown on resistant rootstocks and growers should attempt to prevent the introduction or spread of phylloxera. It might be possible to ameliorate damage somewhat by providing additional water and nutrients.

For leafhoppers, we were able to establish an approximate threshold level and investigate a number of chemical and non-chemical methods of control. The latter includes the use of yellow sticky tape and early season removal of basal leaves. We were able to accurately map the presence of the western grape leafhopper, *Erythroneura elegantula*, and develop effective management strategies for this new pest of grapes in B.C. Important information on the parasites of the western grape leafhopper and Virginia creeper leafhopper, *E. ziczac*, were obtained from laboratory and field studies. *Anagrus daanei*, the egg parasite of the Virginia creeper leafhopper, is not as common or widespread as *A. erythroneurae*. Additional research, such as the provision of additional overwintering and early season hosts, is required to find ways to enhance the activity of this parasite.

Monitoring of cutworm activity in several area vineyards demonstrated that the presence of broadleaf weeds, particularly mustards, in the spring prior to shoot elongation greatly reduces bud damage. We hope to further investigate the effectiveness of mustard

trap crops to control spring-feeding pests of grapes. Registration of several new insecticides for the control of cutworm larvae will be pursued in the future.

A large number of cutworm moth larvae were collected and reared in the laboratory and sent to Jim Troubridge, AAFC Ottawa, for identification. Damage results from the combined activity of at least six species. The spotted cutworm, previously thought to be the major cutworm pest, is not important in the southern interior of B.C.

Findings and recommendations from this research have been transmitted to growers by several means, including formal and informal talks, BCWI Newsletter articles, an update of the insect and mite section of the B.C. Production Guide for Grapes and the publication of a photographic guide to grape pests. Dr. Tom Lowery, Principle Investigator for this project, has represented the B.C. grape industry on several committees and has presented talks at national and international conferences.

In summary, this study has identified the major pests of grapes produced in B.C. It has provided methods to monitor these pests and determined various non-chemical methods for their control. This research forms the basis for the development of a sustainable integrated pests management program for the control of insect and mite pests of grapes in B.C.

Summary of Accomplishments:

< Mapped the distribution of the western grape leafhopper; evaluated the effectiveness of registered insecticides for its control.
< Evaluated the effectiveness of *Anagrus erythroneurae* for control of the western grape leafhopper; overwintering and spring hosts identified.
< Successfully reared Virginia creeper leafhopper in the laboratory; produced a temperature-based developmental model.
< Successfully reared the egg parasite *Anagrus daanei* in the laboratory; evaluated parasitism rates following the release of several thousand parasites; studied its biology and host range; collaborated with Dr. David James, WSU Prosser, on a study to evaluate the effect of pesticides on parasite survival.
< Studied various chemical and non-chemical methods of leafhopper control, including the use of yellow sticky tape, early season removal of basal leaves, and the antifeeedant effects of fungicides.
< Cutworm larvae collected from grape and reared in the laboratory; species determined by Jim Troubridge, AAFC Ottawa; correlation of cutworm damage with various management practices demonstrated that the presence of broadleaf weeds, particularly mustards, early in the season greatly reduces damage levels; evaluated the efficiency of various methods for monitoring cutworm, including the use of attractive adult baits.
< Determined that click beetle were not important pests of grapes in B.C.; correlated production practices and spray applications with numbers of secondary pests, such as

thrips and mites.

< Evaluated the efficacy of certain chemical controls; contacted chemical companies and fellow researchers to determine potential materials for use against cutworm and leafhopper that are compatible with IPM.

< A grower questionnaire was completed; selective information compiled and analyzed.

< Revised the insect and mite section of the B.C. Production Guide for Grapes; colour photo-guide to grape pests published (see draft copy attached); a colour guide to beneficial insects nearing completion.

< Dr. Lowery, Principle Investigator for this project, represented the B.C. grape industry on the Interior Minor Use Committee and is a member of the BCWI Research and Development Committee; presented grape IPM talks at national and international meetings in Niagara Falls, Ont., Victoria, Kelowna, and Penticton, B.C.; provided information to growers at BCWI-sponsored Enology and Viticulture Conferences and grower field days; and published several articles in the BCWI Newsletter.

Progress Report:

Grapes produced in B.C. are attacked by fewer insect and mite pests compared with most other grape-producing regions of the world. A survey of vineyards on Vancouver Island and in the Fraser Valley of B.C. showed that these regions were largely devoid of major arthropod pest problems. Diseases and predation by vertebrate pests (rabbits, deer, racoons) were a greater concern. Insecticides and miticides had been used infrequently or not at all on the surveyed vineyards. For the southern interior, our studies have shown that the major pests consist of cutworm larvae, grape phylloxera, and leafhoppers.

A questionnaire relating to grape pests and grower practices was developed and mailed to over 300 growers at the beginning of this study. Analysis of the information provided baseline data on pesticide use, and it allowed us to correlate grower practices with the presence of specific pests. Based on the results of the survey, it appeared that vineyards in B.C. were receiving slightly more than 1 insecticide application yearly. Follow up discussions and additional information from producers who had failed to respond to the questionnaire suggested that this figure was closer to an average of 1.5 sprays per year. This revised value is still much lower than that for most other grape-producing regions.

In conjunction with the grower questionnaire, intensive and extensive field monitoring over the course of this study helped determine the distribution and economic status of the various grape pests. Many, such as spider mites, thrips and grape mealybug, are secondary pests whose numbers remain low unless pesticide applications reduce numbers of beneficial insects. Grapes can tolerate a great deal of damage to leaves and the

threshold for these pests is, therefore, high. For grape mealybug, a review of the available literature failed to reveal an economic threshold for wine grapes. Damage is restricted to table grapes, where the production of honeydew and the cottony egg masses fouls the fruit. For grape thrips, *Drepanothrips reuteri*, populations usually reach high levels in late summer when a sufficient amount of foliage is present to ripen the fruit and most vines are being hedged.

Monitoring at various times throughout the day and at night revealed that click beetle adults are not serious pests of grapes. Damage to buds that was previously attributed to click beetles was shown to be indistinguishable from that caused by half-grown cutworm larvae. Of greater importance, only a very small number of click beetle were ever discovered feeding on the buds of grapes, even in vineyards where click beetle numbers were very high. The discovery that click beetles cause relatively little damage to grapes is important for several reasons. A great deal of time and money would have been wasted monitoring for these pests; control measures directed against the wrong pest might have been ineffective; it is unnecessary to pursue registration of products for click beetle control.

The major or primary pests of grapes in B.C. were determined to be grape phylloxera, cutworm larvae, and leafhoppers. Research should, therefore, focus on the development of accurate monitoring systems and effective controls for these pests that do not disrupt populations of beneficial insects. An integrated, sustainable management system is required that involves both non-chemical and chemical controls. The impact of chemical sprays on non-target organisms can be minimized in several ways. Pest are distributed unevenly in vineyards, and often only a small portion needs to be treated. Registration of new materials that are more selective in their activity would also help preserve numbers of predators and parasites.

Grape phylloxera, *Daktulosphaira vitifoliae*, were found in large numbers in only a few isolated areas where grapes are grown on heavier soils that are prone to cracking. A review of the available literature and discussions with other researchers determined that the only effective means of control involves the use of resistant rootstocks. Chemical controls are not only ineffective, they usually make the situation worse, most likely the result of unintended damage to populations of beneficial insects that help keep phylloxera in check. Growers establishing new plantings in susceptible areas should attempt to prevent the introduction of phylloxera. The health of infested vines might be maintained somewhat by increasing nutrient supply and avoiding drought stress.

Approximately 500 cutworm moth larvae were collected from vines and reared in the laboratory. Although mortality rates were high, we were able to send nearly 30 moths to Jim Troubridge, AAFC-ECORC Ottawa, for identification. The most common of the seven species identified were the dark-sided cutworm, *Euxoa messoria*, and the W-marked cutworm, *Spaelotis clandestina*. None of the specimens were spotted cutworm, which was previously mentioned in the B.C. Production Guide for Grapes as the species responsible for damaging grapes in the Okanagan Valley.

Several methods for monitoring cutworm were attempted. In collaboration with Dr. Pete Landolt, USDA Yakima, adult moths were captured in baited bucket traps in eight area vineyards. Unfortunately, although a large number of cutworm species were captured, several that cause damage to grape buds were not attracted to the traps. Searches for larvae were also conducted in the soil at the bases of plants, and larvae were collected off vines at night. Perhaps the best method currently available is simply to monitor for the amount of bud damage. An approximate threshold level of 3-5% damaged buds should prevent significant economic losses. Development of improved methods to monitor for cutworm larvae that help predict damage before it occurs would be helpful, however, as damage can escalate very rapidly when the weather is warm.

Cutworm numbers and damage levels were also correlated with management practices and the presence of certain types of vegetation. Good stands of mustard weeds, such as Shepherd=s Purse, in the vine rows were strongly correlated with reduced damage. Native mustards belonging to the genus *Draba* appear to be particularly effective at preventing damage, likely because these pests feed on the mustards in preference to vine buds. We are investigating grower practices that enhance stands of these mustards, and are interested in the possibility of planting commercially available mustards in the fall to prevent damage the following spring. Insecticides that are more selective in their activity are required to prevent outbreaks of secondary pests. A number of potential candidates have been identified and we hope to evaluate their effectiveness over the next two years.

Two species of leafhopper now infest grapes produced in B.C. The western grape leafhopper, *Erythroneura elegantula*, was first recorded in this province in 1997. A survey for western grape leafhopper distribution and abundance was completed as part of this project. It is currently found on the east side of the Okanagan Valley from Penticton to the U.S. border. Damaging populations were associated with repeated sprays of Sevin™ applied at lower rates for control of the Virginia creeper leafhopper, *E. ziczac*. These sprays were ineffective against the more resistant western grape leafhopper, but were harmful to the egg parasite *Anagrus erythroneurae* that normally keeps this pest in check.

In collaboration with a local grower, the effectiveness of registered insecticides was evaluated against both species of leafhopper, and findings were incorporated into the B.C. Production Guide for Grapes. In general, most of the materials provided inadequate control of the western grape leafhopper. Fortunately, a new insecticide (Assail™) that is very effective against both leafhopper species was registered for use in B.C. in 2002. We have recently conducted some research showing that Assail and certain fungicides are repellent to leafhoppers. The use of antifeedants and repellents for the control of leafhoppers requires additional study.

For leafhoppers, a threshold level of 25 nymphs per leaf was established for control of the second generation. This figure is 50 times higher than the level previously contained in the B.C. Production Guide for Grapes. Growers can reduce pesticide use by adopting this higher threshold, and by spraying only those areas that require treatment. An integrated approach to leafhopper control is being developed that relies on a combination of

chemical, biological, cultural and physical controls. Working with a local vineyard owner, we evaluated the effectiveness of registered insecticides for the control of the Virginia creeper leafhopper and the western grape leafhopper and incorporated these findings into the production guide recommendations. Micro-fine clay was shown to be ineffective for leafhopper control, and registration of summer oil sprays is not being pursued due to concerns about phytotoxicity and delayed ripening. Registration of several new insecticides for the control of leafhoppers will be pursued in the future. Timing of insecticide applications for leafhopper control will be assisted by a temperature-based leafhopper developmental model that is being prepared in collaboration with Dr. Gary Judd, PARC Summerland. Because leafhoppers begin to lay eggs after the first grape leaves are fully expanded, there is a need to initiate the model based on vine physiology or to >piggyback= leafhopper development onto a grape development model if an appropriate one is available.

Yellow sticky tape applied below the cordon soon after bud break was shown to reduce leafhopper numbers by more than 90%. Removal of basal leaves early in the season when leafhopper eggs were present is also an effective non-chemical method of control. Possible effects of early removal of basal leaves on disease incidence, fruit quality, plant growth and fruitfulness led to the initiation of a separate three year study that is being conducted in two area vineyards. To date, this change in timing of leaf removal appears to offer several benefits to growers in addition to leafhopper control.

Important information on the parasites of the western grape leafhopper and Virginia creeper leafhopper were obtained from laboratory and field studies. *Anagrus* parasites were collected from dormant woody material and sent to Dr. Serguei Triapitsyn, Univ. of California, for identification. We have accumulated a great deal of information on the alternative hosts of *A. Erythroneurae* and have a better understanding of its biology and impact on the western grape leafhopper. In most locations, *A. erythroneurae* effectively controls the western grape leafhopper unless broad-spectrum insecticides negatively effect their numbers. Early spring, summer, and overwintering hosts have been identified for this parasite, and future research could involve the provision of alternate hosts to enhance parasitism.

Anagrus daanei, the egg parasite of the Virginia creeper leafhopper, is not as common or widespread as *A. erythroneurae*. Rearing parasites in the laboratory for release early in the season was effective, but not economical. *Anagrus* parasites that were reared in the laboratory were also shipped to Dr. David James, WSU Prosser, WA, for use in toxicity studies to determine the effects of insecticides and fungicides on parasite survival. Additional research into methods to preserve and enhance the activity of this parasite is required in order to maximize its effectiveness.

Numbers of beneficial insects and predacious mites that help keep grape pests in check were also monitored in several Okanagan vineyards. Populations were assessed based on numbers counted on leaves and those captured on yellow sticky cards. The results of this study demonstrated that populations of beneficial arthropods varied widely

between vineyards. Pesticide applications had the greatest effect on numbers of beneficial insects, but populations were also influenced by other factors such as the diversity of groundcover plants and frequency of mowing or cultivation.

As part of this study, the insect and mite section of the B.C. Production Guide for grapes was updated and made available to growers. The photographic guide to the insect and mite pests of B.C. grapes (see attached copy), which is a companion to the Production Guide, was completed in time for the BCWI Enology and Viticulture Conference held in June, 2004. Significant progress has been made toward completion of the colour guide to beneficial insects, and we hope to have it completed for the upcoming conference in July, 2005.

Dr. Lowery, the Principle Investigator for this project has made information obtained from this study available to growers via several additional avenues. These include personal consultations and site visits with a number of growers, publication of articles in the BCWI Newsletter (a copy of the latest article is attached), presentations at the last four Enology and Viticulture Conferences, talks at BCWI-sponsored Grower Field Days, and presentations at National and International conferences. The latter includes an invited speaker presentation as part of a grape symposia at the Entomological Society of Canada Annual General Meeting, Niagara Falls, 2001; a presentation at the 2003 Western Pest Management Forum, Kelowna, B.C., and at the 14th Organic World Congress, IFOAM 2002, Victoria, B.C. Information was also presented to the North Okanagan Organic Growers= Association in Vernon, and at a meeting of South Okanagan Grape Producers in Oliver.

Dr. Lowery has also represented the B.C. wine and grape industry in several other ways. These include membership on the B.C. Interior Minor Use Committee and the BCWI Research & Development Committee; communication with chemical company representatives, researchers, and government representatives; and provision of information on grape pest management to students from Okanagan University College, Penticton, and Simon Fraser University. His research on *Anagrus* parasites was featured on the CHBC news.

In summary, the objectives outlined in the proposal were largely met and additional studies initiated based on preliminary findings. This three year research program has determined the economic importance of various insect and mite pests found on grapes in B.C., developed effective monitoring methods and thresholds, and suggested or established effective methods of control. The research arising from this study provides the basis for the development of a sustainable integrated pest management program for the control of insect and mite pests of grapes in B.C.

Financial Statement:

Key Activity: Continue development of appropriate monitoring methods and temperature-based predictive models for leafhoppers and beneficial insects.	cash	in-kind
! Salary, Principle Investigator	$1,000.00	nil
! Salary, Research Assistant	$5,000.00	A
! Salary, Collaborating Scientists	nil	$3,000.00
! Materials and Supplies	$99.23	nil
! Prepared and Serviced Vineyards	nil	$2,500.00
! Vehicle Lease and Travel	A	A
! Office and Laboratory Space	A	$4,000.00
Sub Total	**$6,099.23**	**$9,500.00**

Key Activity: Improve leafhopper and parasite rearing system, further investigate *Anagrus* hosts and biology and effects of management practices on parasitism rates.	cash	in-kind
! Salary, Principle Investigator	$500.00	nil
! Salary, Research Assistant	$5,000.00	A
! Salary, Collaborating Scientists	nil	$1,500.00
! Shipment of *Anagrus* Parasites to Dr. James	$156.35	nil
! Identification of *Anagrus* parasites	$1,430.00	A
! Materials and Supplies	nil	A
! Vehicle Lease and Travel	A	A
! Office and Laboratory Space	A	$5,000.00
Sub Total	**$7,086.35**	**$6,500.00**

Key Activity: Evaluate methods for monitoring cutworm and wireworm populations, assess damage levels, and collect information relating to chemical applications and vegetation management.	cash	in-kind
! Salary, Principle Investigator	$5,000.00	nil
! Salary, Research Assistant	$10,000.00	A
! Salary, Collaborating Scientists	nil	$3,000.00
! Identification of Cutworm	A	$2,500.00
! Materials and Supplies	$195.26	nil
! Prepared and Serviced Vineyards	nil	$10,000.00
! Vehicle Lease and Travel	$111.29	$100.00
! Office and Laboratory Space	nil	$2,500.00
Sub Total	**$15,306.55**	**$18,100.00**

Key Activity: Investigate other pests of grape, including site visits, grower surveys, literature searches, and determine the effect of management practices and chemical applications on numbers of pests and beneficial insects and mites.	cash	in-kind
! Salary, Principle Investigator	$1,000.00	nil
! Salary, Research Assistant	$5,664.00	A
! Salary, Collaborating Scientists	nil	$1,500.00
! Materials and Supplies	A	nil
! Prepared and Serviced Vineyards	A	$2,500.00
! Vehicle Lease and Travel	$100.00	A

! Office and Laboratory Space	nil	$2,500.00
Sub Total	**$6,764.00**	**$6,500.00**

Key Activity: Analyze data, prepare reports and summaries for growers, present findings and recommendations via articles and talks, attend minor use and research and development meetings, communicate with provincial Minor Use Coordinator and chemical company representatives, plan research activities	cash	in-kind
! Salary, Principle Investigator	$2,500.00	nil
! Salary, Research Assistant	$1,000.00	A
! Office and Laboratory Space	nil	$6,000.00
! Materials and Supplies	$360.00	nil
! Vehicle Lease and Travel	$57.00	$150.00
! Support Services	nil	$2,000.00
Sub Total	**$3,917.00**	**$8,150.00**
Total Expenses	**$39,173.13**	**$48,750.00**

Expense Summary: 1 July, 2003, to 9 July, 2004.

	Budget			**Funding Sources**				
	Cash	[in-kind]	Total Value	BCWI	IRAP	Dr. Lowery	AAFC-PARC Summerland	IAF
Salaries & Benefits	$36,664.00	[$9,000.00]	$45,664.00	$10,554.15	$8,703.28	nil	[$9,000.00]	$17,406.57
Materials & Supplies	$810.84	nil	$810.84	$202.71	$202.71	A	nil	$405.42
Prepared and Serviced Vineyards	nil	[$15,000.00]	$15,000.00	[$15,000.00]	nil	A	A	nil
Insect Identification	$1,430.00	[$2,500.00]	$3,930.00	$357.50	$357.50	A	A	$715.00
Vehicle Lease & Travel	$268.29	[$250.00]	$518.29	$67.07	$67.07	[$250.00]	A	$134.15
Office & Laboratory Space, etc.	nil	[$20,000.00]	$20,000.00	nil	nil	nil	[$20,000.00]	nil
Support Services	A	[$2,000.00]	$2,000.00	[$2,000.00]	A	nil	nil	A
Sub-total	**$39,173.13**	**[$48,750.00]**	**$87,923.13**	**$11,181.43 [$17,000.00]**	**$9,330.56**	**[$250.00]**	**[$29,000.00]**	**$18,661.14**

Project Expense Summary:

Salaries:		
Principle Investigator (Lowery Ent. Res. Ltd.)	$60,000.00	
Technical Assistants	$89,271.29	
Total		**$149,271.29**
Materials and Supplies:		
Office Supplies	$1,224.13	
Laboratory and Field Materials	$4,873.32	
Total		**$6,097.45**
Travel Expenses:		
Vehicle Rental and Insurance	$16,953.95	
Fuel and Servicing	$2,388.21	
Mileage	$795.42	
Total		**$20,137.58**
Conference Registration, Accommodation, etc.:		**$1,514.54**
Insect Identification Charges (Dr. Serguei Triapitsyn):		**$1,430.00**
Total		**$178,450.86**
Total contribution from B.C. Investment Agriculture Foundation:		**$88,300.00**