Injury and Yield of Leafhopper-infested Dry Beans

Dale T. Lindgren
West Central Research and Extension Center-Horticulture, University of Nebraska, Route 4, Box 46A, North Platte, NE 69101-9495

Dermot P. Coyne
Department of Horticulture, University of Nebraska, Lincoln, NE 68583-0724

Abstract. Differences in potato leafhopper (Empoasca fabae Harris) injury symptoms were noted in 22 cultivars or lines of dry beans (Phaseolus vulgaris L.) in a 1991 field trial at North Platte, Neb. Seed yield, biomass, and plant injury symptoms were recorded.

Leafhoppers can be a significant production constraint on bean crops throughout the world (Schwartz and Pastor-Corrales, 1989). Leafhopper injury is characterized in plants by curling leaves and stunting, which is often referred to as hopperburn (Nault and Rodrigues, 1985.) When leafhopper injury is severe, crop yields can be reduced.

Bean cultivars vary considerably in susceptibility to injury by the potato leafhopper (Schwartz and Pastor-Corrales, 1989; Vandecoevering and York, 1993; Wolfenbarger and Sleesman, 1961). Leafhopper infestations on snap beans can result in severe yield losses if leafhopper populations are not controlled. Leafhopper injury between lines of dry beans was highly resistant to leafhoppers, with no visual leafhopper injury symptoms in all 3 years. Significant negative correlation coefficients between leafhopper injury on the relationship of leafhopper injury symptoms and yield were recorded in the protected (-0.46) and unprotected (-0.33) plots in 1992 but only in the unprotected (-0.46) plots in 1992. A cultivar x spray interaction response to leafhoppers occurred in 1992 but not in 1993. The degree of leafhopper injury symptoms varied between years.

Materials and Methods

Twenty-two dry bean cultivars or lines (Table 1) varied in the degree of leafhopper injury symptoms in a trial at North Platte, Neb., in 1991. No spray was applied to control leafhoppers in this study. Leafhopper injury ratings, seed yield, and biomass were recorded.

These 22 cultivars or lines were planted in field plots at North Platte on 1 June 1992 and 2 June 1993 in a split-plot design with four replications. Main plots were protected (sprayed with insecticide) vs. unprotected (no insecticide applied), with cultivars as subplots. Plots consisted of a single row, 4.5 m long with 0.75 m between rows. Three meters of each row was harvested for yield in all tests. Leafhopper injury ratings, leafhopper counts, and seed yield were recorded. Biomass was obtained (1991 only) by pulling the whole plants after maturity, drying for 2 weeks in a greenhouse, and weighing the plants. The plants were threshed, and the seed weight of each line was recorded per plot.

Leafhopper injury ratings were recorded on a scale of 1 to 5, with 1 = no injury, 2 = 1% to 20%, 3 = 21% to 40%, 4 = 41% to 70%, and 5 = 71% to 100% of total leaf area showing injury on 7 Aug. 1991. Ratings were recorded on a scale of 1 to 7 with 1 = no injury, 2 = 1% to 10%, 3 = 11% to 20%, 4 = 21% to 30%, 5 = 31% to 40%, 6 = 41% to 50%, and 7 = 51% to 100% of total leaf area showing injury on 11 Aug. 1992 and 8 Aug. 1993. Leafhopper counts were recorded as the number of leafhoppers on three fully expanded trifoliate leaves on 8 Aug. 1992 and 13 Aug. 1993. The insecticide malathion (Cythion 57EC, American Cyanamid Co., Wayne, N.J.) was applied on 14 July (initial flowering), 28 July (pods developing), and 11 Aug. (late pod development) in 1992 and on 8 July (preamber) in 1993. Insecticide numbers on the protected plots.

A hard rain occurred immediately after planting in 1993 and reduced the crop population in some entries. There were not enough plants of six lines (5, 6, 7, 9, 12, and 20) to collect yield data, so these six entries were eliminated in the 1993 trial. The average minimum and maximum daily temperatures for June through August were 56 and 86°F in 1991, 55 and 78°F in 1992, and 57 and 79°F in 1993, respectively.

Results and Discussion

Significant differences were observed between the cultivars or lines for injury symptoms, seed yield, and biomass weights in 1991 (Table 1). Injury ratings ranged from 1.0 (none) for six lines to 5.0 (severe) for the breeding line WM4-89-5. Seed yield varied from 1213 to 2783 kg·ha⁻¹ and biomass weights varied from 2242 to 5920 kg·ha⁻¹ between entries. However, some of the yield differences between lines may be due to genetic differences for yield per se rather than differences in yield caused strictly by leafhopper...
Table 1. Leafhopper injury, seed yield, and biomass of dry bean cultivars and lines (1991).

| Code no. | Leafhopper Cultivar or line | Injury rating<sup>a</sup> | Seed yield (kg·ha<sup>-1</sup>) | Biomass<sup>b</sup> (kg·ha<sup>-1</sup>) |
|----------|-----------------------------|---------------------------|-------------------------------|----------------------------------|
| 1        | A-55                        | 1.3                       | 1711                          | 3870                             |
| 2        | Venezuela 350               | 1.0                       | 1720                          | 4323                             |
| 3        | Tacaragua                   | 1.0                       | 2048                          | 4502                             |
| 4        | UI 59                       | 3.5                       | 1875                          | 3320                             |
| 5        | Beryl                       | 1.0                       | 2087                          | 4058                             |
| 6        | Harris                      | 3.5                       | 1973                          | 4095                             |
| 7        | Spinel                      | 1.0                       | 2101                          | 3950                             |
| 8        | 89003                       | 1.5                       | 2474                          | 4595                             |
| 9        | WM4-89-7                    | 4.0                       | 1845                          | 3490                             |
| 10       | ND6-89-20                   | 4.8                       | 1550                          | 2899                             |
| 11       | Starlight                   | 4.5                       | 1827                          | 3406                             |
| 12       | ND5-89-25                   | 4.8                       | 1213                          | 2242                             |
| 13       | ND6-89-17                   | 4.0                       | 1858                          | 3507                             |
| 14       | ND6-89-15                   | 3.8                       | 2056                          | 3546                             |
| 15       | WM4-89-5                    | 5.0                       | 1689                          | 3180                             |
| 16       | Sierra                      | 1.0                       | 2371                          | 4753                             |
| 17       | WM5-89-3                    | 2.0                       | 2167                          | 4342                             |
| 18       | Chase                       | 2.3                       | 2156                          | 3697                             |
| 19       | WM2-89-10                   | 2.5                       | 2156                          | 4774                             |
| 20       | 87-039-34                   | 2.0                       | 2022                          | 3633                             |
| 21       | WM5-89-1                    | 1.0                       | 2574                          | 5920                             |
| 22       | WM5-89-2                    | 2.0                       | 2783                          | 4981                             |
| LSD      |                             | 0.68                      | 393.0                         | 726.7                             |

<sup>a</sup>Biomass equal to dry weight of above-ground plant parts at harvest time.
<sup>b</sup>Entries 1 to 3 are black seeded, 4 to 15 are great northern, and 16 to 22 are pinto type dry beans.
<sup>c</sup>Based on 1 = no hopperbum injury to 5 = severe hopperbum injury.

Injury. For example, ‘Venezuela 350’ and WM5-89-1 displayed no visual injury symptoms but yields were significantly different (1720 vs. 2574 kg·ha<sup>-1</sup>, respectively). Significant negative correlation coefficients of injury ratings with seed yield (-0.49), and injury ratings with biomass production (-0.62) were observed. A significant positive correlation coefficient of +0.87 between yield and biomass was noted.

There were significant differences between cultivars or lines for seed yield, leafhopper injury, and leafhopper numbers in experiments conducted in 1992 and 1993 (Table 2). Differences were noted for all traits measured in protected and unprotected treated plots in 1992 but only for yield in 1993. Significant interactions of lines × treatments were observed for all variables in 1992 but none occurred in 1993.

Correlation coefficients were significant between leafhopper injury symptoms and yield (-0.50 unprotected, -0.33 protected), leafhopper numbers and yield (-0.31 protected, -0.35 unprotected), and leafhopper injury symptoms and leafhopper numbers (+0.68 protected, +0.63 unprotected) in 1993 (Table 3). Correlation coefficients measured in 1992 were significant for injury symptoms and leafhopper numbers (+0.57 protected and +0.81 unprotected), injury symptoms and yield (-0.46 for the unprotected plots), and leafhopper number and yield (-0.44 for the unprotected plots) in 1992.

Table 2. Statistical significance for variables in the 1992 and 1993 leafhopper studies.

| Source       | 1992 | 1993 | 1992 | 1993 | 1992 | 1993 |
|--------------|------|------|------|------|------|------|
| Bean lines   | **   | **   | **   | **   | **   | **   |
| Protection   | **   | **   | **   | NS   | **   | NS   |
| lines × protection | **   | NS   | **   | NS   | **   | NS   |

**NS** Non-significant, significant at P = 0.01, respectively.

Table 3. Correlation coefficients between variables measured in the 1992 and 1993 leafhopper studies.

|          | Protected |        | Unprotected |        |
|----------|-----------|--------|-------------|--------|
|          | 1992      | 1993   | 1992        | 1993   |
| Injury symptoms | +0.57** | +0.68** | -0.12** | -0.50** |
| Leafhopper no.  | ---      | ---    | -0.16** | -0.31** |
| Protected | +0.81** | +0.63** | -0.46** | -0.33** |
| Unprotected| ---      | ---    | -0.44** | -0.35** |

**NS**, **** Non-significant, significant at P = 0.01 or 0.05, respectively.
Table 4: Yields, leafhopper injury, and leafhopper counts of dry bean cultivars or lines in protected and unprotected plots (1992).

| Code no. | Cultivar or line | Yield (kg·ha⁻¹) | Leafhopper injury | Leafhopper no. |
|----------|-----------------|-----------------|------------------|---------------|
|          | Protected       | Unprotected     | Protected        | Unprotected   |
| 1        | A-55            | 1865            | 1.3              | 1.3           |
| 2        | Venezuela 350   | 2818            | 1.5              | 1.8           |
| 3        | Tacaragua       | 3439            | 1.0              | 1.0           |
| 4        | UI 59           | 1873            | 1.3              | 2.5           |
| 5        | Beryl           | 2115            | 1.0              | 1.5           |
| 6        | Harris          | 2213            | 1.0              | 1.5           |
| 7        | Spinel          | 2422            | 1.0              | 1.5           |
| 8        | 89003           | 2789            | 1.0              | 1.5           |
| 9        | WM4-89-7        | 2464            | 2.8              | 5.5           |
| 10       | ND6-89-20       | 2292            | 3.0              | 6.0           |
| 11       | Starlight       | 2514            | 3.3              | 5.8           |
| 12       | ND5-89-25       | 1708            | 2.0              | 5.3           |
| 13       | ND6-89-17       | 2330            | 2.8              | 5.3           |
| 14       | ND6-89-15       | 2443            | 1.8              | 4.5           |
| 15       | WM4-89-5        | 2356            | 2.5              | 5.8           |
| 16       | Sierra          | 2725            | 1.0              | 1.0           |
| 17       | WM5-89-3        | 2732            | 1.0              | 1.3           |
| 18       | Chase           | 2727            | 1.0              | 1.8           |
| 19       | WM2-89-10       | 2682            | 1.0              | 1.3           |
| 20       | 87-039-34       | 1370            | 1.0              | 1.0           |
| 21       | WM5-89-1        | 3008            | 1.0              | 1.0           |
| 22       | WM5-89-2        | 2544            | 1.0              | 1.0           |

LSD (0.05):
1 = 387
2 = 421

*Average number of leafhoppers on three trifoliate leaves.
†Entries 1 to 3 are black seeded, 4 to 15 are great northern, and 16 to 22 are pinto-type dry beans
‡LSD-1 = comparison of cultivar/lines means within each main plot treatment. LSD-2 = comparison of protected or unprotected treatment means within or between cultivars/lines.

Yield, leafhopper injury, and leafhopper numbers for entries varied between years (Tables 1, 4, and 5). Average yield of unprotected plots varied from 2111 kg·ha⁻¹ in 1991, to 2211 kg·ha⁻¹ in 1992, to 1982 kg·ha⁻¹ in 1993, a result implying that year differences in yield potential were present.

‘Tacaragua’ and ‘Sierra’ showed no visual injury symptoms in 1992.

Table 5. Yields, leafhopper injury, and leafhopper counts of dry bean cultivars or lines in protected and unprotected plots (1993).

| Code no. | Cultivar or line | Yield (kg·ha⁻¹) | Leafhopper injury | Leafhopper no. |
|----------|-----------------|-----------------|------------------|---------------|
|          | Protected       | Unprotected     | Protected        | Unprotected   |
| 1        | A-55            | 2182            | 1.3              | 1.3           |
| 2        | Venezuela 350   | 2695            | 1.3              | 1.5           |
| 3        | Tacaragua       | 2612            | 1.0              | 1.0           |
| 4        | UI 59           | 1385            | 2.0              | 1.8           |
| 8        | 89003           | 2093            | 1.8              | 1.8           |
| 10       | ND6-89-20       | 1592            | 3.8              | 3.8           |
| 11       | Starlight       | 1788            | 3.8              | 3.3           |
| 13       | ND6-89-15       | 2292            | 3.5              | 2.8           |
| 15       | WM4-89-5        | 1900            | 4.0              | 4.8           |
| 16       | Sierra          | 2318            | 1.0              | 1.0           |
| 17       | WM5-89-3        | 2315            | 1.0              | 1.0           |
| 18       | Chase           | 2246            | 1.3              | 1.0           |
| 19       | WM2-89-10       | 2480            | 1.0              | 1.5           |
| 21       | WM5-89-1        | 3219            | 1.0              | 1.3           |
| 22       | WM5-89-2        | 2074            | 1.0              | 1.0           |

LSD (0.05):
1 = 310
2 = 439

*Average number of leafhoppers on three trifoliate leaves.
†Same code numbers as in tables 1 and 4. Some numbers are missing because of weather injury to plants.
‡Entries 1 to 3 are black seeded, 8 to 15 are great northern, and 16 to 22 are pinto-type dry beans
§LSD-1 = Comparison of cultivar/lines within each main plot treatment. LSD-2 = Comparison of protected or unprotected treatment means within or between cultivar lines.
all 3 years. ‘Beryl’ and ‘Spinel’ showed no visual injury in the 2 years they were included in the studies. All other lines displayed some degree of injury symptoms. Entry numbers 9 through 15 were considered highly susceptible to leafhopper injury based on injury ratings over all years they were included in the trials (Tables 1, 4, and 5). However, these differences were not always reflected in yield differences between protected vs. unprotected treatments.

The results confirm that differences exist between bean germplasm, cultivars, or lines in susceptibility to injury by the potato leafhopper based on visual symptoms. Lines A-55, ‘Tacaragua’, ‘Venezuela 350’, and pinto ‘Sierra’ expressed high resistance to leafhopper injury. The new pinto cultivar ‘Chase’ expressed high to moderate resistance to leafhopper injury depending on the year. The resistance to leafhopper injury expressed by ‘Chase’ was probably derived from the black-seeded ‘Tacaragua’ (Venezuela), one of its parents (Coyne et al., 1994). Lines 9 to 15, which had the most leafhopper injury symptoms and the highest number of leafhoppers, all had similar pedigrees, suggesting that parental material conveyed leafhopper injury susceptibility to these lines (Tables 1, 4, and 5). This information should be useful to bean breeders when developing cultivars for environments in which leafhoppers are present.

Yield reductions in protected vs. unprotected plots were not always consistent between bean lines over years. However, significant yield losses can be reduced by spraying susceptible cultivars with an appropriate insecticide when leafhopper injury potential is high. Injury also varied between years, a result that could be related to the number of leafhoppers present, weather conditions, and other factors affecting plant performance.

**Literature Cited**

Coyne, D.P., D.S. Nuland, D.T. Lindgren, and J.R. Steadman. 1994. ‘Chase’ pinto dry bean. HortScience 29:44-45.

Gonzales, A.L. and J.A. Wyman. 1991. Effect of varying potato leafhopper (Homoptera: Cicadellidae) population densities on snap bean yield. J. Econ. Entomol. 84:644-649.

Nault, L.R. and J.G. Rodrigues. 1985. The leafhoppers and planthoppers. Wiley, New York.

Schwartz, H. and M.A. Pastor-Con-ales. 1989. Bean production problems in the tropics. Centro Internacional de Agricultura Tropical, Cali, Columbia.

Vandecoevering, J.P. and A.C. York. 1993. Varietal preferences of the potato leafhopper (Empoasca fabae Harris) for various snap beans (Phaseolus vulgaris L.) cultivars. Annu. Rpt. Bean Improvement Coop. 36:135-136.

Wolfenbarger, D. and J.P. Sleesman. 1961. Resistance in common bean lines to the potato leafhopper. J. Econ. Entomol. 54:846-849.