The Value of Crop Borders for Management of *Potato Virus Y* (PVY) in Seed Potatoes

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Over the past 20 years, *Potato virus Y* (PVY) has become a very serious problem throughout most major seed potato producing states because the commercial potato industry is dependent upon the availability of disease-free seed tubers. Planting seed tubers with more than modest levels of virus infection (e.g., >10%) can result in yield and quality losses for the commercial grower (Killick 1979; Reestman 1970; van der Zaag 1987).

PVY is one of two virus diseases that are of particular concern in seed potato production. For example, seed lots that failed to meet recertification standards (> 0.5% virus) for PVY in the winter tests of the Minnesota State Seed Potato Certification Program averaged 42.1% from 1998 to 2004 with a range 28.3 to 61.2%. As a result of high PVY levels, seed potato production has declined 50%, and the number of seed producers has declined by 40% in the region. If a seed lots exceeds tolerance, it can be downgraded to a more advanced generation in a limited generation production scheme (maximum of 5 field seasons) or rejected outright. Thus, virus incidence has an immediate impact on the price received and seed producers' gross revenue.

PVY is transmitted in a nonpersistent manner by numerous vector species (such as aphids), some of which are only transient visitors to potato (Boiteau et al. 1988; Harrington et al. 1986; Heimbach et al. 1998, Sigvald 1987, 1989; van Harten 1983). Since PVY is a nonpersistently transmitted virus, any vector loses its ability to spread the virus after a feed for mere seconds on non-infected plants. Thus, cultural methods have been proposed as alternatives to insecticides. Indeed, cultural methods have been shown to be more successful than insecticides in the control of PVY. Insecticides seldom kill quickly enough to prevent spread of PVY (Ragsdale et al. 1994).

Crop borders (i.e., barrier crops) are one cultural method that has been proposed and is being used by seed potato producers to control spread of PVY. If immigrating alatae (i.e., winged aphids) arrive already carrying PVY and they are attracted to and feed first on the crop border, they will lose their virus inoculum before moving into the potatoes since PVY is transmitted in a nonpersistent manner (DiFonzo et al. 1996).

The use of crop borders to protect seed potatoes, especially high value, early generation seed, from PVY spread has been adopted by some Minnesota and North Dakota seed producers. The recent emergence of soybean aphid as a major pest throughout the Midwest and the discovery that this insect is a capable vector of PVY has caused some producers to question the advisability of continuing to use soybean as a crop border. Thus a study was undertaken to reassess the value of crop borders for controlling PVY. As part of this study, seed potato producers in Northwestern Minnesota and Eastern North Dakota were surveyed to assess their perception and the value of using crop borders to manage PVY in seed lots. Their responses were used to estimate the impact and value of using crop borders in seed potato production.

METHODS

Initial interviews with seed potato producers who already use crop borders were used to formulate questions on producers' use and nonuse of crop borders. The preliminary survey was tested by mailing to a small subset of producers. Based on their responses, the survey was finalized and mailed to every seed potato producer in Minnesota and North Dakota (92 in total) on February 23, 2005. Forty-seven producers were in Minnesota and 45 in North Dakota. A reminder postcard was sent a week later, and another complete survey two weeks after that. Reminders were also sent by email from the North Dakota and Minnesota state seed potato producers associations. Twenty-three surveys were returned and deemed usable—a 25% return

rate. The strength of relationships between producers' responses to one question compared to another question was tested using the Chi-square test or Fishers' Exact test when needed due to the small number of responses (SAS Institute). The importance of factors explaining differences in gross income per acre of seed potatoes was analyzed using PROC REG in SAS.

RESULTS

Of the 23 respondents, 5 said they had used crop borders for their seed potato lots in 2004 and had used crop borders for an average of 4 years. The range was 2-5 years. Nine producers said they had used crop borders but had quit: 6 because it didn't appear to reduce PVY and 3 because of inconvenience or cost. Four said they had considered using crop borders but had decided against it. Five said they didn't have enough information to use crop borders.

Of the 23 producers who responded, 19 producers have been farming for more than 10 years, and 15 producers have been growing seed potatoes for more than 10 years. Twelve producers said more than 25 percent of their total net farm income came from seed potatoes. Ten of the producers had completed college, 6 had completed a trade or technical school, 2 had received some post high school education, and 2 had gone to or completed graduate or professional education. Compared to other problems in seed potato production, 13 of the 23 producers said damage caused by PVY (or mosaic) infection was very important on their farm, 6 said it was important; 2 said it was somewhat important, and 1 said it was not important.

The producers' stated importance of damage caused by PVY (mosaic) infection was significantly ($p <= 0.10$) related to their use or lack of use of crop borders (Table 1). However, it does not appear to be a simple relationship. While those using crop borders indicated that damage caused by PVY infection was "very important" relative to other problems in seed potato production, most of the producers who had never used crop borders also said the damage was

"very important." Those producers who had used crop borders but had quit were more likely to say the damage was "important" than "very important."

Table 1. Frequency of producers' use of crop borders compared to their self-reported importance of damage caused by PVY (mosaic) infection on their farm.*

	Very important	Important	Somewhat important	Not important	Total
Never used crop borders	6	1	1	0	8
Used crop borders but quit	3	5	0	1	9
Used crop borders in 2004	4	0	1	0	5
Total	13	6	2	1	22
*Fisher's Exact test (for relationship) probability = 0.08 so hypothesis of independence between use of crop borders and reported importance is rejected at $p<0.10$.					

In 2004, these 23 producers entered 152 seed lots into state seed certification programs. The median number of seed lots was 4 per producer. Of these seed lots entered into the certification programs in 2004, the median number of seed lots rejected for PVY was 0 based on summer inspection and 1 based on winter trials.

Of the 152 seed lots, these producers said they had entered into state seed certification programs, they reported detailed information on 108 lots. Thirty-two of these 108 lots were planted within crop borders. The most common potato varieties were Red Norland, Russet Burbank, and Dark Red Norland. Ninety-three (or 86%) of the 108 reported seed lots were generations 1 through 4. Generations 1 and 2 accounted for 72% of the 32 seed lots planted within a crop border.

Of the 108 seed lots, 104 were reported to have passed summer inspection for PVY. Of the 89 seed lots for which winter test results were reported, 62 lots (or 74%) were reported to have passed the winter test for PVY (Table 2). The Chi-square test for relationship showed passing the winter test was significantly related to the use of crop borders. Thirty-one (or 97%)

of the 32 seed lots planted reported to be planted within crop borders passed the winter test compared to 31 (or 54%) of the 57 seed lots that reported winter test results but did not use crop borders. The use of a mineral or crop oil appears at first to have a positive impact on passing the winter test, but when combined with the use of crop borders, the impact of an oil application disappears.

Table 2. Frequency of passing the winter test compared to use of crop borders.*

	Passed Winter test:		
	No	Yes	Total
Did NOT use crop border	26	31	57
DID use crop border	1	31	32
Total	27	62	89
*Frequency of 89 lots with winter test results reported; results were not reported for 19 lots. The Chi-Square value of 17.5 has a probability < 0.0001 so the hypothesis of independence between use of crop borders and passing the winter test is rejected at p<0.01.			

The average lot size of the 108 seed lots was 40 acres with a median seed lot size of 27 acres and a range of 0.2 acres to 350 acres over all seed generations, varieties, and locations. For the 24 seed lots reporting, the crop border averaged 26.6 feet with a median width of 20 feet and a range of 4 to 60 feet wide. The most common border crop reported was winter wheat (10 seed lots). The next most common border crops were soybean and rye (7 lots); wheat and alfalfa (6); and sudan grass (4). Wheat alone and potatoes were also reported on one seed lot each. Since 28 seed lots passed the winter test of the 29 seed lots reporting the border crop used, no relationship between the choice of border crop and passing the winter test was found.

Over all generations, varieties, and lots, the average yield of seed potatoes was 255 cwt per acre with a median of 223.5 cwt and a range from 110 to 579 cwt per acre. For those who reported price, the average price received (or expected) was $7.68 per cwt with a median price of $7.50 and a range from $3 to $17 considering all generations.

The importance of producer characteristics and management practices in explaining the level of gross income per acre was estimated using linear regression. Gross income was calculated by multiplying the reported seed potato yield times expected price. Eighty-three lots had both price and yield information reported. These lots had average gross revenue of $2,014 per acre. The minimum was $617.5; maximum, $5,475; and standard deviation, $1,171.

The explanatory variables chosen for explaining variations in gross income were the producers' years farming, the percent of their net farm income from seed potatoes, generation of the seed potato, the reason for chemically killing the vine and whether a crop border was used. The number of years farming was expected to have a positive impact on gross income from seed potato production due to the increased experience. The percent of the producer's net farm income from seed potatoes was expected to have a positive impact due to the greater attention given seed potato production as its importance increased. The generation of the seed was expected to have a negative impact due to the youngest generation usually perceived by producers to have the highest potential gross income and the fact that the variable was scored from the youngest to oldest. The reasons for killing the vine (and the score given that reason) were (1) normal plant maturity, (2) maximum yield potential, (3) potential for non certification, and (4) other. The reason for the vine kill was expected to have a negative impact due to the higher scored reasons being a sign of greater stress or danger of non certification of the seed (which could have a very negative impact on price). The use of a crop border was expected to have a positive effect due to controlling the level of PVY infection. The use of mineral or crop oils, the levels of fungicide and fertilizer expenses, and the use of irrigation were excluded from the analysis due to high correlations among these variables and the resulting statistical problems.

The results show mixed results on expectations and significance (Table 3). Years of farming had a significant but unexpected negative effect. The percent of net farm income did not have a significant effect. Seed generation had the expected significant effect of older generations not having as high a value. The reason for vine kill had the expected significant negative effect. The use of the crop border had the expected significant positive effect.

Table 3. Importance of explanatory variables in explaining differences in gross income per acre.

	Coefficient Estimate
Intercept	4252.4
Years farming	-320.8*
Percent of net farm income	-294.6
Seed generation	-240.5*
Reason for vine kill	-149.9*
Use of crop border	1438.6**
$R^2 = 0.70$ Adj. $R^2 = 0.68$ *Significant at p<=0.10 **Significant at p<=0.01	

While these estimates show the significance of using a crop border for seed potatoes, they should be interpreted with caution. The correlation of the use of the crop borders with variables such as expenditures on fertilizer and fungicides, the days for growing between planting and vine kill, the use of a mineral or crop oil for PVY control, and the use of irrigation suggest that any of these variables may reflect a more intensive management level than the name and intent of the variable implies. Further research is underway to separate the impact of these variables and to provide a better picture of the importance and value of using crop borders.

CONCLUDING COMMENTS

The increasing problems caused by PVY have created a need to search for a way to manage this disease. Although the use of crop borders (including soybean) to protect seed potatoes from PVY spread had been adopted by some producers, the recent emergence of

soybean aphid as a major pest throughout the Midwest has caused some producers to question the advisability of continuing to use soybean as a crop border. The seed potato producers surveyed in Northwestern Minnesota and Eastern North Dakota have shown crop borders continue to have value as management tool for PVY in seed lots. Even though the number of responses is low, the 23 who did respond represent 25% of the population of seed producers, not just 25% of those sampled from a larger population.

Of the 23 producers who responded, 5 said they had used crop borders in 2004. Nine producers said they had tried using crop borders in the past but had quit using them. These producers entered 152 seed lots into state seed certification programs and reported detailed information on 108 lots.

Even with the small number of responses, the impact and value of using a crop border can be seen easily. The producers sent 89 seed lots in for the winter test and reported that 74% passed the PVY test. When divided between those lots planted with a crop border and those that did not, the importance of using crop borders to protect seed potatoes cannot be dismissed since the percent that passed the winter test having used crop borders (97%) was significantly different that the percent that passed when a crop border was not used (54%). The value of crop borders for management of PVY can also be seen in the significant and positive impact of using a crop border in the regression analysis of the factors explaining gross revenue from seed production.

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