PREDICTING DISEASE SEVERITY FOR SUGAR BEET ROOT ROTS USING A PRE-PLANT SOIL DISEASE ASSAY

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ABSTRACT

Aphanomyces cochlioides and *Rhizoctonia solani* are important soilborne pathogens responsible for significant root disease problems that are primary constraints to sugar beet production in Nebraska. These types of diseases are difficult to control because they are often not noticed until substantial damage has already occurred. Efforts to manage them would be more effective if predictive techniques were available for those affected by these pathogens, rather than reactive ones. Therefore, a new technique with the purpose of estimating relative pathogen populations in the soil and predicting potential for root disease problems later in the season is currently being tested from pre-plant soil samples collected from fields to be sown with sugar beets. Samples are planted with a susceptible cultivar and the test is conducted for one month. A disease index is developed based on the time period during the test that seedlings become infected and is calculated on a 0-100 scale. Pre-plant index values are then compared with yields obtained from the same fields after harvest. To obtain a better understanding of soil index values, we are additionally conducting tests in soils using known pathogen concentrations as standards. Data obtained to this point suggests that this technique provides promise for predicting potential root disease problems. For example, sugar yields obtained in 2004 from 21 low index fields averaged 2800 kg/ha (2500 lbs) more than 6 high index fields. This technique not only estimates pathogen concentrations, but additionally identifies specific pathogens involved, enhancing the grower's disease management decisions.

INTRODUCTION

Root diseases are significant problems in Nebraska sugar beet production fields. The most widespread and consistently identified root diseases now include Rhizoctonia root and crown rot and Aphanomyces root rot, caused by the soilborne fungal pathogens *Rhizoctonia solani*, and *Aphanomyces cochlioides*, respectively. It is becoming more common to find both pathogens infesting fields and infecting crops simultaneously (Harveson and Carlson, 1993).

The two pathogens possess several common characteristics, including the ability to cause both a seedling disease and a root rot later in the season. Additionally, both pathogens are soilborne, can survive in the soil for many years, and are favored by generally warm and moist soil temperatures. Yet they also differ substantially. Taxonomically, they are not closely related, and *Aphanomyces* is much more dependent upon high levels of soil moisture than *Rhizoctonia*. Additionally, *Rhizoctonia* attacks a wider range of host plants, including dry beans, whereas *Aphanomyces* is limited to causing disease on plants related to sugar beets.

A number of options are available for managing both diseases, including seed treatments with several different fungicides, using resistant cultivars, and cultural

practices like early planting and irrigation management. All will contribute to reducing disease problems due to these diseases, but unfortunately, no one method by itself will adequately address those situations where both pathogens are present. Thus, some type of predictive technique would be welcome for estimating potential for root disease problems later in the season, allowing greater flexibility for growers to make management decisions.

MATERIALS AND METHODS

We are currently investigating a new technique begun in 2003 that attempts to estimate relative pathogen populations in field soil, and predict potential root disease problems while also identifying specific pathogens present in soil samples (Harveson, 1996). We call this technique the "disease index". It is based on a similar concept from Sweden (Ewaldz, 1992) and entails using soil samples collected from fields to be planted to sugar beets the following season. The samples should be taken from the upper 4-6 inch depth from multiple locations within a field to give a better representation of the entire field, similar to those samples taken for fertility analysis.

Disease Index:

The collected samples are brought to the University of Nebraska's Panhandle REC plant pathology diagnostic lab, and are planted with a susceptible cultivar and maintained for 4 weeks. Seedlings are observed daily, and pathogens identified after disease symptoms appear. The index is based on the time during the 30 day test when seedlings become infected, and is calculated on a 0-100 scale based on the formula:

$$DI = \frac{[\#\,IS^{*}\,(1^{st}\,wk) \times 4 + \#IS\,(2^{nd}\,wk) \times 3 + \#IS\,(3^{rd}\,wk) \times 2 + \#IS\,(4^{th}\,wk)]}{(\text{total plants emerged} \times 4)}$$

***IS = infected seedlings**

An index value of 40-65 represents a moderate risk of disease problems later in the season. Anything above 65 would represent a high risk, while below 40 would be considered to be a low risk.

We are also attempting to compare our index results with yield and sugar data collected from these same fields after harvest to further evaluate this technique for predicting potential root disease problems caused by Rhizoctonia and Aphanomyces root rots (Tables 1 and 2).

Known Concentration Standards:

To get a better idea quantitatively of what these index values from test fields may mean in terms of real pathogen numbers in soils, we additionally set up experiments testing known pathogen concentrations to establish standards for both *A. cochlioides* and *R. solani*. For *Aphanomyces*, pots were filled with sterile soil and infested with 3 concentrations of *A. cochlioides* – 500, 1,000, and 2000 oospores per pot. *Rhizoctonia* utilized grams of colonized barley seed as inoculum, and consisted of 0.5g, 1.0g, 2.0g, and 4.0g seeds per pot. Each pot contained approximately 600 g soil, utilizing 6 replications/pots per treatment. Inoculum for both pathogens was prepared as previously

described (Harveson, 2006). These data are presented in Tables 3 and 4 as the average of two tests.

RESULTS

Yield data were obtained from 38 and 18 of the test fields from 2004 and 2005, respectively, and compared with the calculated index values for the same fields prior to planting, and are presented in Tables 1 and 2 as averages for the fields corresponding to each of the three distinct index values.

Table 1. Results of Harvest Data from 2004 Averaged Over Test Fields by the Three Distinct Index Categories

Fields	Index	Tons/A	%Sugar	lbs Sugar/A
21	<40	26.3	17.95	9441.7
11	40-65	23.5	17.83	8380.1
6	>65	20.1	17.25	6934.5

Table 2. Results of Harvest Data from 2005 Averaged Over Test Fields by the Three Distinct Index Categories

Fields	Index	Tons/A	%Sugar	lbs Sugar/A
14	<40	24.7	17.28	8536.3
2	40-65	19.4	16.67	6479.6
2*	**>65**	**24.5**	**16.60**	**8134.0**

*** Both high index fields treated with azoxystrobin (Quadris) after being determined to have high populations of *R. solani*.**

The yields obtained from fields in both seasons suggest a strong relationship between the pre-plant disease index and resulting root and sugar yields. The average sugar yields in 2004 from the 21 fields testing as low risk (<40) produced 2500 lbs (6 tons/acre) more than did those from the 6 fields testing as high risk (>65). As would be expected, the moderate risk category (40-65) was also intermediate between the two extremes. However, this still amounted to an improvement of almost 1100 lbs sugar for the low risk compared to the moderate risk category.

These data indicate that the fields with higher disease indices also resulted in lower yields and total sugar per acre. The exception to this is from the 2 fields in 2005 with a high index value. The yields were comparable with the low index values and better than the moderate, however these fields were also treated with azoxystrobin (Quadris) during the season, which likely explains the difference. This is an example of growers utilizing the information from the calculated index assay and exercising their options for addressing the problems observed. In addition to the creation of the overall disease index, we can also identify the specific pathogens and estimate their relative numbers from the samples.

No yield information has been collected yet from the 2006 season, but 198 samples (fields) were tested, ranging in value from 0 to 97. The breakout for each disease potential severity category is: low potential (<40) – 137 fields, moderate potential (40-65) – 51 fields, and high potential (>65) – 10 fields. An additional 180 samples were submitted and processed during Fall 2006 for the upcoming 2007 season.

Table 3. Disease Index Standards for *Aphanomyces* (average of 2 tests).

Inoculum level*	**Disease Index**
Control	0.0
500 oospores	32.02
1,000 oospores	35.05
2,000 oospores	46.02

* inoculum level is based on number of oospores per pot (600 g of soil)

Table 4. Disease Index Standards for *Rhizoctonia* (average of 2 tests).

Inoculum level*	**Disease Index**	**Emergence**
Control	0.0	88%
0.5 g	34.4	64%
1.0 g	19.4	60%
2.0 g	35.8	53%
4.0 g	48.9	36%

* inoculum level is based on grams of infested barley kernels per pot (600 g of soil)

The index values obtained from *Aphanomyces* testing (Table 3) suggested that it took a level of 2,000 oospores to produce an index value in the moderate risk category, while somewhere between 2.0 and 4.0 g of *Rhizoctonia* were necessary to get into this category (Table 4). A high level of *Aphanomyces* found may require a seed treatment of Tachigaren, or perhaps the selection of a tolerant cultivar for chronic root rot that potentially may appear later in the season. Since the beginning of this project, growers have used this information to make these types of decisions based on the index tests.

Note also the low number of seedlings that emerged from the higher *Rhizoctonia* inoculum concentration treatments. This was eventually demonstrated to be caused by pre-emergence damping-off by *R. solani*. The higher concentrations in this treatment were apparently enabling the pathogen to attack and kill the seeds before they could emerge. The 0.5 g level also resulted in a higher index than the 1 g treatment and equal to the 2 g treatment. This is assumed to be due to higher number of seedlings emerging and dying after emergence – (the index is based on this aspect). This is new information that suggests some modifications may need to be considered in order to optimize the standards tests. More evaluations will be continued to build a more accurate data base for estimating pathogen concentrations in field soils.

Conclusions and Status of the Project

The data obtained to this point are very encouraging and continue to suggest that predicting root disease potential from *R. solani* and *A. cochlioides* and achieving better yields based on the results of testing soils pre-plant with the disease index method is still a viable possibility. However, this test will not effectively predict root disease from rhizomania or Fusarium yellows because the pathogens causing these diseases are not commonly found infecting seedlings. Their presence in soils can be evaluated, but requires a different type of greenhouse test with longer time duration, which we are also currently using and investigating. We have also been able to detect herbicide residues in soils from emerged seedlings using this technique.

The popularity and knowledge of this service's availability has increased since its inception in 2003. The samples submitted for testing over the last four years are as follows: 44 in 2003, 150 in 2004, 113 in 2005, and 198 in 2006. We have additionally received 180 samples in September-November 2006 for the upcoming 2007 season, which has not occurred until this time. This is exactly what we envisioned when beginning this concept. By identifying potential disease problems early, growers have more time to better evaluate their management options, such as purchasing certain seed cultivars early the following year before planting time.

For the short term, we think this technique will continue to assist growers in making decisions before planting by proactively identifying specific pathogens and estimating their relative concentrations in field soils. Growers in Nebraska, Colorado, Montana, and Wyoming are currently using these tests in a variety of ways, including:

1) deciding which cultivars to plant
2) choosing fungicide treatments for protecting emerging seedlings
3) being prepared to spray fungicides (Quadris for *Rhizoctonia*)

4) deciding whether to even plant sugar beets in certain fields
5) testing fields to be planted to sugar beets in 2008.

For the long term we want to continue to test this concept by collecting disease index information and comparing it to the standards in the greenhouse using known concentrations of pathogens, yield data collected from test fields, and environmental conditions (soil moisture and temperatures) within fields with the ultimate goal of developing a risk assessment (forecasting) system for sugar beet root diseases caused by *A. cochlioides* and *R. solani*.

REFERENCES

1. Ewaldz, T. 1992. Determining the risk of damping-off in sugar beets. Bulletin OILB/SROP, 15: 169-171.
2. Harveson, R. M., and Carlson, C. C. 2003. Response of sugar beet cultivars to Aphanomyces and Rhizoctonia root rots under optimum conditions. Proc. of 1st Joint IIRB-ASSBT Congress 865-869.
3. Harveson, 2006. Identifying and distinguishing seedling and root rot diseases of sugar beets. Plant Health Progress, doi: 10.1094/PHP-2006-0915-01-DG.
4. Harveson, R. M. 2007. A predictive technique for sugar beet root diseases utilizing a pre-plant soil assay. Phytopathology 96: In press.