

*2009  
National  
Cotton  
Fusarium  
Wilt  
Report*



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RICHARD GUTHRIE, DIRECTOR  
AUBURN UNIVERSITY  
AUBURN, AL 36849*

THIS REPORT IS A JOINT CONTRIBUTION BETWEEN  
USDA-ARS, CROP SCIENCE RESEARCH LABORATORY, MISSISSIPPI STATE UNIVERSITY, MISSISSIPPI, AND  
THE ALABAMA AGRICULTURAL EXPERIMENT STATION, AUBURN UNIVERSITY, ALABAMA

## 2009 NATIONAL COTTON FUSARIUM WILT REPORT

**Kathryn M. Glass<sup>1</sup>, William S. Gazaway<sup>2</sup>, Katheryn Lawrence<sup>4</sup>, and Edzard van Santen<sup>3</sup>**

<sup>1,3</sup> Advisor III, Natl Res. Programs and Professor, respectively, Dept. of Agronomy and Soils, Auburn University, AL 36849

<sup>2</sup> Professor Emeritus and Extension Pathologist/Nematologist/Associate Professor, Dept. of Entomology and Plant Pathology, Auburn University, 36849

Cotton cultivars and elite breeding lines submitted by 10 cooperators were evaluated for Fusarium wilt resistance under field conditions at the E. V. Smith Research Center, Plant Breeding Unit, Tallahassee, Alabama. These entries were grown on an Independence loamy fine sand highly infested with the Fusarium wilt fungus (*Fusarium oxysporum*) Schlecht. f. *vasinfectum* [Atk.] (Snyd. & Hans.) and southern root-knot nematodes (*Meloidogyne incognita*).

In 2008, a soil analysis for nematodes revealed that southern root-knot (*Meloidogyne incognita*) was the predominant nematode species in the test plots. The North Fusarium wilt field plot contains a population of *M. incognita* that ranges from 155 to 1546 J2 per 150 cc of soil with an mean of 711 J2. The populations in the South Fusarium wilt field are lower with a range from 77 to 1004 J2 per 150 cc of soil and a mean population of 378. Other nematode genera present are stubby root (*Trichodorus* sp.) and stunt (*Tylenchorhynchus* sp.). Root-knot nematodes, however, appear to be causing the major damage to cotton in the Fusarium Wilt Test as indicated by the high galling indices found on the roots of all cotton lines. The root-knot nematode population throughout the entire test area, i.e., even the areas with the lowest root-knot nematode populations, is more than sufficient to cause a high incidence of Fusarium wilt.

Cotton lines submitted to the Fusarium Wilt Trial were examined to determine their response to both pathogens the root-knot nematode (*Meloidogyne incognita* race 3) and *Fusarium oxysporium* f. sp. *vasinfectum* (Table 2, page 10). The field has a long history of root-knot nematode infestation. Plots consisted of 1 row, 20 ft long, with 36 in row spacing and were planted in a randomized complete block design with four replications. All plots were maintained throughout the season using standard herbicide, insecticide, and fertility production practices as recommended by the Alabama Cooperative Extension System. Three plants per plot were removed on July 22. The fresh root weights were recorded and nematodes were extracted from the root system by shaking in 0.6% NaOCl counted under the inverted microscope. Fusarium was aseptically isolated on acidified potato dextrose media from systematic plants removed July. Data was statistically analyzed by GLM and means, compared using Fisher's protected least significant difference test. Monthly average maximum temperatures from June to October were 90.1, 86.7, 87.1, 81.2, and 70.1 °F; average minimum temperatures of 66.7, 66.4, 66.9, 64.6 and 50.2 °F. Total rainfall amounts from June to October were 1.1, 5.5, 4.2, 4.6, and 6.5 in. The total rainfall for the growing season was 21.9 in.

The 2009 season, environmentally, was conducive for the root-knot nematode and Fusarium wilt pathogens. The numbers of root-knot nematodes increase in all the cotton samples submitted. The standard susceptible cotton, Rowden, averaged 1150 root-knot J2 and eggs per gram of root while the M-315 resistant cotton supported 460 root-knot J2 and eggs per gram of root. Lonren 1 which was released as a reniform nematode resistant genotype, supported root-knot nematode numbers in between the susceptible Rowden and resistant M-315. Nematode juveniles and eggs extracted from the root systems for all the submission ranged from a high of 12,483 in PHY-MM1 to a low 242 in DJ-5. The reproductive potential observed varied widely from highly susceptible (PHY-MM1, PHY-FB2, PHY-FB7, FB-5, CW-1, FB-2, PHY-MM2) to low susceptibilities (DF-5, Dj-2, PHY-MM3, CW-5) depending on the cotton submission. Re-isolation of the Fusarium wilt fungus *Fusarium oxysporum* f. sp. *vasinfectum* was conducted to confirm the presence of the disease pathogen. The fungal pathogen was not found in the resistant M -315 cotton but was readily isolated from Rowden and Lonren 1. Over all the cotton submissions planted in 2009, 76.25% were colonized by *F. oxysporum* f. sp. *vasinfectum*.

Entries were planted in single 20-foot rows on 36-inch centers, separated by 6-foot alleys. Four replications of the test entries and checks were evaluated in a randomized complete block design with a split plot restriction on randomization. The set of eight test cultivars submitted by a cooperator was always evaluated as a group together with two control plots within each replicate. Both susceptible (Rowden) and resistant (M-315) cultivars were included as check subplots in the two center rows of each main plot (Fig. 1).

Lack of moisture delayed planting on May 20. Initial plant counts were made on June 26. Wilted plants were counted and removed on July 14, July 29, August 12, and August 26. The remaining live plants were counted and recorded on September 17. Total percent wilted plants were then determined and mean wilting for a given entry calculated.

The average % wilted plants for the susceptible check **Rowden** was 75%, with a range from 23 to 97% on an individual plot basis (Fig. 1). Wilt development was quite uniform in all blocks with rep averages ranging from 17 to 19%. The resistant check **M-315** had an average of 2% wilted plants, with a range of 0 to 13%. **Critical evaluations of breeding lines should be made relative to the Rowden check listed at the bottom of each group.**

**Fig. 1.** Field plot layout and % wilt for control plot of Rowden (susceptible) and M-315 (resistant). Distances (ft) from the SE corner of the trial are given in the left hand column and the bottom row.

|     |        |        |        |        |        |        |        |        |
|-----|--------|--------|--------|--------|--------|--------|--------|--------|
| NS  | 80     | 2      | 75     | 2      | 88     | 13     | 76     | 8      |
| 234 | Rowden | M-315  | Rowden | M-315  | Rowden | M-315  | Rowden | M-315  |
|     | 90     | 2      | 86     | 1      | 1      | 88     | 73     | 8      |
| 208 | Rowden | M-315  | Rowden | M-315  | M-315  | Rowden | Rowden | M-315  |
|     | 4      | 83     | 0      | 49     | 0      | 80     | 69     | 3      |
| 182 | M-315  | Rowden | M-315  | Rowden | M-315  | Rowden | Rowden | M-315  |
|     | 7      | 84     | 0      | 49     | 74     | 0      | 0      | 74     |
| 156 | M-315  | Rowden | M-315  | Rowden | Rowden | M-315  | M-315  | Rowden |
|     | 6      | 88     | 1      | 81     | 49     | 2      | 84     | 3      |
| 130 | M-315  | Rowden | M-315  | Rowden | Rowden | M-315  | Rowden | M-315  |
|     | 4      | 85     | 2      | 97     | 96     | 0      | 0      | 68     |
| 104 | M-315  | Rowden | M-315  | Rowden | Rowden | M-315  | M-315  | Rowden |
|     | 88     | 1      | 1      | 69     | 1      | 86     | 2      | 72     |
| 78  | Rowden | M-315  | M-315  | Rowden | M-315  | Rowden | M-315  | Rowden |
|     | 73     | 0      | 0      | 69     | 92     | 0      | 70     | 1      |
| 52  | Rowden | M-315  | M-315  | Rowden | Rowden | M-315  | Rowden | M-315  |
|     | 3      | 77     | 79     | 2      | 71     | 1      | 66     | 0      |
| 26  | M-315  | Rowden | Rowden | M-315  | Rowden | M-315  | Rowden | M-315  |
|     | 8      | 76     | 2      | 72     | 57     | 0      | 23     | 0      |
| 0   | M-315  | Rowden | M-315  | Rowden | Rowden | M-315  | Rowden | M-315  |
| EW  | 24     |        | 54     |        | 84     |        | 114    |        |

**Table 1.** Percent wilted plants for entries and check in each replicate, least squares estimate of the average, *P*-value based on Dunnett's versus the resistant check M-315, and initial average number of plants per plot.

| Entry  | Cultivar/Line | Percent wilted plants |      |      |      |      | Avg. <i>P</i> -value | Avg. no. of plants |
|--|---------------|-----------------------|------|------|------|------|----------------------|--------------------|
|  |               | Rep1                  | Rep2 | Rep3 | Rep4 | Avg. |                      |                    |
| O. Lloyd May, Delta and Pine Land Co., 381 William Gibbs Rd, Tifton, GA 31794    |               |                       |      |      |      |      |                      |                    |
| 101  | LM-1          | 12                    | 19   | 34   | 32   | 24   | 0.013                | 66                 |
| 102  | LM-2          | 15                    | 15   | 57   | 40   | 35   | 0.005                | 78                 |
| 103  | LM-3          | 6                     | 19   | 11   | 27   | 15   | 0.035                | 71                 |
| 104  | LM-4          | 27                    | 23   | 25   | 6    | 20   | 0.020                | 85                 |
| 105  | LM-5          | 5                     | 3    | 2    | 9    | 5    | 0.188                | 77                 |
| 106  | LM-6          | 19                    | 4    | 15   | 57   | 24   | 0.012                | 75                 |
| 107  | LM-7          | 5                     | 17   | 0    | 27   | 11   | 0.056                | 63                 |
| 108  | LM-8          | 21                    | 14   | 4    | 17   | 14   | 0.038                | 74                 |
|  | Rowden        | 69                    | 72   | 81   | 90   | 77   | <0.001               | 81                 |
|  | M-315         | 0                     | 2    | 1    | 2    | 1    |                      | 62                 |
| Dawn Fraser, Monsanto Company, P.O. Box 1529, Hartsville, SC 29550               |               |                       |      |      |      |      |                      |                    |
| 201  | DJ-1          | 7                     | 12   | 1    | 1    | 5    | 0.140                | 75                 |
| 202  | DJ-2          | 11                    | 15   | 10   | 17   | 13   | 0.023                | 57                 |
| 203  | DJ-3          | 33                    | 16   | 16   | 9    | 19   | 0.006                | 66                 |
| 204  | DJ-4          | 5                     | 4    | 9    | 17   | 8    | 0.061                | 76                 |
| 205  | DJ-5          | 26                    | 4    | 7    | 6    | 11   | 0.033                | 73                 |
| 206  | DJ-6          | 6                     | 1    | 2    | 17   | 7    | 0.087                | 68                 |
| 207  | DJ-7          | 8                     | 12   | 16   | 15   | 13   | 0.022                | 63                 |
| 208  | DJ-8          | 14                    | 4    | 4    | 7    | 7    | 0.087                | 72                 |
|  | Rowden        | 66                    | 92   | 74   | 73   | 76   | <0.001               | 84                 |
|  | M-315         | 0                     | 0    | 0    | 8    | 2    |                      | 68                 |
| Curtis Williams, Delta and Pine Land Co., 381 William Gibbs Rd, Tifton, GA 31794 |               |                       |      |      |      |      |                      |                    |
| 301  | CW-1          | 13                    | 7    | 1    | 0    | 4    | 0.325                | 76                 |
| 302  | CW-2          | 14                    | 40   | 10   | 14   | 19   | 0.015                | 74                 |
| 303  | CW-3          | 28                    | 12   | 33   | 29   | 26   | 0.005                | 74                 |
| 304  | CW-4          | 5                     | 10   | 14   | 8    | 9    | 0.116                | 42                 |
| 305  | CW-5          | 11                    | 42   | 16   | 30   | 25   | 0.006                | 57                 |
| 306  | CW-6          | 1                     | 11   | 25   | 1    | 9    | 0.105                | 67                 |
| 307  | CW-7          | 20                    | 2    | 19   | 6    | 12   | 0.057                | 59                 |
| 308  | CW-8          | 32                    | 14   | 14   | 23   | 20   | 0.012                | 73                 |
|  | Rowden        | 73                    | 85   | 88   | 88   | 85   | <0.001               | 73                 |
|  | M-315         | 0                     | 4    | 6    | 1    | 3    |                      | 57                 |

† The number listed in the average column is the estimate of the average wilt percentage based on a generalized linear mixed model with the binomial distribution for fixed effects. This estimate will generally be close, but may or may not be identical to the arithmetic average obtained by averaging the numbers in the columns representing the 4 reps.

Table 1. *continued*

| Entry   | Cultivar/Line | Percent wilted plants |      |      |      |      | Avg. no. of plants | P-value |
|---|---------------|-----------------------|------|------|------|------|--------------------|---------|
|   |               | Rep1                  | Rep2 | Rep3 | Rep4 | Avg. |                    |         |
| Dawn Fraser, Delta and Pine Land Co., P.O. Box 1529, Hartsville, SC 29550               |               |                       |      |      |      |      |                    |         |
| 401   | DF-1          | 10                    | 8    | 13   | 0    | 8    | 0.122              | 67      |
| 402   | DF-2          | 6                     | 5    | 4    | 0    | 4    | 0.268              | 74      |
| 403   | DF-3          | 48                    | 25   | 8    | 18   | 26   | 0.013              | 64      |
| 404   | DF-4          | 15                    | 25   | 8    | 31   | 19   | 0.027              | 67      |
| 405   | DF-5          | 9                     | 13   | 9    | 2    | 8    | 0.115              | 70      |
| 406   | DF-6          | 27                    | 1    | 43   | 26   | 26   | 0.013              | 75      |
| 407   | DF-7          | 8                     | 4    | 0    | 2    | 4    | 0.241              | 66      |
| 408   | DF-8          | 2                     | 32   | 24   | 16   | 17   | 0.036              | 46      |
|   | Rowden        | 23                    | 68   | 49   | 76   | 53   | 0.001              | 79      |
|   | M-315         | 0                     | 0    | 0    | 8    | 2    |                    | 61      |
| Frank Bordelon, PhytoGen Seed Co., LLC, P.O. Box 27, Leland, MS 38756                   |               |                       |      |      |      |      |                    |         |
| 501   | PHY-FB1       | 3                     | 4    | 5    | 3    | 3    | 0.188              | 80      |
| 502   | PHY-FB2       | 5                     | 9    | 2    | 27   | 10   | 0.024              | 84      |
| 503   | PHY-FB3       | 4                     | 11   | 12   | 4    | 8    | 0.043              | 81      |
| 504   | PHY-FB4       | 8                     | 6    | 2    | 12   | 7    | 0.066              | 69      |
| 505   | PHY-FB5       | 5                     | 1    | 6    | 3    | 4    | 0.158              | 70      |
| 506   | PHY-FB6       | 15                    | 15   | 18   | 6    | 13   | 0.013              | 77      |
| 507   | PHY-FB7       | 3                     | 0    | 0    | 3    | 1    | 0.440              | 75      |
| 508   | PHY-FB8       | 16                    | 3    | 4    | 14   | 9    | 0.035              | 66      |
|   | Rowden        | 71                    | 96   | 49   | 75   | 73   | <0.001             | 88      |
|   | M-315         | 1                     | 0    | 2    | 2    | 1    |                    | 66      |
| Daryl Bowman, University of North Carolina, 3709 Hillsborough Street, Raleigh, NC 27607 |               |                       |      |      |      |      |                    |         |
| 601   | NC1           | 0                     | 0    | 4    | 3    | 2    | 0.497              | 70      |
| 602   | NC2           | 5                     | 0    | 6    | 5    | 4    | 0.260              | 73      |
| 603   | NC3           | 6                     | 5    | 19   | 4    | 8    | 0.096              | 61      |
| 604   | NC4           | 13                    | 12   | 32   | 5    | 15   | 0.028              | 77      |
| 605   | NC5           | 16                    | 3    | 20   | 3    | 10   | 0.070              | 78      |
| David Weaver, Auburn University, 201 Funchess Hall, Auburn, AL 36849-5415               |               |                       |      |      |      |      |                    |         |
| 606   | AU 1065       | 43                    | 5    | 10   | 4    | 14   | 0.033              | 78      |
| 607   | AU 1327       | 11                    | 10   | 4    | 0    | 6    | 0.166              | 59      |
| 608   | AU 3202       | 43                    | 19   | 5    | 3    | 15   | 0.030              | 62      |
|   | Rowden        | 77                    | 97   | 83   | 80   | 85   | <0.001             | 86      |
|   | M-315         | 3                     | 2    | 4    | 0    | 2    |                    | 60      |

**Table 1.** *continued*

| Entry  | Cultivar/Line | Percent wilted plants |      |      |      |      | P-value | Avg. no.<br>of plants |
|--|---------------|-----------------------|------|------|------|------|---------|-----------------------|
|  |               | Rep1                  | Rep2 | Rep3 | Rep4 | Avg. |         |                       |
| Mustafa McPherson, PhytoGen Seed Co., LLC, P.O. Box 27, Leland, MS 38756 |               |                       |      |      |      |      |         |                       |
| 701  | PHY- MM1      | 5                     | 0    | 0    | 0    | 1    | 0.834   | 68                    |
| 702  | PHY- MM2      | 22                    | 35   | 34   | 49   | 35   | <0.001  | 88                    |
| 703  | PHY- MM3      | 0                     | 1    | 1    | 0    | 1    | 0.886   | 75                    |
| 704  | PHY- MM4      | 0                     | 0    | 3    | 11   | 4    | 0.571   | 74                    |
| 705  | PHY- MM5      | 4                     | 1    | 3    | 2    | 3    | 0.698   | 69                    |
| 706  | PHY- MM6      | 20                    | 7    | 13   | 10   | 13   | 0.045   | 78                    |
| 707  | PHY- MM7      | 19                    | 37   | 37   | 59   | 38   | <0.001  | 85                    |
| 708  | PHY- MM8      | 16                    | 2    | 0    | 1    | 5    | 0.444   | 78                    |
|  | Rowden        | 76                    | 69   | 84   | 86   | 79   | <0.001  | 96                    |
|  | M-315         | 8                     | 1    | 7    | 1    | 4    |         | 55                    |
| Fred Bourland, University of Arkansas, P.O. Box 48, Keiser, AR 72351     |               |                       |      |      |      |      |         |                       |
| 801  | FB-1          | 8                     | 4    | 8    | 1    | 5    | 0.166   | 76                    |
| 802  | FB-2          | 5                     | 1    | 0    | 14   | 5    | 0.173   | 71                    |
| 803  | FB-3          | 41                    | 29   | 2    | 10   | 20   | 0.024   | 55                    |
| 804  | FB-4          | 9                     | 14   | 21   | 24   | 16   | 0.034   | 69                    |
| 805  | FB-5          | 1                     | 7    | 6    | 6    | 5    | 0.181   | 63                    |
| 806  | FB-6          | 21                    | 32   | 33   | 23   | 28   | 0.012   | 62                    |
| 807  | FB-7          | 61                    | 64   | 13   | 33   | 42   | 0.004   | 91                    |
| 808  | FB-8          | 15                    | 40   | 3    | 8    | 16   | 0.036   | 70                    |
|  | Rowden        | 72                    | 88   | 49   | 69   | 67   | 0.001   | 67                    |
|  | M-315         | 2                     | 1    | 0    | 3    | 1    |         | 54                    |
| Brent Styles, Bayer Crop Science, 4205 Williamson Road, Wilson, NC 27893 |               |                       |      |      |      |      |         |                       |
| 901  | MS-2          | 0                     | 9    | 3    | 3    | 3    | 0.539   | 58                    |
| 902  | MS-3          | 13                    | 2    | 3    | 8    | 7    | 0.267   | 12                    |
| 903  | MS-4          | 4                     | 8    | 15   | 11   | 9    | 0.136   | 24                    |
| 904  | MS-5          | 4                     | 16   | 38   | 8    | 17   | 0.016   | 27                    |
| 905  | MS-6          | 6                     | 21   | 8    | 0    | 8    | 0.115   | 81                    |
| 906  | FS-1          | 2                     | 1    | 5    | 10   | 4    | 0.417   | 88                    |
| 907  | FS-2          | 2                     | 0    | 0    | 6    | 2    | 0.771   | 91                    |
| 908  | FS-3          | 10                    | 7    | 4    | 4    | 7    | 0.213   | 72                    |
|  | Rowden        | 57                    | 86   | 84   | 88   | 79   | <0.001  | 91                    |
|  | M-315         | 0                     | 1    | 3    | 13   | 4    |         | 62                    |



**Table 1.** *continued*

| Entry   | Cultivar/Line | Percent wilted plants |      |      |      |      | Avg. no. of plants | P-value |
|---|---------------|-----------------------|------|------|------|------|--------------------|---------|
|   |               | Rep1                  | Rep2 | Rep3 | Rep4 | Avg. |                    |         |
| Brent Styles, Bayer Crop Science, 4205 Williamson Road, Wilson, NC 27893  |               |                       |      |      |      |      |                    |         |
| 1001  | TP-4          | 6                     | 4    | 2    | 5    | 4    | 0.143              | 67      |
| 1002  | TP-5          | 13                    | 1    | 1    | 3    | 4    | 0.148              | 70      |
| 1003  | TP-6          | 25                    | 21   | 21   | 20   | 22   | 0.004              | 85      |
| 1004  | TP-7          | 13                    | 0    | 1    | 0    | 3    | 0.191              | 81      |
| 1005  | MB-3          | 13                    | 32   | 1    | 13   | 15   | 0.011              | 44      |
| 1006  | SC-3          | 0                     | 14   | 0    | 13   | 7    | 0.055              | 68      |
| 1007  | TL-6          | 50                    | 48   | 32   | 49   | 45   | <0.001             | 55      |
| David Weaver, Auburn University, 201 Funchess Hall, Auburn, AL 36849-5415 |               |                       |      |      |      |      |                    |         |
| 1008  | Lonren 1      | 46                    | 20   | 32   | 42   | 36   | 0.001              | 85      |
|   | Rowden        | 79                    | 70   | 74   | 80   | 76   | <0.001             | 60      |
|   | M-315         | 2                     | 1    | 0    | 2    | 1    |                    | 54      |

**Table 2.** Least squares mean root knot number per gram of root fresh weight, root fresh weight in grams, and presence of *F. oxysporum* f. sp. *vasinfectum* in the tissue of five plants per plot. The data were log-normally distributed, hence 90% confidence intervals are given for each entry rather than an overall standard error.

| Entry | Cultivar | <i>M. incognita</i> per gm root |             |      | Root fresh weight [g] |            | <i>F. oxysporum</i> f. sp.<br><i>vasinfectum</i> |
|-------|----------|---------------------------------|-------------|------|-----------------------|------------|--|
|       |          | Mean                            | 95% CI      | Rank | Mean                  | 95% CI     | Present  |
| 101   | LM-1     | 402                             | (140, 1148) | 12   | 1.3                   | (1.1, 3.1) | YES  |
| 102   | LM-2     | 462                             | (161, 1320) | 15   | 4.4                   | (2.1, 8.1) | YES  |
| 103   | LM-3     | 1303                            | (456, 3728) | 63   | 2.9                   | (1.1, 6.1) | YES  |
| 104   | LM-4     | 588                             | (206, 1683) | 23   | 2.5                   | (1.1, 5.1) | YES  |
| 105   | LM-5     | 1501                            | (525, 4294) | 67   | 3.3                   | (2.1, 6.1) | YES  |
| 106   | LM-6     | 593                             | (207, 1696) | 25   | 2.8                   | (1.1, 6.1) | YES  |
| 107   | LM-7     | 1753                            | (613, 5015) | 74   | 1.1                   | (1.1, 2.1) | YES  |
| 108   | LM-8     | 1174                            | (411, 3359) | 57   | 3.0                   | (2.1, 6.1) | YES  |
| 109   | Rowden   | 783                             | (274, 2241) | 32   | 2.4                   | (1.1, 5.1) | YES  |
| 110   | M-315    | 224                             | (78, 641)   | 3    | 1.4                   | (1.1, 3.1) | NO   |
| 201   | DJ-1     | 354                             | (124, 1012) | 9    | 3.3                   | (2.1, 6.1) | YES  |
| 202   | DJ-2     | 211                             | (74, 605)   | 2    | 1.6                   | (1.1, 3.1) | YES  |
| 203   | DJ-3     | 1020                            | (357, 2917) | 48   | 2.2                   | (1.1, 4.1) | YES  |
| 204   | DJ-4     | 278                             | (97, 795)   | 6    | 4.9                   | (2.1, 9.1) | NO   |
| 205   | DJ-5     | 642                             | (224, 1836) | 26   | 4.4                   | (2.1, 9.1) | YES  |
| 206   | DJ-6     | 654                             | (229, 1870) | 29   | 2.6                   | (1.1, 5.1) | YES  |
| 207   | DJ-7     | 589                             | (206, 1685) | 24   | 2.7                   | (1.1, 5.1) | YES  |
| 208   | DJ-8     | 508                             | (178, 1454) | 18   | 3.2                   | (2.1, 6.1) | NO   |
| 301   | CW-1     | 2837                            | (992, 8115) | 80   | 2.6                   | (1.1, 5.1) | YES  |
| 302   | CW-2     | 423                             | (148, 1210) | 13   | 2.6                   | (1.1, 5.1) | YES  |
| 303   | CW-3     | 899                             | (314, 2571) | 41   | 1.7                   | (1.1, 3.1) | YES  |
| 304   | CW-4     | 449                             | (157, 1284) | 14   | 4.7                   | (2.1, 9.1) | YES  |
| 305   | CW-5     | 342                             | (119, 977)  | 8    | 3.3                   | (2.1, 6.1) | NO   |
| 306   | CW-6     | 819                             | (286, 2344) | 35   | 2.5                   | (1.1, 5.1) | YES  |
| 307   | CW-7     | 804                             | (281, 2299) | 33   | 2.9                   | (1.1, 6.1) | YES  |
| 308   | CW-8     | 1437                            | (502, 4110) | 65   | 2.7                   | (1.1, 5.1) | NO   |
| 401   | DF-1     | 1189                            | (416, 3401) | 59   | 1.6                   | (1.1, 3.1) | YES  |
| 402   | DF-2     | 357                             | (125, 1020) | 11   | 1.7                   | (1.1, 3.1) | YES  |
| 403   | DF-3     | 503                             | (176, 1439) | 17   | 2.2                   | (1.1, 4.1) | YES  |
| 404   | DF-4     | 1028                            | (359, 2939) | 50   | 1.6                   | (1.1, 3.1) | YES  |
| 405   | DF-5     | 204                             | (71, 583)   | 1    | 2.6                   | (1.1, 5.1) | YES  |
| 406   | DF-6     | 468                             | (164, 1338) | 16   | 3.9                   | (2.1, 8.1) | YES  |
| 407   | DF-7     | 1772                            | (620, 5069) | 75   | 2.6                   | (1.1, 5.1) | YES  |
| 408   | DF-8     | 237                             | (83, 678)   | 5    | 3.6                   | (2.1, 7.1) | YES  |

Table 2. *continued*

| Entry | Cultivar | <i>M. incognita</i> per gm root |               |      | Root fresh weight [g] |            | <i>F. oxysporum</i> f. sp.<br><i>vasinfectum</i> |
|-------|----------|---------------------------------|---------------|------|-----------------------|------------|--|
|       |          | Mean                            | 95% CI        | Rank | Mean                  | 95% CI     | Present  |
| 501   | PHY-FB1  | 1227                            | (429, 3510)   | 60   | 2.7                   | (1.1, 5.1) | YES  |
| 502   | PHY-FB2  | 2370                            | (829, 6779)   | 77   | 2.1                   | (1.1, 4.1) | YES  |
| 503   | PHY-FB3  | 1452                            | (508, 4152)   | 66   | 4.2                   | (2.1, 8.1) | YES  |
| 504   | PHY-FB4  | 1010                            | (353, 2889)   | 47   | 4.6                   | (2.1, 9.1) | YES  |
| 505   | PHY-FB5  | 1178                            | (412, 3368)   | 58   | 3.8                   | (2.1, 7.1) | YES  |
| 506   | PHY-FB6  | 232                             | (81, 663)     | 4    | 2.3                   | (1.1, 4.1) | YES  |
| 507   | PHY-FB7  | 2747                            | (961, 7858)   | 78   | 2.4                   | (1.1, 5.1) | NO   |
| 508   | PHY-FB8  | 1506                            | (527, 4308)   | 68   | 3.9                   | (2.1, 7.1) | YES  |
| 601   | NC1      | 1041                            | (364, 2977)   | 52   | 1.9                   | (1.1, 4.1) | NO   |
| 602   | NC2      | 989                             | (346, 2829)   | 46   | 1.7                   | (1.1, 3.1) | YES  |
| 603   | NC3      | 518                             | (181, 1481)   | 19   | 2.4                   | (1.1, 5.1) | YES  |
| 604   | NC4      | 313                             | (109, 894)    | 7    | 1.4                   | (1.1, 3.1) | YES  |
| 605   | NC5      | 578                             | (202, 1652)   | 21   | 2.5                   | (1.1, 5.1) | NO   |
| 606   | AU 1065  | 1635                            | (572, 4678)   | 71   | 3.1                   | (2.1, 6.1) | YES  |
| 607   | AU 1327  | 749                             | (262, 2141)   | 31   | 1.4                   | (1.1, 3.1) | YES  |
| 608   | AU 3202  | 928                             | (325, 2655)   | 44   | 2.0                   | (1.1, 4.1) | YES  |
| 701   | PHY- MM1 | 7693                            | (2690, 22003) | 82   | 1.7                   | (1.1, 3.1) | NO   |
| 702   | PHY- MM2 | 2818                            | (985, 8060)   | 79   | 2.7                   | (1.1, 5.1) | YES  |
| 703   | PHY- MM3 | 356                             | (125, 1019)   | 10   | 1.3                   | (1.1, 2.1) | YES  |
| 704   | PHY- MM4 | 876                             | (306, 2507)   | 40   | 1.6                   | (1.1, 3.1) | NO   |
| 705   | PHY- MM5 | 522                             | (182, 1492)   | 20   | 2.0                   | (1.1, 4.1) | YES  |
| 706   | PHY- MM6 | 1244                            | (435, 3559)   | 61   | 1.7                   | (1.1, 3.1) | YES  |
| 707   | PHY- MM7 | 1155                            | (404, 3303)   | 54   | 1.5                   | (1.1, 3.1) | YES  |
| 708   | PHY- MM8 | 819                             | (286, 2342)   | 34   | 3.0                   | (2.1, 6.1) | YES  |
| 801   | FB-1     | 1632                            | (571, 4668)   | 70   | 3.4                   | (2.1, 7.1) | YES  |
| 802   | FB-2     | 1028                            | (360, 2941)   | 51   | 3.7                   | (2.1, 7.1) | NO   |
| 803   | FB-3     | 913                             | (319, 2612)   | 43   | 3.7                   | (2.1, 7.1) | YES  |
| 804   | FB-4     | 1169                            | (409, 3343)   | 56   | 2.5                   | (1.1, 5.1) | YES  |
| 805   | FB-5     | 3192                            | (1116, 9130)  | 81   | 3.1                   | (2.1, 6.1) | NO   |
| 806   | FB-6     | 911                             | (318, 2605)   | 42   | 3.3                   | (2.1, 6.1) | YES  |
| 807   | FB-7     | 643                             | (225, 1840)   | 27   | 1.4                   | (1.1, 3.1) | YES  |
| 808   | FB-8     | 1102                            | (385, 3152)   | 53   | 2.1                   | (1.1, 4.1) | YES  |

**Table 2.** *continued*

| Entry | Cultivar | <i>M. incognita</i> per gm root |             |      | Root fresh weight [g] |             | <i>F. oxysporum</i> f. sp.<br><i>vasinfectum</i> |
|-------|----------|---------------------------------|-------------|------|-----------------------|-------------|--|
|       |          | Mean                            | 95% CI      | Rank | Mean                  | 95% CI      | Present  |
| 901   | MS-2     | 945                             | (331, 2704) | 45   | 3.6                   | (2.1, 7.1)  | NO   |
| 902   | MS-3     | 826                             | (289, 2363) | 37   | 5.9                   | (3.1, 11.1) | NO   |
| 903   | MS-4     | 824                             | (288, 2356) | 36   | 3.8                   | (2.1, 7.1)  | YES  |
| 904   | MS-5     | 1611                            | (563, 4607) | 69   | 2.9                   | (1.1, 6.1)  | NO   |
| 905   | MS-6     | 845                             | (295, 2416) | 39   | 2.9                   | (1.1, 6.1)  | YES  |
| 906   | FS-1     | 648                             | (196, 2148) | 28   | 3.4                   | (2.1, 7.1)  | YES  |
| 907   | FS-2     | 1658                            | (580, 4741) | 72   | 3.0                   | (2.1, 6.1)  | NO   |
| 908   | FS-3     | 727                             | (254, 2081) | 30   | 4.0                   | (2.1, 8.1)  | NO   |
| 1001  | TP-4     | 1682                            | (588, 4810) | 73   | 3.3                   | (2.1, 6.1)  | NO   |
| 1002  | TP-5     | 845                             | (295, 2415) | 38   | 2.1                   | (1.1, 4.1)  | NO   |
| 1003  | TP-6     | 1027                            | (359, 2938) | 49   | 3.3                   | (2.1, 6.1)  | YES  |
| 1004  | TP-7     | 1376                            | (481, 3935) | 64   | 3.1                   | (2.1, 6.1)  | YES  |
| 1005  | MB-3     | 1155                            | (404, 3304) | 55   | 5.2                   | (3.1, 10.1) | YES  |
| 1006  | SC-3     | 1245                            | (435, 3562) | 62   | 5.6                   | (3.1, 11.1) | NO   |
| 1007  | TL-6     | 1874                            | (655, 5361) | 76   | 3.8                   | (2.1, 7.1)  | YES  |
| 1008  | Lonren 1 | 585                             | (204, 1672) | 22   | 4.3                   | (2.1, 8.1)  | YES  |