**Impacts of Soybean Vein Necrosis Disease on Delaware Soybeans**
***Final report for 2015 Season***

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## Introduction

In 2011, a new virus causing Soybean Vein Necrosis disease (SVNd) was identified in Maryland and Delaware soybean fields. Soybean Vein Necrosis Virus is acquired by Soybean thrips during the first two larval stages and transmitted in a persistent, propagative manner. Symptoms of SVNd include vein clearing or necrosis, which can spread over the entire foliar surface over time. Increased SVNd has been associated with reduced grain quality in Midwestern soybean production regions; however, the significance of SVNd on Mid-Atlantic soybean production remains unclear.

There were two main **objectives** to the 2015 DSB project on SVNd:

1. Document SVNd occurrence and severity in Delaware soybeans planted in full and double crop production systems for a second consecutive season
2. Examine the effects of SVNd on soybean yield using replicated, small plot studies

To address these objectives, a survey, predominantly funded by USDA NIFA, and small plot research studies funded by DSB were conducted in Delaware during the 2015 growing season.

## Methods

*Survey*

In 2015, we surveyed 30 full season and 20 double crop fields in Delaware. Fields were each surveyed twice to target early (vegetative or early reproductive) and late (mid-to late pod fill) stages in development (**Figure 1**). Within each field, twenty sites consisting of 3 row feet were haphazardly selected and assessed for the presence of plants with SVNd. Symptomatic

trifoliates were collected, placed on ice, and shipped overnight for confirmation of the virus through Enzyme Linked Immunosorbant Assays (Agdia, Inc.). Data were analyzed using repeated measures ANOVA (JMP 12.0). DSB funds were used for confirmation of SVNV through Agdia, as explained in the initial proposal.

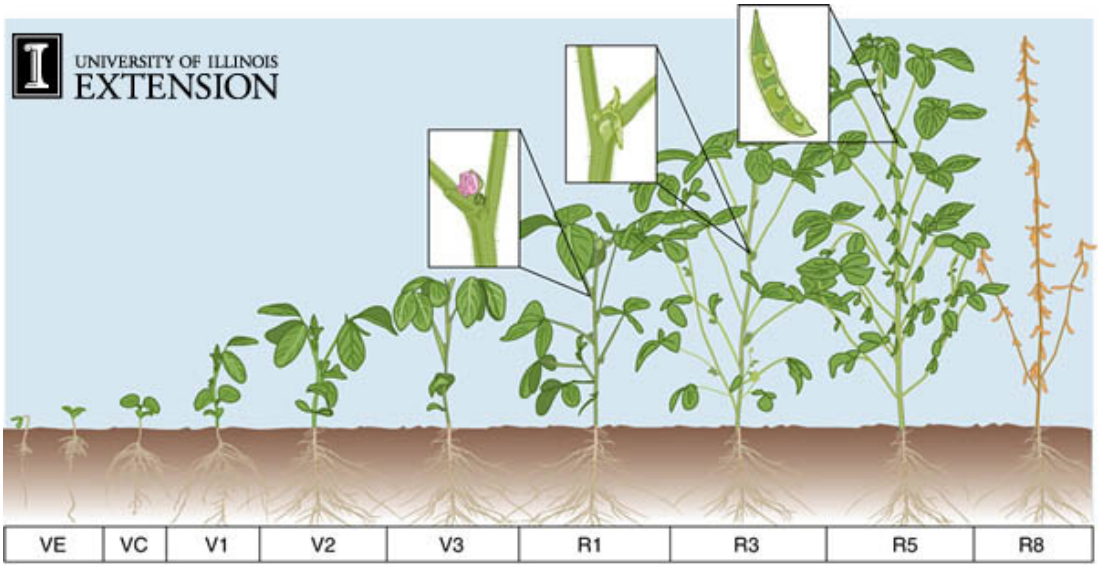


**Figure 1.** The stages of soybean growth and development. A plant at R6 would have at least one green pod on the upper four nodes filled to capacity.

*Trial 1 Effects of Thrips on SVNd and Yield*

Two trials were conducted to examine the impact of thrips numbers on SVNd and yield. The first trial was planted as full season and the second as double crop. Thrips numbers were manipulated through application of a neonicotinoid seed treatment and sequential foliar insecticide applications. The design was a randomized complete block with six reps per treatment. Treatments included: 1) untreated control, 2) neonicotinoid (Gaucho 2 oz./hundred weight) seed treatment (s), 3) S + V5 foliar application of spinosad (Blackhawk; 2 oz./A); 4) S+V5 + R1, 5) S+V5 + R1 + R3, and 6) S + V5 + R1 + R3 + R5. Plots were 10 ft. x 23 ft., with soybean cultivar SS 3914NS R2 planted on 30’ rows at a target population of 171,000 plants / A. Treatments were applied to plots at 40 PSI with a $CO_2$ pressurized backpack sprayer. Blackhawk was chosen as it has been shown to have good thrips activity in other systems. Thrips were

monitored every 7-14 days until a week after R5. At R6, SVNd severity was determined from 10 plants at the center of each plot. Twenty trifoliates were haphazardly selected from the upper 1/3 of the canopy and rated for percent foliar severity. Disease index was calculated using the formula index = (Incidence x severity) x 100. Plots were harvested and yields adjusted to 13% moisture. Virus was confirmed in symptomatic tissue by Agdia, Inc. Thrips data were analyzed using repeated measures ANOVA. Yield and total thrips data were analyzed using a random mixed model analysis of variance (JMP 12.0).

*Trial 2 Effects of variety and planting date on SVNd*

A third study was conducted due to serendipity, as SVNd was severely and evenly distributed in one of the UMD soybean variety trials. The 2015 UMD soybean variety trial was used to assess the impacts of variety and cropping system on SVNd severity and yield. All cultivars were planted in a full season and double crop production system at the Wye Research and Education center located in Queenstown, MD in a random complete block design with three reps per variety. Ten cultivars were selected from the variety trials based on arbitrary categorization to symptom expression level (low, medium, high). SVNd index was calculated as described in Trial 1 at R6. Plots were harvested and yields adjusted to 13% moisture. Data were analyzed using a random mixed model analysis of variance (JMP 12.0).

## Results

*Survey*

Survey results indicated that 72% of fields had detectable levels of disease by R5-R6, with 69% of full season and 93% of double crop fields affected. The within field severity ranged from 41% to 53% in full season vs double crop fields, respectively (**Table 1**). Statistical analyses indicated significant effects of evaluation time and cropping system on SVNd severity [Cropping System x Stage at Rating P ($F$) = 0.014]. SVNd developed earlier and to a greater degree in double crop soybeans compared to full season soybeans (**Figure 2**). In the full season fields, SVNd incidence at the reproductive stage was similar to the vegetative stage in double crop systems. This is similar to what was observed in the 2014 SVNV survey.

**Table 1**. Overall survey data showing indicating the location, cropping system, as well as overall levels of symptomatic plants in Delaware, 2015.

| Cropping system | County (# fields) | Fields with SVNd | Average Within Field Incidence[y] |
|---|---|---|---|
| Full Season | Newcastle (8) | 75% | 38% |
| | Kent (12) | 82% | 39% |
| | Sussex (10) | 50% | 45% |
| Double Crop | Newcastle (9) | 100% | 76% |
| | Kent (6) | 100% | 50% |
| | Sussex (5) | 80% | 34% |

[Y] Incidence is the percent of infected plants within an infected field

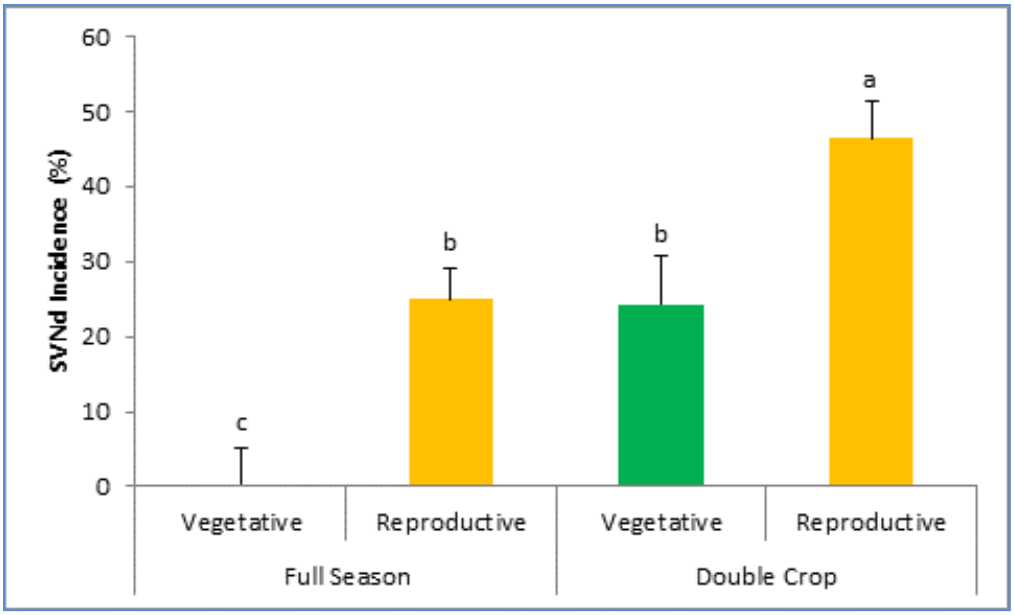


**Figure 2.** The effects of stage at rating and cropping system on SVNd incidence. Statistical analysis indicated that SVNd incidence was significantly impacted by the cropping system and that infection started earlier in double crop systems. Different letters indicate significant differences using Fisher's Protected LSD ($\alpha = 0.05$).

*Trial 1- Effects of Thrips on SVNd and Yield*

Unfortunately technical issues prevented us from utilizing data from the full season study. . In the double crop planting, insecticide treatments significantly reduced thrips up to seven days after treatment on three of the six assessment dates [Time x Treatment; P(*F*) <0.0001] . Plants receiving three or four foliar insecticide applications had significantly lower total numbers of thrips than other treatments (**Table 2**). However, thrips reduction did not impact SVNd index or yield (**Table 2**). Overall, SVNd levels for this trial were very low.

**Table 2**. Effects of sequential applications of Blackhawk insecticide (2 oz./A) and seed Gaucho treatment on thrips numbers, SVNd severity, and yield.

| | No. Thrips per 20 Leaflets | | | | | | Total Thrips | SVNd Index | Yield (bu/A) |
|---|---|---|---|---|---|---|---|---|---|
| **Treatment** | **3-Aug** | **10-Aug** | **17-Aug** | **25-Aug** | **11-Sep** | **15-Sep** | | | |
| *control* [x] | 3 | 12 a[y] | 7 | 26 | 22 a | 10 ab | 80 a | 0.035 | 33 |
| *Seed treatment (S)* | 5 | 11 a | 6 | 24 | 15 bc | 11 a | 71 ab | 0.069 | 36 |
| *S+V4* | 5 | 6 b | 9 | 28 | 15 bcd | 9 abc | 72 ab | 0.037 | 35 |
| *S+V4+R1* | 5 | 5 bc | 7 | 22 | 19 ab | 9 ab | 66 b | 0.051 | 36 |
| *S+V4+R1+R3* | 3 | 2 c | 6 | 23 | 13 cd | 7 bc | 54 c | 0.055 | 35 |
| *S+V4+R1+R3+R5* | 5 | 6 bc | 6 | 20 | 10 d | 6 c | 52 c | 0.068 | 35 |
| P(*F*) | NS | <0.0001 | NS | NS | <0.001 | 0.028 | <0.001 | NS | NS |

[x]Planted on 7/15/2015; Foliar applications of Blackhawk (2 oz. /A) occurred on 8/6, 8/18. 8/27, and 9/8 2015. [y]Treatment means not sharing the same letter are significantly different using Fishers LSD ($\alpha$=0.05)

*Trial 2 Effects of variety and planting date on SVNd*

Overall, full season beans out-yielded double crop beans (78.8 vs 56.7 bu /A). SVNd index was 250% greater in double crop beans when compared to full season beans (5.5 vs 2.2%). Variety significantly impacted both yield and SVNd index within both systems [Variety P(*F*) <0.0001]. SVNd index was lowest for cultivar 74B42R in both cropping systems (**Figure 3A**). For a given cultivar, SVNd index was greater for the double crop system when compared to the corresponding full season system in seven of the ten cultivars rated (**Figure 3B**). Across all varieties and systems we detected a moderate, but significant negative linear relationship between log SVNd index and yield [P(*F*) <0.0001; **Figure 4**].

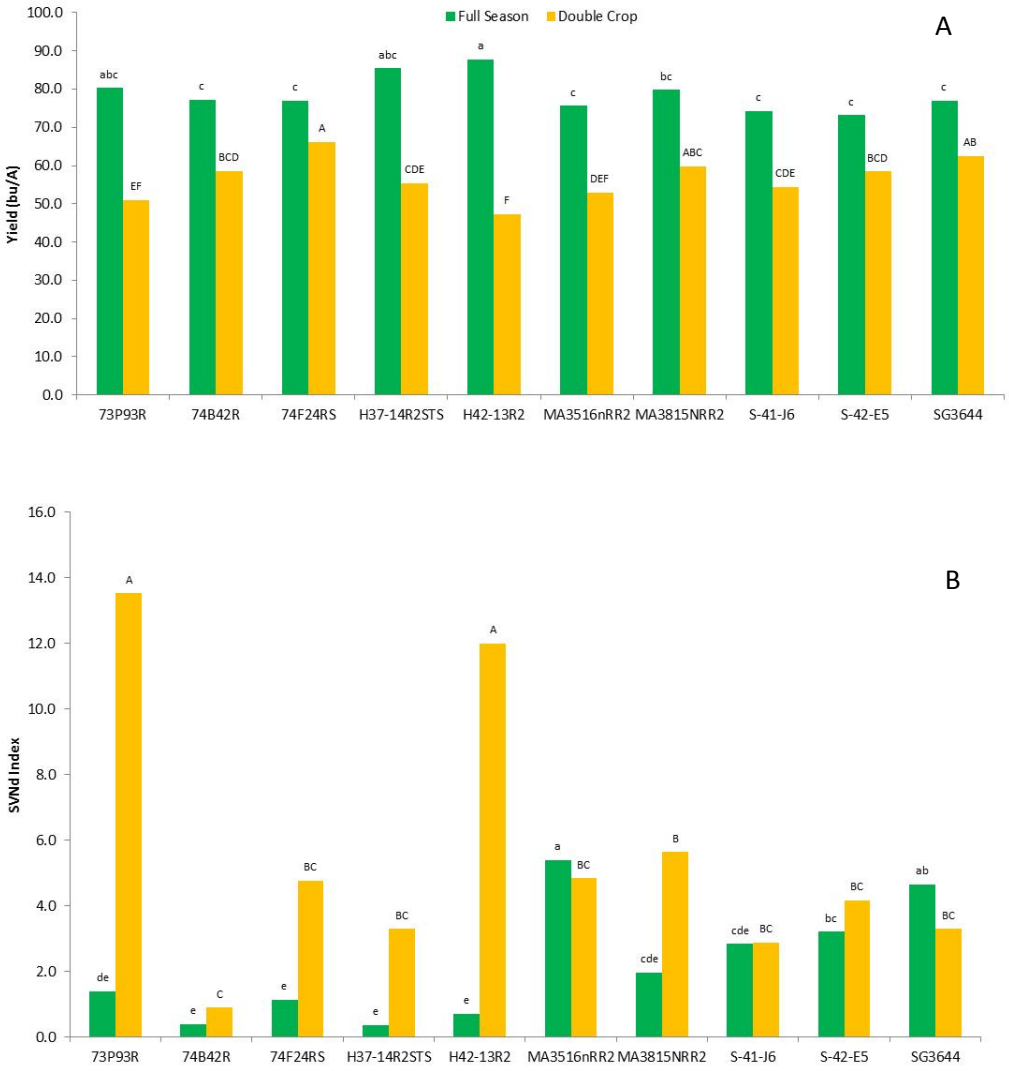


**Figure 3A-B**. Yield and SVNd Response of ten soybean cultivars planted in full season and double cropping systems in 2015. A) Yields significantly differed between cultivars, with full season yielding better than double crop, as expected. B) Cultivars significantly differed in SVNd response. In general, SVNd was lower for most cultivars in full season plantings when compared to double crop plantings. The cultivar 74B429 contained significantly less SVNd in both full season and double crop plantings. Treatment means within the same capitalization scheme not sharing the same letter are significantly different using Fishers LSD ($\alpha$=0.05).

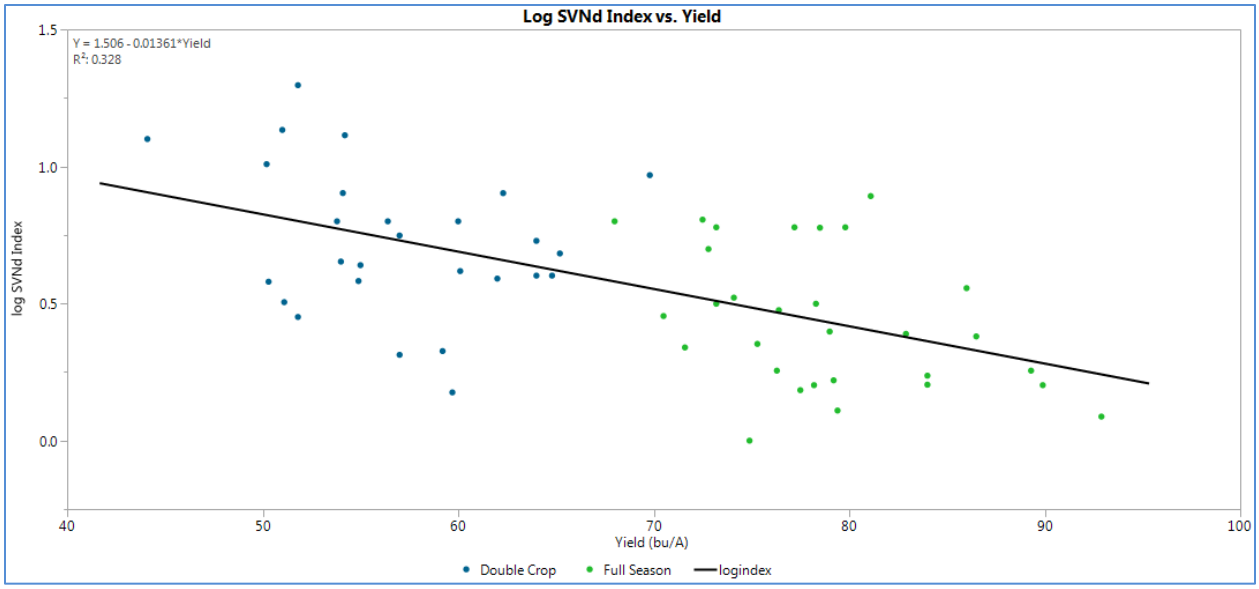


**Figure 4**. A significant negative, linear relationship was detected between log SVNd index and yield for ten soybean varieties planted in full season and double crop systems.

**Discussion**

For the second consecutive season, we have documented SVNd to be a prevalent viral disease in both full season and double crop soybeans grown in Delaware. Survey and research plot trials support the hypothesis that double crop soybeans may be impacted by SVNd to a greater degree than full season beans. Double crop beans are planted later in the growing season, which may result in exposure to greater numbers of thrips carrying SVNV and therefore increased SVNd earlier in plant development. Our results show that soybean cultivars may vary significantly in disease expression. Of the ten cultivars examined, foliar disease expression was consistently and significantly lower in cultivar 74B42R when compared to other tested cultivars. Our data showed a moderate, but significant relationship between logarithmic relationship between SVNd index and yield. To our knowledge, this is the first report of a negative yield impact associated with SVNd. It must be noted that the correlation between index and yield was conducted across a range of cultivars with different SVNd expression levels. Variation in response to SVNd by a particular variety can occur as a result of variety level responses. Thus, the correlation observed here may be stronger if expression patterns of various varieties are taken into account. Unfortunately, such analysis is beyond the scope of the present study but may be considered in future years.

Preliminary data from replicated trials conducted across the United States indicate that SVNd symptomology may be associated with changes in bean quality, particularly oil (Paper under review). Although beans were harvested for quality analysis in Trial 2, data are not expected until 2016. Shifts in oil content may be important to growers planting high oleic soybeans because the purchase of these beans and associated premiums may not be realized if oleic oil content falls below a stated level. A better understanding of the responses of high oleic soybeans to SVNd may be an appropriate avenue to explore in the near future.

Although insecticides did reduce thrips numbers, the reduction was not sufficient to reduce SVNd. Great effort was taken to ensure adequate coverage of the foliage with Blackhawk insecticide; however, we were able to detect living thrips on foliage, regardless of when tissue was assessed in relation to treatment application. Edge effect, plant growth in between applications, and coverage may have contributed to these results. It is important to remember that the virus is transmitted persistently (throughout the lifespan of the insect after the acquisition phase) and sufficient disease transmission may be achieved in the presence of relatively low numbers of infected insects. Untreated areas can serve as reservoirs allowing reestablishment of the insect. Trial 2 was bordered by woods to facilitate infestation by thrips. Although this may have helped establish SVDd, it also may have provided a means for thrips to rapidly reestablish on untreated tissues and plots following a treatment. Regardless, the purpose of Trial 2 was not to test the effectiveness of Blackhawk or seed treatment insecticides for managing thrips. Rather, the goal was to generate a range of thrips pressure that would create a gradient of SVNd symptoms within a single soybean variety. We were unable to achieve this goal in Trial 2. The role of insecticides for thrips / SVNd management remains unclear.

Our results indicate that SVNd is prevalent across Delaware and that it may be associated with reductions in yield in some instances. Although we do not currently have any recommendations for management because the factors associated with yield loss need to be better defined, planting date and variety will likely play a significant role in managing SVNd if the need arises in the future. The methods for rating described in this report are simple, repeatable, and should allow breeders, variety trial coordinators, plant pathologists, and other industry to assess varieties for SVNd and provide these data to growers in technical and extension publications.

**Future Directions**

There are many aspects of SVNd that we do not understand. For example, we do not know which species of thrips may transmit the virus in soybeans grown in Delaware. Research indicates that soybean thrips are a vector, but are there other thrips in our region that may contribute to the disease? Where are these thrips overwintering? Although there are preliminary data on host range in the literature, we do not know what weeds or cultivated species important to Delaware may serve as alternate hosts for the virus. A better understanding of these factors will improve our knowledge of this soybean virus and its potential management in future years.