Final Report for: Compile Estimates of Soybean Yield Suppression by Diseases in the U.S. During 2013 (Project no. 1420-532-5637)

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Objectives: This project has a short-term and a long-term objective. The short-term objective was to determine which soybean diseases were most important for yield reduction in the U.S. in the 2013 season. The long-term objective was to evaluate the estimated yield loss data collected from 1996 to 201**3** to identify trends and relationships with other factors.

Methodology: University plant pathologists or other university extension specialists from 28 different states were contacted and asked to estimate percentage soybean yield losses caused by different soybean pathogens. These percentage estimates were converted to estimated bushel losses based on USDA-NASS production estimates for each state.

Data collected from 1996 to 2013 were categorized using quartile functions into either a 2- or 4-category system (based on exploratory analysis of loss profiles).

Two category: 1 = lower 50%; 2 = upper 50%

Four category: 1 = lower 25%; 2 = 25-50%; 3 = 50-75%; 4 = upper 75%

A systematic approach was used for analyses. The definition of injury profiles was using cluster analysis of diseases based on contingency tables. The number of clusters was defined as 4 based on Ward criterion and Euclidean distance. Chi-square analyses were conducted to examine each disease against injury profile. Multiple correspondence analysis was conducted to identify patterns of diseases in terms of the injury profiles. Further chi-square analyses were conducted to examine which factors, such as year, region or state, in terms of injury profiles, and from which correspondence analysis was used to determine the relative orientation of these factors. Analyses were conducted using a combination of R (Version 3.1.0, “Spring Dance”, [www.r-project.org](http://www.r-project.org)), SAS (Version 9.2, SAS Institute, Inc.), and SYSTAT (Systat Software, Inc.).

Results: The total soybean yield reduction in the U.S. due to diseases for 201**3** was estimated to be over 406 million bushels (Table 1). The top ten diseases/pathogens that caused the most yield reductions (in order) were: soybean cyst nematode, seedling diseases, charcoal rot, Phytophthora root rot, sudden death syndrome, Septoria brown spot, frogeye leaf spot, Sclerotinia stem rot (a.k.a. white mold), brown stem rot, and root knot nematode.

The top ten diseases varied somewhat when state estimates were categorized into “northern” and “southern” states. For the northern states, which included Illinois, Indiana, Iowa, Kansas, Michigan, Minnesota, Nebraska, North Dakota, Ohio, Pennsylvania, South Dakota, and Wisconsin, the top ten diseases/pathogens were (in order): soybean cyst nematode, seedling diseases, charcoal rot, Phytophthora root rot, Septoria brown spot, sudden death syndrome, Sclerotinia stem rot (white mold), brown stem rot, virus diseases, and stem canker. For the southern states, which included Alabama, Arkansas, Delaware, Florida, Georgia, Kentucky, Louisiana, Maryland, Mississippi, Missouri, North Carolina, Oklahoma, South Carolina, Tennessee, Texas, and Virginia, the top ten diseases/pathogens were (in order): soybean rust, “other” nematodes, bacterial diseases, brown stem rot, Phomopsis seed decay, seedling diseases, southern blight, pod and stem blight, stem canker, and Cercospora blight/purple seed stain.“Other nematodes” that were recorded for the southern states were stubby root, sting, Columbia lance, and reniform.

For the analysis of the long-term data collected between 1996 and 2013, a few key points can be summarized:

* Diseases and pathogens grouped into different clusters (Fig. 1):
  1. Cluster A = corresponded to diseases or pathogens that caused losses classified in the lowest categories
  2. Cluster B = corresponded to diseases that caused a range of losses, but one where several of the diseases of importance correlated with region equal to the South
  3. Cluster C = this cluster corresponded to many diseases that caused large losses in the northern region
  4. Cluster D = corresponded to some diseases of less importance, although there were several of the most important diseases, including, Phytophthora root and stem rot, and soybean cyst nematode
* Regionally, the south grouped to disease clusters A and B, while in the north groups C and D were most prevalent (Table 2)
* Year-to-year variability (Fig. 2) was noted, with the years prior to 2000 grouping mostly with cluster A, years 2001-2003 with cluster D, and from 2004 onwards correlated cluster C. Cluster B did not correlated specifically with year, but this can be partly explained by the idea that this cluster correlated well with the south, and realistically in any given year, greatest losses are observed in the north.
* States (Fig. 3) were mostly grouped into one of the disease clusters, nonetheless several states, Michigan, Mississippi, Oklahoma, Tennessee, Texas, and Virginia, did not correlate to any given cluster. In states such as Oklahoma and Texas, one explanation may be that in recent years, very dry conditions have limited the effect of disease, whereas for a state such as Michigan, specific diseases such as Sudden death syndrome or white mold can have pronounced effects but are very sporadic in nature in comparison with other states.
* States that were grouped into one of the four clusters correlated well with the specific cluster type indicated previously.
  1. Cluster A: Alabama, Maryland, Georgia, Delaware
  2. Cluster B: South Carolina, Louisiana, North Carolina, Arkansas
  3. Cluster C: Wisconsin, Illinois, South Dakota, Kentucky, Indiana, Nebraska
  4. Cluster D: North Dakota, Ohio, Minnesota, Kansas, Missouri, Iowa, Pennsylvania

Publications:

Esker, P. D., Koenning, S. R., Wrather, J. A., and Bradley, C. A. 2014. Patterns of disease loss in soybean – exploration of the soybean yield loss database in the United States. Phytopathology 104 (Suppl. 3):S3 38 (Abstract).

Soybean yield loss estimates due to diseases in the U.S. online database. Available at: <http://extension.cropsci.illinois.edu/table_test.php>.

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Table 1. Estimated soybean yield losses due to diseases/pathogens from 28 different states in 2013.

|  |  |
| --- | --- |
| **Disease** | **(Bu loss)** |
| Soybean Cyst Nematode | 133,115,238 |
| Seedling Diseases due to Rhizoctonia, Pythium, Fusarium, and/or Phomopsis | 44,317,103 |
| Charcoal Rot | 39,169,879 |
| Phytophthora Root & Stem Rot | 30,203,419 |
| Sudden Death Syndrome | 28,554,330 |
| Septoria Brown Spot | 21,809,762 |
| Frogeye Leaf Spot (Cercospora sojina) | 17,037,789 |
| Sclerotinia stem rot (White Mold) | 16,115,617 |
| Brown Stem Rot | 10,468,833 |
| Root Knot Nematode | 10,184,137 |
| Pod and Stem Blight | 9,520,772 |
| Virus Diseases (please list) | 8,821,787 |
| Fusarium Wilt & Root Rot | 8,749,832 |
| Stem Canker | 6,762,166 |
| Diaporthe/Phomopsis complex (seed rot) | 5,892,112 |
| Purple Stain or Cercospora blight (Cercospora kikuchii) | 4,960,492 |
| Anthracnose | 2,821,429 |
| Other Nematodes (please list) | 2,422,212 |
| Other Diseases (please list) | 1,490,652 |
| Downy Mildew | 1,142,923 |
| Soybean Rust | 1,056,574 |
| Bacterial Diseases | 861,480 |
| Rhizoctonia Aerial Blight | 470,078 |
| Southern Blight (Sclerotium rolfsii) | 100,572 |
| **Total** | **406,049,180** |

Table 2. Chi-square analysis1 of disease cluster versus region.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Disease cluster | | | |
| Region | A | B | C | D |
| North | 32 | 7 | 113 | 82 |
| South | 118 | 110 | 40 | 0 |

1 Χ2 = 255.7, 3 df, P < 0.0001



Fig. 1. Multiple correspondence analysis of disease clusters with individual disease classes. The first twos axes explained 13.86 and 13.01% of the inertia, respectively.



Fig. 2. Correspondence analysis of disease clusters (A, B, C, D) with year. The first two dimensions explained 82% of the accumulated inertia.



Fig. 3. Correspondence analysis of disease clusters (A, B, C, D) with state. The first two dimensions explained 73% of the accumulated inertia.