Final Report Submitted to:

SLV Research Center Committee
and the
Colorado Potato Administrative Committee (Area II)

Title: Utilization of green manure crops in continuous potato production to suppress soil-borne diseases.

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Project Justification: For various economic reasons some potato growers in the San Luis Valley are moving away from the traditional grain-potato-grain rotation. Despite that this is not a recommended practice, much of the increase in potato acreage in recent years has been at the expense of crop rotation. Continual potato production will deplete soil organic matter, foster soil-borne diseases and stockpile nitrates. A deep-rooted green manure crop can salvage nitrates and, upon decomposition, kill soil fungi and nematodes. Given the direction in which our potato industry is developing the consequences of less-than-ideal cropping practices need to be examined. Green manure crops could be valuable in the San Luis Valley. However, several economic and biological questions need to be answered.

Project Status: Ongoing

Significant Accomplishments for 1994:

Objective 1) Establish a long-term study site at the SLVRC for evaluating green manure crops in potato production. A site for the study was established in 1994 on the northwest corner of the Research Center farm. An area: 120' X 220' containing 12 plots 40' X 40' was laid out under a solid-set sprinkler system. Before planting each plot was soil sampled to 24 inches for nitrates and soil type. Soils and nitrates were uniform across the site. The 1994 planting consisted of nine plots of Centennial Russet, two plots of barley, and one plot of green manure crop. In early August, the green manure plot was tilled under and the barley plots combined. Following harvest of the potato plots soil samples for *Verticillium* analysis were collected from each plot. Results of the *Verticillium* assays showed that the average count (microsclerotia/g of soil) for potato plots was 26, barley plots 25, and the green manure plot 3. One of the plots on which potato had been grown was fumigated on October 18 by spinkler application of Busan.

Objective 2) Evaluate crops for use as green manure. Three varieties of sudan grass and three varieties of corn were tested as sources of green manure. For agronomic reasons and ease of tillage the sudan grass variety Trudan 8 was selected for long-term use in the study.

Objectives for 1995:

1. Run a second growing season of crop sequences.

2. Collect data on soil nitrates, *Verticillium* levels in soil and in plant tissue and yields of potato and barley.

3. Collect data on nematode populations.

4. Optimize fumigation procedure.

5. Optimize green manure production and tillage.

Significant Accomplishments for 1995

Objective 1. Run a second growing season of crop sequences. The first true crop rotation was carried out in the 1995 growing season. Potato, barley and sudan grass were planted according to the long-range study plan. Trudan 8 was planted in the green manure blocks and Russet Norkotah was planted in all potato blocks. All three crops being utilized in the study were planted on time, grown and harvested according to plan. A winter rye cover crop treatment was added to the study in 1995 to assess its value in N uptake and impact on *Verticillium* in a continuous potato scheme.

Objective 2. Collect data on Verticillium levels in soil and yields of potato and barley. Replicated soil samples were collected from all blocks in the study and mid-season and assayed for *Verticillium*. The overall incidence of *Verticillium* microscloratia/gram of soil (VPPG) was lower in 1995 than in 1994. This is likely an artifact of the assay technique employed in 1995. Nevertheless, blocks in continuous potato without fumigation averaged 5 VPPG. In the block where Busan was applied in the fall of 1994 only 1 VPPG was detected. Similar to this, in the block where green manure was incorporated, no *Verticillium* could be detected. Blocks in a potato/barley rotation showed no change in *Verticillium* levels. The average yield of potato across all blocks was 210 cwt/A. Neither crop sequence or fumigation significantly affected total yield or percent U.S. number 1 grade potatoes. The block planted to barley yielded 99 bushels per acre.

Objective 3. Collect data on nematode populations. Soil samples collected at mid-season from all blocks in the study revealed the presence of the lesion nematode and stubby root nematode. The average nematode count per 100 grams of soil were 80 and 8 respectively. This level is well below the threshold considered important for potato. Crop sequence and fumigation had no effect on nematode numbers.

Objective 4. Optimize fumigation procedures. A new properly sized electric pump and sprinkler were purchased for the project. Busan was applied on October 18 according to the label with no complications.

Objective 5. Optimize green manure production and tillage. Based on the results of testing three corn varieties and three sudan grass varieties during 1994, the sudan grass Trudan 8 was selected for the study. Trudan 8 was planted in 1995 for green manure production. Due, however, to a much-cooler-than-normal growing season Trudan 8 performed poorly. By the third week in August, it had grown to only about four feet tall. At that point the sudan grass was mowed down and then incorporated with a tractor-mounted rototiller. At this point it appears that Trudan 8 is acceptable and our cultural practices are adequate for good growth if the growing season is favorable.

Objective for 1996:

Run a third growing season of crop sequences. Collect data on Verticillium levels in the soil and yields of potato.

Significant Accomplishments for 1996:

The rotation trial was planted on May 16 with G3 Russet Norkotah cut seed. On May 17 the green manure crop of sweet corn was planted. The irrigation system for the trial operated correctly throughout the season allowing the potato, barley and corn crops to develop according to plan. The corn crop was chopped and incorporated on August 26. The barley was harvested on September 18. Potatoes in the trial were top killed on September 9 and allowed to dry down for harvest on September 23. Within each treatment block 20 feet of the center four rows were harvested for yield and grade. Yield results for the trial are shown in Table 1. The effect of continuous cropping sequence and fumigation are very evident from the data. The effect of continuous cropping of potato suppressed yields to 122 cwt/A. Treatment with Busan, however, boosted the crop, while beneficial, did not outperform the traditional potato-barely-potato rotation. Surprisingly, fumigating proved to still be beneficial even in the second potato crop following application. While the soil assays for *Verticillium* showed a trend, the results are inconclusive. On October 8 an attempt was made to apply Busan in the trial. Unfortunately, I had not been informed that the power on the west side of the "Research Center" had been changed during the summer from 220 to 440 volts. This, of course, immediately destroyed the motor on the pump, aborting the whole effort. Another attempt will be made to apply Busan in the spring about three weeks before planting. Nevertheless, the project has been seriously compromised at this point.

Significant accomplishments in 1997:

Due to technical problems, Busan was not applied as planned in October of 1996. In an effort to salvage the soil fumigation component of the study, Vapam was applied on April 28, 1997. The trial was planted on May 21 with donated G2 Russet Norkotah cut seed. Trudan 8 was planted for a green manure crop on June 10. The season proceeded without event. The Trudan 8 developed rather poorly due to a cool growing season. In late August, the Trudan 8 was mowed down however, never truly tilled under for rapid decomposition. Tuber harvest occurred on September 23. Results for 1997 are shown in Table 2. Neither fumigation, green manure or cropping sequence had any effect on percent marketable tubers (4-12 oz). The highest concentration of *Verticillium* (22 VPPC) occurred in plots planted continuously to potato with no green manure fumigation or barley crop rotation. The lowest levels of *Verticillium* (3VPPG) were detected in the plot treated with Vapam

in the spring of 1997. Total tuber yield was the highest at 170 cwt/A following the spring application of Vapam. The lowest tuber yields occurred in plots where potatoes had been planted three or more years consecutively. The traditional potato-barley-potato rotation yielded 148 cwt/A.

Conclusions:

1. The number of Verticillium microscloratia per gram of soil increases each year that potatoes are grown on the same plot when there is no crop rotation to barely or other mitigating factor such as fumigation or green manure.

2. A green manure crop or soil fumigation with metam sodium does substantially reduce *Verticillium* levels in the soil and to about the same degree. Both treatments also appear to delay the rebound of Verticillium number in the soil for two or more years.

3. A potato-barley-potato rotation shows the build up of *Verticillium* when compared to continuous cropping to potato.

4. Total tuber yield was not directly correlated to VPPG, other factors are likely involved in potato yield suppression.

5. Following either a fall or spring application of metam sodium, a measurable increase in total tuber yield was documented. A fall application of metam sodium however, is more effective and predictable than a spring application.

6. From a biological stand point, a green manure crop is an effective tool for managing *Verticillium* and in this study it was comparable to metam sodium. Unfortunately, under San Luis Valley conditions a green manure crop requires a full growing season and therefore is not an economic alternative to fumigation at this time.

7. The biological benefits of a green manure crop for managing *Verticillium* and nematodes have been well demonstrated in the San Luis Valley and in several other potato production areas. For now, we have several chemical tools for controlling these pests. In a few years however, these chemical tools will likely no longer be available. Therefore, we must push forward in developing the agronomics and economics of green manure crop production for the San Luis Valley if we are to have a sustainable system for pest management.

Table 1. Effect of croping sequences and fumigation on tuber yield and levels of soil *Verticillium* in the cultivar Russet Norkotah, 1996

Treatment	Yield, cwt/A[a]	%Marketable[c]	VPPG[d]
Continuous Potato[b]	122	76	10
Busan fall 94, Potato 95, Potato 96	172	77	6
Busan fall 95, Potato 96	189	87	4
Green manure 94, Potato 95, Potato 96	129	71	4
Green manure 95, Potato 96	141	73	2
Potato 94, Barley 95, Potato 96	141	74	10

[a] Yields based on 80 feet of row
[b] Continuous potato yields based on four plots within the trial, 320 feet of row
[c] Marketable yield based on tubers of 4-12 oz
[d] Number of Verticillium microscloratia/gram of soil.
Soil samples for Verticillium analysis were collected in the fall of 1995.

Table 2. Effect of crop sequence and fumigation on tuber yield and levels of soil *Verticillium* in Russet Norkotah, 1997

Treatment by year[a]						
94	95	96	97	Yield, cwt/a[b]	% Marketable[c]	VPPG[d]
P	P	P	P	132	77	22
GM	P	P	P	128	76	8
P	GM	P	P	145	85	6
P	P	GM	P	148	78	6
P + FB	P	P	P	131	80	7
P	P + FB	P	P	161	80	6
P	P	P	SV + P	170	82	3
B	P	B	P	148	85	12
Mean				145	80	8.7

[a] GM = green manure, P = potato, FB = fall Busan, SV = spring Vapam, B = Barley
[b] Yields based on 80 feet of row, 2 replications per treatment
[c] Marketable yield based on tubers 4 - 12 oz in size
[d] Number of Verticillium microscloratia/gram of soil, samples collected on 9-10-97