Injury and Yield of Leafhopper-infested Dry Beans

Dale T. Lindgren¹

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

Dermot P. Coyne¹

Department of Horticulture, University of Nebraska, Lincoln, NE 68583-0724

Additional index words. *Phaseolus vulgaris*, *Empoasca fabae*, resistance, yield, leafhopper counts, insecticide

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. The same 22 dry bean cultivars or lines were planted in a split-plot design, with main plots protected (sprayed with insecticide) vs. unprotected (not sprayed) and cultivars or lines as subplots in 1992 and 1993. Significant differences were observed between cultivars/lines for leafhopper injury and yield in all 3 years. 'Tacaragua' (black-seeded) and pinto 'Sierra' were highly resistant to leafhoppers, with no visual leafhopper injury symptoms in all 3 years. Significant negative correlation coefficients between leafhopper injury symptoms and yield were recorded in the protected (4.50) and unprotected (-0.33) plots in 1993 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.

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 intensity, duration and initial time of infestation, and plant variety, temperature, plant disease incidence, and their interactions influence crop yield (Gonzales and Wyman, 1991). Information on the relationship of leafhopper injury symptoms to yield is needed to determine the economic importance of this pest and develop strategies to minimize the use of pesticides to control the insects.

The objectives of this study were to determine 1) differences in leafhopper injury between bean cultivars or lines, 2) the relationship between injury and yield, and 3) the relationship of leafhopper injury and symptoms and the number of leafhoppers per unit area with yield in beans in sprayed (protected) and unsprayed (unprotected) plots.

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 (preflowering), 6 Aug (early pod setting), and 23 Aug. (pod fill) in 1993 to reduce leafhopper numbers in the protected plots.

A hard rain occurred immediately after planting in 1993 and reduced the plant 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 86F in 1991, 55 and 78F in 1992, and 57 and 79F 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

Received for publication 4 Nov. 1994. Accepted for publication 13 Mar. 1995. Univ. of Nebraska, Lincoln, Agricultural Research Division Journal series paper no. 10922. The cost of publishing this paper was defrayed in part by the payment of page charges. Under postal regulations, this paper therefore must be hereby marked *advertisement* solely to indicate this fact.

¹Professor.

Table 1. Leafhopper injury, seed yield, and biomass of dry bean cultivars and lines (1991).

Code no.	Leafhopper Cultivar or line ^y	Injury rating ^x	Seed yield (kg·ha ⁻¹)	Biomass ^z (kg·ha ⁻¹)
1	A-55	1.5	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

^zBiomass equal to dry weight of above-ground plant parts at harvest time.

^yEntries 1 to 3 are black seeded, 4 to 15 are great northern, and 16 to 22 are pinto type dry beans.

^xBased 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⁻¹, 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	Yield		Injury		Leafhopper no.	
	1992	1993	1992	1993	1992	1993
Bean lines	**	**	**	**	**	**
Protection	**	**	**	NS	**	NS
Lines × protection	**	NS	**	NS	**	NS

NS, **Nonsignificant, significant at $P = 0.01$, respectively.

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

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

NS, *, **Nonsignificant, 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 ^y	Yield (kg·ha ⁻¹)		Leafhopper injury		Leafhopper no. ^z	
		Protected	Unprotected	Protected	Unprotected	Protected	Unprotected
1	A-55	1865	2247	1.3	1.8	1.3	10.0
2	Venezuela 350	2818	3289	1.5	1.8	0.3	5.5
3	Tacaragua	3439	3137	1.0	1.0	2.3	3.3
4	UI 59	1873	1348	1.3	2.5	4.8	9.0
5	Beryl	2115	2265	1.0	1.0	1.5	6.5
6	Harris	2213	1965	1.0	1.5	2.5	8.8
7	Spinel	2422	2119	1.0	1.0	2.0	4.3
8	89003	2789	2879	1.0	1.5	0.0	2.3
9	WM4-89-7	2464	2082	2.8	5.5	4.8	24.3
10	ND6-89-20	2292	1643	3.0	6.0	5.3	19.8
11	Starlight	2514	2015	3.3	5.8	6.0	19.5
12	ND5-89-25	1708	1311	2.0	5.3	3.5	18.0
13	ND6-89-17	2330	1804	2.8	5.3	5.8	32.0
14	ND6-89-15	2443	2216	1.8	4.5	3.8	13.5
15	WM4-89-5	2356	1821	2.5	5.8	5.3	26.5
16	Sierra	2725	2908	1.0	1.0	1.3	2.5
17	WM5-89-3	2732	2444	1.0	1.3	2.3	4.5
18	Chase	2727	2382	1.0	1.8	1.0	4.3
19	WM2-89-10	2682	2173	1.0	1.3	2.3	3.5
20	87-039-34	1370	1426	1.0	1.0	1.3	3.8
21	WM5-89-1	3008	3077	1.0	1.0	1.5	2.3
22	WM5-89-2	2544	2102	1.0	1.0	2.0	4.5
LSD (0.05) ^x		1 = 387	2 = 421	1 = 0.5	2 = 0.7	1 = 4.5	2 = 6.4

^xAverage number of leafhoppers on three trifoliolate leaves.^yEntries 1 to 3 are black seeded, 4 to 15 are great northern, and 16 to 22 are pinto-type dry beans^zLSD-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 2011 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

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

Code no. ^y	Cultivar or line ^x	Yield (kg·ha ⁻¹)		Leafhopper injury		Leafhopper no. ^z	
		Protected	Unprotected	Protected	Unprotected	Protected	Unprotected
1	A-55	2182	1668	1.3	1.3	4.8	5.3
2	Venezuela 350	2695	2189	1.3	1.5	2.8	4.5
3	Tacaragua	2612	2347	1.0	1.0	4.3	2.5
4	UI 59	1385	1063	2.0	1.8	5.3	5.5
8	89003	2093	2139	1.8	1.8	1.0	2.3
10	ND6-89-20	1592	1671	3.8	3.8	10.5	13.5
11	Starlight	1788	1564	3.8	3.3	8.0	8.5
13	ND6-89-15	2292	2070	3.5	2.8	8.8	9.3
14	ND6-89-15	1885	1854	2.8	3.0	6.7	8.8
15	WM4-89-5	1900	1666	4.0	4.8	18.8	14.5
16	Sierra	2318	2553	1.0	1.0	1.8	2.0
17	WM5-89-3	2315	1757	1.0	1.0	4.3	5.5
18	Chase	2246	2163	1.3	1.0	3.5	6.8
19	WM2-89-10	2480	2075	1.0	1.5	2.0	5.5
21	WM5-89-1	3219	2960	1.0	1.3	1.5	3.3
22	WM5-89-2	2074	1972	1.0	1.0	4.8	3.3
LSD(0.05) ^w		1 = 310	2 = 439	1 = 0.5	2 = 0.7	1 = 3.2	2 = 4.6

^xAverage number of leafhopper counts on three trifoliolate leaves.^ySame code numbers as in tables 1 and 4. Some numbers are missing because of weather injury to plants.^zEntries 1 to 3 are black seeded, 8 to 15 are great northern, and 16 to 22 are pinto-type dry beans^wLSD-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-Conales. 1989. Bean production problems in the tropics. Centro Internacional de Agricultura Tropical, Cali, Columbia.
- Vandecoeveing, 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. Slesman. 1961. Resistance in common bean lines to the potato leafhopper. *J. Econ. Entomol.* 54:846-849.