PROPOSAL TO THE AGRICULTURE RESEARCH FOUNDATION - 2001
FOR THE SLV RESEARCH CENTER COMMITTEE AND THE
COLORADO POTATO ADMINISTRATIVE COMMITTEE (AREA II)

TITLE: Biology and Management of Columbia Root-knot Nematodes (*Meloidogyne chitwoodi*) of Potato in the San Luis Valley, Colorado

PROJECT LEADER:

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Agro Engineering, 0210 Rd 2 South, Alamosa, CO
Hooper Farming

PROJECT JUSTIFICATION:

Potato producers are required to control numerous plant pathogens present within fields in order to maintain the highest quality product. Although Columbia root-knot nematode (*Meloidogyne chitwoodi*) is not visible to the naked eye, the symptoms of their presence in tubers can not be mistaken. Nematodes developing within the tuber cause bumps (galls) on the tuber surface and minute brown spots inside the tuber as deep as the vascular ring. Both symptoms are considered a quality defect and cause for the tuber to be culled. Even a small percentage of culls within a crop may cause that crop to be devalued or rejected by buyers. While the Pacific Northwest (PNW) region has been dealing with the Columbia root-knot nematode for many decades, the San Luis Valley region of Colorado is relatively new to the problems caused by this pest. Although the presence of the nematode has been known for many years (Pinkerton and McIntyre 1987), the number of fields infested and severity of infestations appear to be increasing with time. Since tuber infection is a function of nematode density, which is dependent on soil temperature, tuber damage is much more severe in warmer growing seasons. If several warm seasons should occur in succession, the problem could be come very serious. Unfortunately, very little research has been conducted on the biology of *M. chitwoodi* in the SLV or on management procedures that are appropriate for this region.

Columbia root-knot nematode is controlled by fumigation in most areas of the PNW. Since most of these fields are infested with *Verticillium dahliae* (the major cause of early dying disease) as well as nematodes, the industry standard has become a double fumigation with metam sodium, which controls *Verticillium* but not nematodes, and Telone, which controls nematodes but not *Verticillium.* However, since the SLV generally has a shorter, cooler, growing season than other areas where Columbia root-knot nematode is found, less intensive measures may be adequate for control in the SLV.

In recent years, the control strategy for root-knot nematode in the SLV has been a fall application of metam sodium alone. This procedure is expensive (up to $175/acre), results in large amounts of pesticide (162 lb a.i./acre) added to the soil, and may non-selectively kill beneficial organisms as well as plant pathogens. Spring applications of metam sodium are not possible in the SLV due to the time required between application and planting and the short growing season. Consequently, if a field is not treated in the fall, control strategies are severely limited.

Recent research in the PNW has indicated that Vydate (oxamyl) may be effective in areas with low to moderate population pressure of *M. chitwoodi*. Vydate is currently the only nematicide registered for use on potato after emergence, and the only control option if nematodes are found after planting. Vydate is not a fumigant, but rather a "nonfumigant" nematicide, which also functions as a nematostat at lower concentrations. A "nematostat" will disorient a nematode and prevent infection without killing the nematode on contact. While Vydate has some systemic activity, it is most effective on soil-dwelling nematode stages which, for root-knot nematodes are the second stage juveniles (J2) and males, which are rare and do not damage tubers.

Periodic applications of Vydate through overhead sprinklers have proven effective in controlling root-knot nematodes when following a fumigant in the PNW. Adequate control of root-knot nematode may be accomplished by using Vydate alone in cooler growing regions, such as the SLV. Vydate is also effective on stubby-root nematode (*Paratrichodorus allius*), which vectors tobacco rattle virus to cause corky ringspot disease, and root-lesion nematodes (*Pratylenchus* spp.) that can be associated with early dying. Interestingly, Vydate is also an excellent insecticide and provides good control of aphids. Therefore, a nematode management strategy using Vydate may not need additional insecticide applications, so the comparison in cost with a fumigation management strategy should be the cost of metam sodium <u>plus</u> insecticides compared to the cost of Vydate treatments without additional insecticides. This may represent a substantial cost savings to the grower in combined nematode-insect management.

In order to achieve maximum control using Vydate, it is essential to know when the first generation of eggs hatch and release J2 into the soil, when subsequent generations hatch, and how many generations of nematodes are produced. This information can be determined by sampling for population dynamics and then can be predicted by a soil temperature degree-day model. Since Vydate has a relatively short half-life, periodic applications are required to maintain suppression of root and tuber infection. However, the optimum number of applications, timing of applications and the rate required to minimize cost and maximize control is not known. Furthermore, since the SLV has such a cool, short growing season, there may be a threshold level of *M. chitwoodi* density below which damage would not occur even if left untreated.

The purpose of this project is to benefit the potato growers in the San Luis Valley by specifically tailoring nematode research to the San Luis Valley. This will be accomplished by observing the population dynamics of Columbia root-knot nematode in the San Luis

Valley, determining the threshold density that requires treatment, and determining the most cost-effective treatment, beginning with a Vydate management strategy. As more is learned about the biology of this pest in the San Luis Valley, more effective, less expensive and/or ecologically sustainable control strategies may be developed.

PROJECT STATUS: New

OBJECTIVES :

1. Determine the density of Columbia root-knot nematodes at which unacceptable tuber damage occurs if left untreated.

2. Determine the density of Columbia root-knot nematode that can be controlled with Vydate alone.

3. Determine the optimum timing and rate of Vydate applications for effective control at the least cost.

4. Determine the effects of storage on nematode development in tubers grown in the San Luis Valley.

5. Monitor population dynamics of Columbia root-knot nematode in relation to soil temperature and develop a degree-day model to predict nematode development for the San Luis Valley.

Additional opportunities to test other products with support from the product manufacturers may also occur once a nematode project is initiated in the region.

PROCEDURES:

Objective 1. Determine the density of Columbia root-knot nematodes at which unacceptable tuber damage occurs if left untreated.

Objective 2. Determine the density of Columbia root-knot nematode that can be controlled with Vydate alone.

A grower's field has been identified that has a wide range in density of Columbia root-knot nematode, including areas with very high populations. The field will be treated commercially with Vydate in 2001, but a wedge of the circle near the pivot road will be left untreated. Immediately after planting, transects will be established in the area not to be treated and an adjacent area which will be treated with Vydate. Nematode samples will be taken from fifty, 20 ft sections of row within each transect to find areas with a wide range of initial nematode density. At harvest, a tuber sample will be taken from 25 of the plots that best represent the range of nematodes recovered at planting in each of the treated and untreated areas. The level of tuber infection (see general methods below) will be determined for each of these plots and related to the initial density recovered. ***Plots with unacceptable damage from the untreated transect will establish the population density above which treatment is required. Population levels which cause unacceptable damage in the Vydate-treated transect will establish the upper population***

level for which Vydate will be effective. This field will be planted to Centennial Russet which has an intermediate growing season length and degree-day accumulation for cultivars grown in the SLV. While we would prefer to be in a field with Russet Nuggets to assess the worst case scenario of a long season cultivar, it was not possible to find a Russet Nugget field with appropriate nematode densities for 2001.

Objective 3. Determine the optimum timing and rate of Vydate applications for effective control at the least cost.

Plots 6 rows wide and 40 feet long will be established in a section of the grower's field that will not be treated and is known to have high nematode densities from previous grid samples. The treatments listed below will be applied to these plots by chemigation through individual sprinkler simulators. Each treatment will be replicated five times in a randomized block design. All data will be collected from the middle two rows.

1. Untreated Control
2. Vydate at 1.0 lb a.i./a at 950 DD_5 and then every two weeks
3. Vydate at 1.5 lb a.i./a at 950 DD_5 and then every two weeks
4. Vydate at 1.0 lb a.i./a at 950 DD_5 and then every 250 DD_5
5. Vydate at 1.5 lb a.i./a at 950 DD_5 and then every 250 DD_5

All treatments will begin at 950 degree-days at a base temperature of 5 C (DD_5). This is the predicted time that the second generation of nematodes begins hatching from eggs. Before this time, nematodes are migrating into roots where they develop and Vydate applications are not considered to be cost effective during this period. Current EPA restrictions limit Vydate applications through chemigation to 1.0 lb a.i./a (2.1 pints Vydate C-LV). Dupont is addressing this issue and their new Vydate label will recommend an application at 1.5 lb a.i./a every two weeks (treatment 3). ***However, since the growing season is cooler and shorter in the SLV than in the PNW, a lower rate of 1.0 a.i./a may be still be adequate for this region (treatments 2 and 4).*** Biologically, it may make more sense to time applications with population development rather than by the calendar. Since generations are completed every 500-600 DD_5, treatments 4 and 5 will be applied at the completion of generations. However, since the half-life of Vydate is short, it may not remain effective for 500 degree-days, so we will also apply an application halfway through the development of each generation. Therefore this strategy results in an application every 250 DD_5. (Degree-days will be monitored with Watchdog data loggers, see objective 5). This degree-day interval may change as we learn more about nematode developmental rates in the SLV. ***The important consideration concerning the two timing models is that better control may result with the degree-day schedule and, in a cool region like the SLV, fewer applications may be necessary than on a two-week schedule.*** If the degree-day schedule is superior, a web site can be established that calculates degree-days for growers so they can be advised of the optimum times to treat.

Objective 4. Determine the effects of storage on nematode development in tubers grown in the San Luis Valley.

Preliminary degree-day measurements and generation calculations from 2000 suggest that many potato crops in the SLV may be harvested right at the end of the second generation. This may mean that tubers experience a heavy infection right before harvest, but do not have time to express symptoms. ***Since M. chitwoodi can continue to develop at storage temperatures, tubers placed into storage without symptoms may have symptoms when they are taken out of storage. Therefore, treatment strategies must not only control symptoms expressed at harvest but also prevent infections that may develop and express symptoms during storage.*** To guarantee the treatments we test will satisfy this criteria, two additional tuber samples will be taken from each plot. One sample will be held at ambient temperatures for three weeks to simulate additional degree-days that may accumulate with later harvest and/or a warmer growing season than that experienced during the year of the trial. The last sample will be placed in storage and evaluated for infection the following spring. Temperature data loggers will be placed in the sample bags to record the number of degree-days that accumulate during the storage period.

Objective 5. Monitor population dynamics of Columbia root-knot nematode in relation to soil temperature and develop a degree-day model to predict nematode development for the San Luis Valley.

Since no information on nematode population development in relation to soil temperature exists for the SLV, one of the middle rows of each plot will be sampled on a one- to two–week basis. Just prior to the anticipated completion of the first generation, tuber samples will be collected and shipped to Oregon State University on a weekly basis where they will be sliced and stained to determine when tuber infection occurs and how effective the different Vydate treatments are at preventing tuber infection. Spectrum Watchdog data loggers will be established in the plot and read on a weekly basis to determine cumulative degree-day accumulations. The relation of nematode development with temperature in the SLV will then be compared to that observed from other areas to determine if there is a unique relationship for the SLV.

Routine Methods

Nematode Population Monitoring

Nematode populations will be sampled from of each plot by taking ten cores to 12 in depth from one of the middle rows of each plot and combining these cores into a single sample/plot. Samples will be taken by SLV area cooperators at Agro Engineering and shipped to Oregon State University. Soil samples will be sieved, mixed and nematodes will be extracted from a 250 g subsample by wet sieving-sucrose centrifugation (Jenkins, 1964) as modified in Ingham (1994) and counted at 50X under a dissecting microscope.

Root-knot Evaluations

Root-knot nematode infection will be assessed by examining three sets of 25 randomly selected 6-10 oz tubers from each plot. One sample will be evaluated immediately after harvest. Another sample will be evaluated three weeks later to simulate further development during a longer or warmer growing season. The last sample will be placed in storage and evaluated in the spring. Each tuber to be evaluated will be peeled under a magnifying lamp to count the number of nematode infection sites. Data recorded will include percent tuber infection (one or more infection sites), percent culled tubers (tubers with six or more infection sites), and infection index as a measure of infection intensity (0 = 0, 1 = 1-3, 2 = 4-5, 3 = 6-9, 4 = 10-49, 5 = 50-99, 6 = 100+ nematodes/tuber [Pinkerton et al., 1986]).

Corky Ringspot Evaluations
If corky ringspot disease is present in the plot area, CRS symptoms will be assessed by examining the same tubers evaluated for root-knot infection. After root-knot evaluations, each tuber will be cut longitudinally to inspect for symptoms of CRS. If no or only slight symptoms were found, the tubers will be further sliced into 1/2 in transverse slices. Only spots or arcs exceeding 1/8 in diameter will be counted. Categories will include no infection, 1-5% of internal surface blemished (No. 1 grade), 5-10% of internal surface blemished (No. 2 grade) and more than 10% of internal surface blemished (cull).

REFERENCES

Ingham, R.E. 1994. Nematodes. Pp. 459-490 *in* Methods of soil analysis, Part 2, Microbiological and biochemical properties. R.W. Weaver, J.S. Angle, and P.J. Bottemley (eds). Madison, WI: Soil Science Society of America.

Jenkins, W.R. 1964. A rapid centrifugal-flotation technique for separating nematodes from soil. Plant Disease Reporter 48:692.

Pinkerton, J.N., G.S. Santo, R.P. Ponti, and J.S. Wilson. 1986. Control of *Meloidogyne chitwoodi* in commercially grown Russet Burbank potatoes. Plant Disease 70:860-863.

Pinkerton, J.N. and G.A. McIntyre. 1987. The occurrence of *Meloidogyne chitwoodi* in potato fields in Colorado. Plant Disease 71:192.

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TITLE: Biology and Management of Columbia Root-knot Nematodes (*Meloidogyne chitwoodi*) of Potato in the San Luis Valley, Colorado

BUDGET FOR 2001-02

Faculty Research Assistant Salary	$ 6,863
Faculty Research Assistant OPE (0.53 of salary)	3,637
Supplies	1,000
Travel to research plots	5,586
Subtotal	$17,086
ARF administrative fee (5%)	854
Total	**$17,940**

Other Expenses

We have estimated that it will cost $1,820 to collect and ship samples to us during the season and that shipping costs will be $1,945. **This brings the total request for this project to $21,705**. If possible, we recommend that the $3,765 for sample collection and shipping be set up in an account at the SLV Research Center. This would probably be much more expedient than if the money came to Oregon and then was paid back to Agro Engineering.

Other Financial Contributions

Oregon State University is providing $22,322 for 2000-01 in the form of a graduate student stipend, benefits and tuition to support Nick David.

Dupont is providing the necessary equipment and product for all applications and will be responsible for making applications or contracting (Katy Watts) for the applications to be made. While this support is less definable, it still represents a substantial dollar contribution to the project.

BUDGET JUSTIFICATION

Faculty Research Assistant Salary and Benefits

The majority of the work for this project will be conducted by Nick David who is paid on a graduate assistantship provided by Oregon State University. However, Nick will require some technical assistance from a faculty research assistant in order to process the large number of soil and tuber samples associated with this project.

Travel

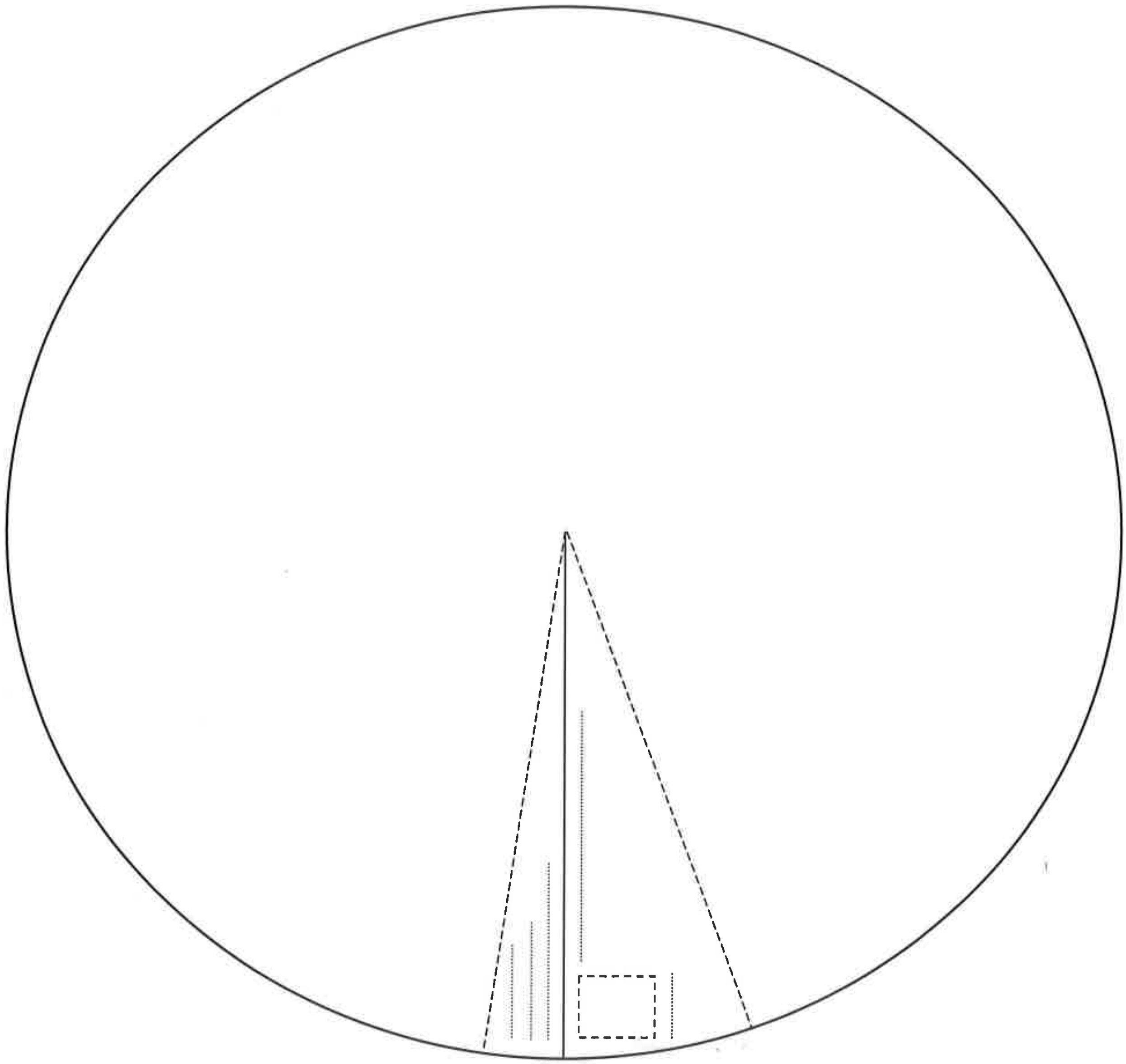
Dr. Russ Ingham and Nick David will travel to the SLV research sites at planting to set up plots and instruct SLV cooperators on work needed during the season, at the time of the first application to make applications and train SLV cooperators on application methods for the rest of the season and at harvest to collect and evaluate tubers. An assessment of the cost of driving or flying from Oregon to Colorado determined that flying and renting a car was less than driving either a motor pool or personal vehicle. Funds are also requested for Russ or Nick to attend the Annual Potato and Grain Conference to present results.

Supplies
Funds are requested for a JMC Backsaver soil probe that can be left with Agro Engineering for use by ourselves and Agro Engineering, two Spectrum Watchdog data loggers and accompanying radiation shields and software for downloading and managing data logger data, and a minimal amount for miscellaneous expenses.

Funds for Agro Engineering Cooperators
Personal from Agro Engineering will be collecting soil and tuber samples, downloading data loggers and shipping samples and temperature data to Oregon. Support is requested at a rate of $140/week for this assistance.

Shipping Costs
Money is requested for shipping soil and tuber samples to Oregon for analysis.

HOOPER FARMING
CIRCLE #5
(7N 107 SW OF SECTION)



HOOPER PLOT MAP
CIRCLE #5

SOUTH EDGE OF PLOT

DRIVE	DRIVE	502	HARVEST	SAMPLE		505	HARVEST	SAMPLE		DRIVE	DRIVE	503	HARVEST	SAMPLE		504	HARVEST	SAMPLE		DRIVE	DRIVE	501	HARVEST	SAMPLE		150'
DRIVE	DRIVE	404	HARVEST	SAMPLE		401	HARVEST	SAMPLE		DRIVE	DRIVE	402	HARVEST	SAMPLE		405	HARVEST	SAMPLE		DRIVE	DRIVE	403	HARVEST	SAMPLE		120'
DRIVE	DRIVE	301	HARVEST	SAMPLE		303	HARVEST	SAMPLE		DRIVE	DRIVE	304	HARVEST	SAMPLE		302	HARVEST	SAMPLE		DRIVE	DRIVE	305	HARVEST	SAMPLE		90'
DRIVE	DRIVE	205	HARVEST	SAMPLE		202	HARVEST	SAMPLE		DRIVE	DRIVE	201	HARVEST	SAMPLE		203	HARVEST	SAMPLE		DRIVE	DRIVE	204	HARVEST	SAMPLE		60'
DRIVE	DRIVE	103	HARVEST	SAMPLE		104	HARVEST	SAMPLE		DRIVE	DRIVE	105	HARVEST	SAMPLE		101	HARVEST	SAMPLE		DRIVE	DRIVE	102	HARVEST	SAMPLE		30'

0'

First drive row is 11 rows west of pivot road

Northern edge of plot is 97 feet from edge of road pavement (7N &106.5)

NORTH EDGE OF PLOT