Research Note

FIELD EVALUATION OF COMMON BEAN FOR REACTION TO WEB BLIGHT AND HIGH TEMPERATURE[1]

Juan C. Rosas[2], *James S. Beaver*[3], *Consuelo Estévez de Jensen*[3], *Abiezer González*[4], *Daniel Rocha-Clavijo*[5] *and Raúl Macchiavelli*[3]

J. Agric. Univ. P.R. 102 (1-2):113-121 (2018)

During the past 30 years, common bean (*Phaseolus vulgaris* L.) production in Central America has expanded into the humid, lowlands (Gourdji et al., 2014; Aldana de León, 2010). This allows for production during non-traditional growing seasons, resulting in a greater and more stable supply of beans in the region. In the humid tropics, seed yield and seed quality of beans are threatened by web blight caused by *Rhizoctonia solani* Kühn (teleomorph: *Thanatephorus cucumeris* Frank Donk) (Godoy de Lutz et al., 2008). High temperatures can disrupt reproductive development and reduce seed yield of heat-sensitive bean genotypes (Porch and Jahn, 2001). This study aimed to identify the response of breeding lines to web blight using a spatial model.

A field trial was conducted at the Isabela Substation of the University of Puerto Rico Agricultural Experiment Station (18.47°, - 67.05°) at 128 m above sea level. The soil at the field site is an Oxisol (very-fine, kaolinitic isohyperthermic Typic Hapludox) (Muñoz et al., 2018). The trial was planted on 13 June 2017. An augmented design with two replications was used. The treatments were 479 F_7 common bean-breeding lines from Zamorano University that were selected from the third cycle of recurrent selection for resistance to web blight. The pink bean PR0401-259 and the black bean MHN 322-49 were resistant check lines and the white bean cultivar 'Morales' and the small red bean cultivar 'Amadeus 77' were susceptible checks in the field trial. The four checks were randomized within sub-blocks containing 20 rows. The experimental units were single l-m rows spaced at 0.76 m between rows. Thirteen seeds were planted in each row.

Approximately 30 d after planting, the lines in the field trial were inoculated with a mycelial suspension of *Rhizoctonia solani* Kühn using the methods described by Takegami et al. (2004). The isolate which was originally collected at the Isabela Substation from bean plants with web blight symptoms and characterized in the subgroup AG-1-1E in a different study (González et al., 2012). The isolate, stored in sterile sand, was recovered, multiplied and used to inoculate bean plants at 45 days after planting. The disease reactions on the leaves were evaluated at 34 d after inoculation using the CIAT 1 to 9 scale (van Schoonhaven and Pastor-Corrales, 1987). Experimental units (1-m row lengths) were harvested to estimate seed yield. Damaged seed was removed from each experimental unit to estimate percentage (%) of damaged seed.

[1]Manuscript submitted to Editorial Board 13 August 2018.

[2]Zamorano University, PO Box 93, Tegucigalpa, Honduras.

[3]Professor, Dept. of Agroenvironmental Sciences, PO Box 9000, Univ. of Puerto Rico-Mayagüez Campus, Mayagüez, PR 00680-9000.

[4]Agricultural Experiment Station, Univ. of Puerto Rico-Mayagüez Campus

[5]Graduate Student, Dept. of Mathematical Sciences, Univ. of Puerto Rico-Mayagüez Campus.

The data was analyzed using a model for an incomplete block design (IBD) with the following response variables: web blight scores at 34 days, percentage of damaged seeds, and seed yield. The model included a fixed line effect and random replication and blocks within repetition effects. Since the blocks consisted of long strips, several models with spatial correlation were also considered to account for a possible spatial correlation between the responses, and, hence, to attain smaller standard errors to compare the means. The best spatial model (exponential correlation) was selected using the Akaike and Bayesian Information Criteria (AIC and BIC) as fitted using the GLIMMIX and Variogram procedures in SAS v. 9.4 software (SAS Institute, Cary, NC).

Web blight scores at 34 days after inoculation

A comparison of the square root of the average of the squared standard errors of the means shows that the spatial correlation model (exponential) produced a value of 0.582, whereas the model that considers the design structure IBD had a value of 0.614. Since the objective was to compare means of bean lines, the spatial model is more appropriate, because it yields means with greater precision.

In the field map the observations of the web blight scores at 34 days vary spatially, which is why the model that considered this spatial correlation fits better than the model that considered blocks and repetitions. The high, medium and low values of the web blight scores at 34 days tended to be grouped in space. It should be noted, however, that each observation comes from a different bean line. The spatial correlation models consider the correlation between residuals, and the map of these residuals also show spatial trends. Therefore, there seems to be a spatial association for the variable score of web blight at 34 days (percentage of severity of the disease).

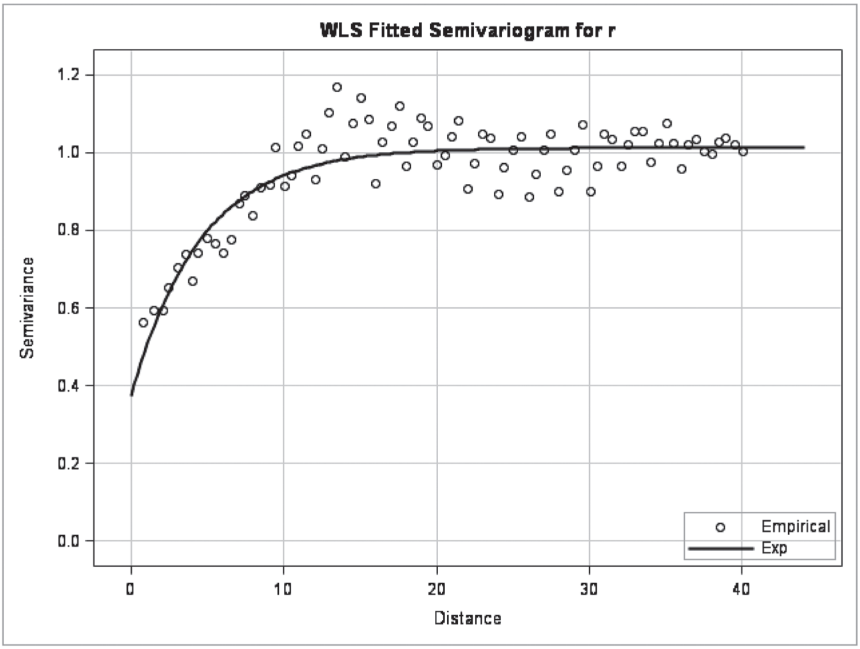


FIGURE 1. Relation between semivariance and distance (m) between plots.

Results from the semivariogram model suggest that experimental units separated by distances < 10 meters are spatially correlated (Figure 1). At distances > 10 meters, the fitted semivariance begins to flatten. Therefore, plots that are spaced > 10 m apart could be considered independent for practical purposes.

The IBD model and the spatial correlation (exponential) model were considered for percentage of disease severity of web blight at 34 days after inoculation. The means based on the corresponding model (LSMEANS) were ranked from lowest to highest web blight score. Figure 2 shows a strong correlation (r=0.95) between rankings of means from the IBD and the exponential correlation models.

Percentage of damaged seeds

For this variable, the assumption of variance homogeneity was not met. Therefore, a logarithmic transformation of percentage of damaged seeds plus one was used. The variogram and the AIC and BIC criteria showed that the IBD model was better than models considering spatial correlation; hence the results for this variable are based on the IBD model. There seems to be no spatial correlation for this variable.

A list of the bean lines (treatments) was created including ranking of the average percentage of damaged seeds and average web blight scores (severity of disease) at 34 days after inoculation that are in the first quartile; that is, the 120 best bean lines with respect to web blight scores were matched with the 120 best bean lines with respect to percentage of damaged seeds and the intersection identified. A plot of the rankings of these two characteristics show bean lines with the best overall performance in the lower right quadrant (Figure 3). Eleven bean lines are among the 25% having the lowest web

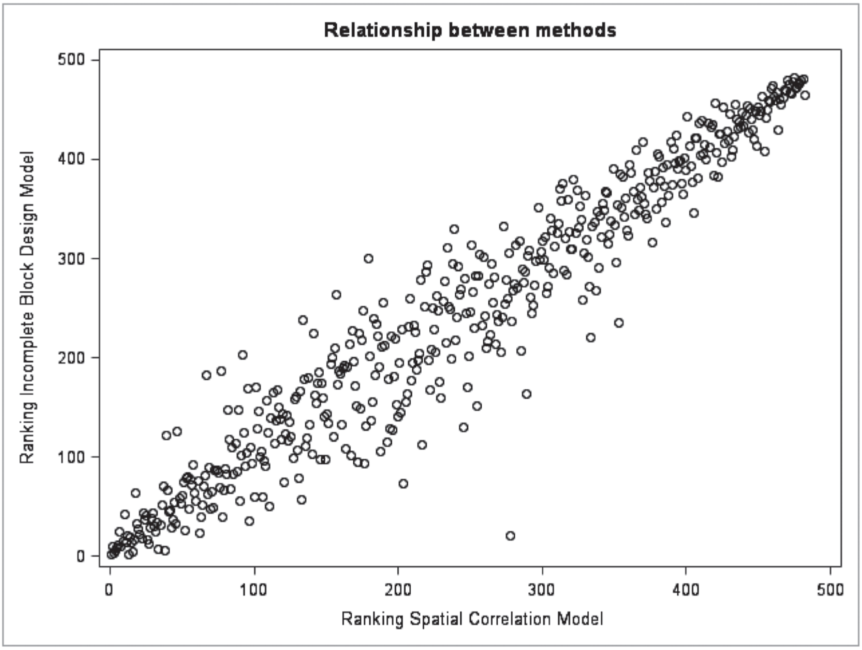
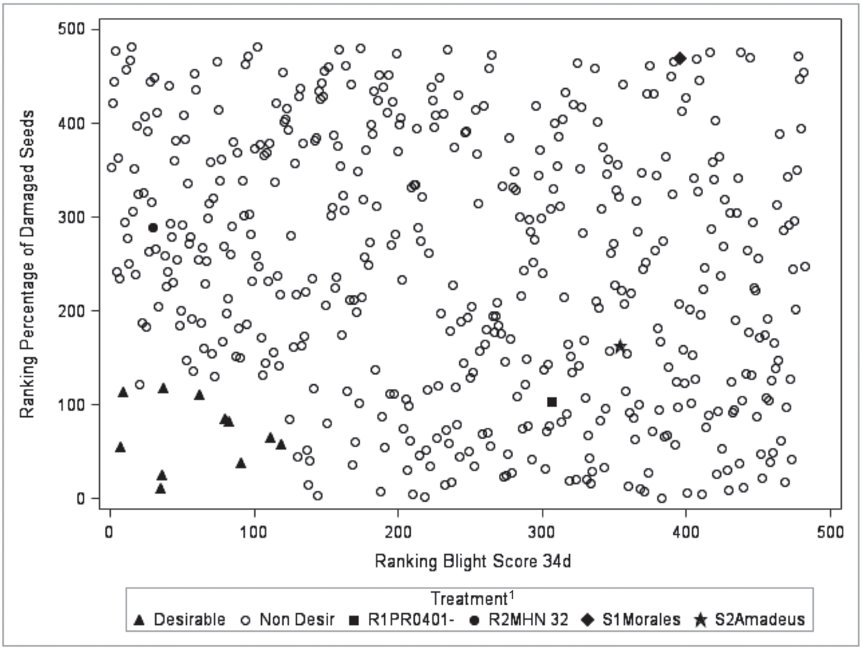


FIGURE 2. Correlation (0.95) between rankings of means from the DBI and the exponential correlation models.

TABLE 1.—*Means and rankings of percentage of damaged seed and web blight scores that are in the most desirable quartile of lines.*

Line (treatment number)	Mean percentage of damaged seed	Ranking of % damaged seed	Mean web blight scores[1] at 34 days after inoculation	Ranking of web blight scores at 34 days after inoculation
MHC 3-1-3 (1)	3.9	118	3.5	37
MHC 3-1-15 (5)	3.3	84	3.9	80
MHC 3-1-17 (6)	3.9	113	3.0	9
MHC 3-4-13 (48)	2.4	38	3.9	91
MHC 3-4-31 (55)	3.3	82	3.9	83
MHC 3-8-25 (115)	2.9	58	4.0	119
MHC 3-11-17 (129)	2.1	25	3.5	36
MHC 3-17-35 (208)	1.4	10	3.5	35
MHC 3-18-9 (212)	3.0	65	4.0	112
MHC 3-20-22 (247)	2.8	54	3.0	8
MHC 3-29-7 (348)	3.8	110	3.8	62

[1]Rated using the CIAT 1-9 scale where 1 = no symptoms and 9 = very severe symptoms.



[1]Desirable and undesirable lines and resistant (PR0401-259 and MHN 322-49) and susceptible control lines ('Morales' and 'Amadeus 77') are highlighted in the graph.

FIGURE 3. Ranking of the average percentage of damaged seeds and average web blight scores (percentage severity of disease) at 34 days after inoculation.

blight scores at 34 days after inoculation and among the 25% of the bean lines having the lowest percentage of seed damage (Table 1).

Seed yield

The LSMEANS using the best spatial correlation model (exponential) for seed yield (kg/ha) was ranked from highest to lowest. A list was prepared containing the rankings of average seed yield and ranks of average web blight scores at 34 DAI that were in the first quartile, that is, the 120 best bean lines with respect to web blight scores at 34 DAI and the 120 best bean lines with respect to seed yield (Figure 4). There were 34 bean lines that appear in both lists. Both rankings were plotted with the lower right quadrant showing the 34 best bean lines with respect to both characteristics (Table 2).

Bean lines combining superior seed yield and low levels of leaf and seed damage were identified. Lines 55 (MHC 3-4-31) and 129 (MHC 3-11-17) were the only lines that were simultaneously in the top quartile for all three traits. Line 398 (MHC 3-32-11) line 399 (MHC 3-32-16) and line 403 (MHC 3-32- 24), which are in the desirable quartile for web blight scores and seed yield in Puerto Rico also had had resistant scores (3.0) to web blight in trials conducted at Zamorano University in Honduras (data not shown.).

The pink bean line PR0401-259 was a good check for resistance to web blight and tolerance to heat and 'Morales' was a good susceptible check for both traits. The black bean line MHN 332-49 had low levels of web blight symptoms in the leaves but produced low seed yield due to sensitivity to heat. The small red cultivar 'Amadeus 77' yielded under

TABLE 2.—*Means and rankings web blight scores at 34 days after inoculation (DAI) and seed yield that are in the most desirable quartile of lines.*

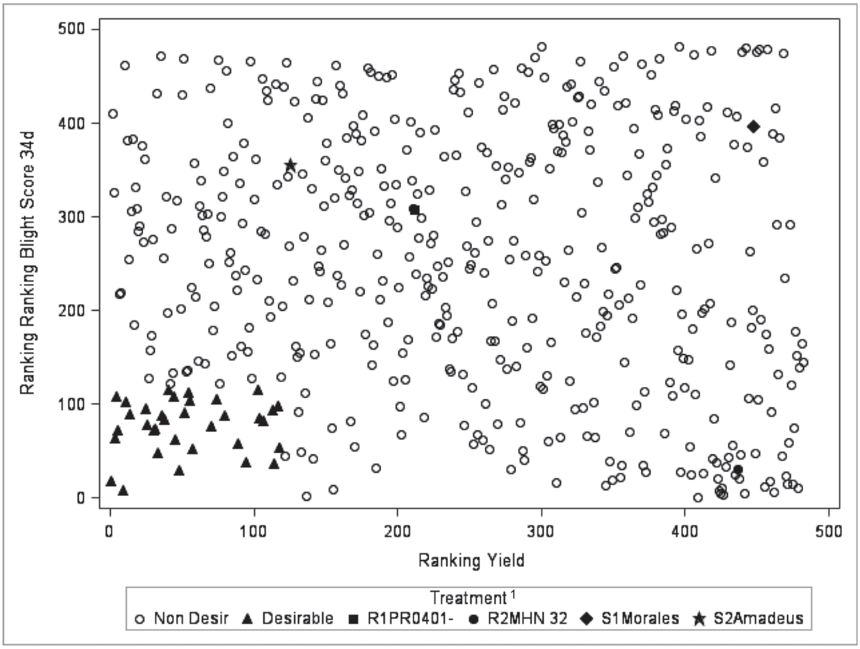
(Treatment number)	Mean web blight score[1] at 34 DAI	Ranking of web blight scores at 34 DAI	Mean seed yield (kg/ha)	Ranking of mean seed yield
MHC 3-1-7 (2)	3.6	48	2,786	34
MHC 3-1-27 (10)	3.2	18	3,329	1
MHC 3-1-32 (12)	3.7	61	2,668	46
MHC 3-1-35 (13)	3.8	63	3,110	4
MHC 3-3-19 (36)	4.0	115	2,398	103
MHC 3-4-31 (55)	3.9	83	2,728	38
MHC 3-5-11 (64)	3.9	89	2,972	14
MHC 3-5-12 (65)	4.0	97	2,321	117
MHC 3-5-14 (66)	3.0	7	3,028	9
MHC 3-5-15 (67)	3.4	29	2,652	48
MHC 3-5-18 (69)	3.9	87	2,466	80
MHC 3-7-12 (95)	4.0	107	3,046	5
MHC 3-7-13 (96)	4.0	105	2,498	74
MHC 3-7-38 (105)	3.7	53	2,319	118
MHC 3-11-17 (129)	3.5	36	2,333	114
MHC 3-15-36 (179)	3.7	57	2,429	89
MHC 3-16-8 (181)	4.0	101	3,015	11
MHC 3-16-37 (193)	4.0	95	2,844	25
MHC 3-18-9 (212)	4.0	112	2,607	55
MHC 3-18-35 (224)	3.5	38	2,414	95
MHC 3-20-6 (242)	3.9	90	2,617	52
MHC 3-21-21 (264)	3.9	76	2,522	71
MHC 3-22-24 (277)	4.0	114	2,713	41
MHC 3-24-26 (308)	3.9	85	2,397	104

[1]Rated using the CIAT 1 to 9 scale, where 1 = no symptoms and 9 = very severe symptoms

TABLE 2.—(Continued) *Means and rankings web blight scores at 34 days after inoculation (DAI) and seed yield that are in the most desirable quartile of lines.*

(Treatment number)	Mean web blight score[1] at 34 DAI	Ranking of web blight scores at 34 DAI	Mean seed yield (kg/ha)	Ranking of mean seed yield
MHC 3-25-18 (323)	4.0	103	2,600	56
MHC 3-29-38 (360)	3.7	52	2,583	58
MHC 3-31-3 (377)	3.8	73	2,812	32
MHC 3-32-1 (391)	4.0	93	2,334	113
MHC 3-32-5 (392)	4.0	108	2,669	45
MHC 3-32-11 (398)	3.8	71	2,824	31
MHC 3-32-16 (399)	3.8	72	3,036	6
MHC 3-32-24 (403)	3.9	88	2,758	36
MHC 3-34-35 (434)	3.9	82	2,374	107
MHC 3-34-40 (435)	3.9	78	2,836	26

[1]Rated using the CIAT 1 to 9 scale, where 1 = no symptoms and 9 = very severe symptoms



[1]Desirable and undesirable lines and resistant (PR0401-259 and MHN 322-49) and susceptible control lines ('Morales' and 'Amadeus 77') are highlighted in the graph.

FIGURE 4. Ranking of and average web blight scores (percentage severity of disease) at 34 days after inoculation and seed yield.

higher temperatures but had a susceptible reaction to web blight on the leaves. It would be useful to determine what enabled 'Amadeus 77' to have low levels of seed damage.

LITERATURE CITED

Aldana de León, L. F., 2010. Manual producción comercial y de semilla de frijol (*Phaseolus vulgaris* L.). Manual Técnico Agrícola. Instituto de Ciencia y Tecnología Agrícolas. Quetzaltenango, Guatemala. 38 pp.

Godoy de Lutz, G., S. Kuninaga and J. R. Steadman, 2008. Phylogenetic analysis of *Rhizoctonia solani* subgroups associated with web blight symptoms on common bean based on ITS-5.8S rDNA. *J. Gen. Plant Pathology* 74: 32-40.

González, N., G. Godoy-Lutz, J. R. Steadman, R. Higgins and K. M. Eskridge, 2012. Assessing genetic diversity in the web blight pathogen *Thanatephorus cucumeris* (anamorph = *Rhizoctonia solani*) subgroups AG-1-IE and AG-1-IF with molecular markers. *J. Gen. Plant Patho*logy 78: 85-98.

Gourdji, S., P. Laderach, A. Martínez-Valle and C. Zelaya-Martínez, 2014. Historical climate trends, deforestation, and maize and bean yields in Nicaragua. *Agricultural and Forest Meteorology* 200: 270-281.

Muñoz, M. A., W. I. Lugo, C. Santiago, M. Matos, S. Ríos and J. Lugo, 2018. Taxonomic Classification of the Soils of Puerto Rico, 2017. University of Puerto Rico, Mayagüez Campus. College of Agricultural Sciences, Agricultural Experiment Station. San Juan, Puerto Rico. Bulletin 313. 73 p.

Porch, T. G. and M. Jahn, 2001. Effects of high-temperature stress on microsporogenesis in heat-sensitive and heat-tolerant genotypes of *Phaseolus vulgaris*. *Plant, Cell and Environment* 24: 723-731.

Takegami, J. C., J. S. Beaver, G. Godoy de Lutz, R. Echávez-Badel and J. R. Steadman, 2004. Inheritance of web blight resistance in common bean. *J. Agric. Univ. P.R.* 88: 45-54.

van Schoonhoven, A. and M. A. Pastor-Corrales, 1987. Standard system for the evaluation of bean germplasm. CIAT, Cali, Colombia. 53 pp.