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A comparison of web blight epidemics on common bean cultivars with different growth habits

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ABSTRACT

The progress of web blight caused by *Thanatephorus cucumeris* on common bean (*Phaseolus vulgaris*) "Carioca" cultivars with different growth habits was compared in a three-season study. Field trials were conducted in 2004/2005, 2005/2006 and 2006/2007 in a naturally infested area, with 10 susceptible cultivars from group I (determinate bush, upright plants: cvs. Iapar 81, BRS Horizonte and FT Magnífico); group II (indeterminate bush plants: cvs. BRS Pontal, and Pérola) and group III (plants of indeterminate prostrate growth: cvs. BRSMG Talismã, Aporé, BRS Requinte, Carioca, Carioca Precoce). Severity of web blight was assessed weekly and the resulting progress curves were fit to the monomolecular model. Overall disease impacts were estimated by the area under the disease progress curve (AUDPC), disease progress rate and disease onset. No significant interaction between AUDPC and planting season was detected. Cultivars BRS Horizonte, FT Magnífico and Iapar 81, with upright architecture, short guides, high pods and closer branches presented the lowest AUDPCs. The highest AUDPCs were found among indeterminate lodged plants with long guides and low pods (cvs Aporé and Carioca Precoce), while indeterminate bush cultivars were fitted in an intermediate rank. Differences in disease epidemics among the three groups were confirmed by intercept and disease progress rates of linearized models. Such parameters were significantly lower for upright genotypes, probably because they result in late contact between neighbor plants and consequently delay the establishment of conducive microclimate and mycelial bridges for web blight development. Yields were strongly reduced due to the extremely high disease levels that prevailed at all three seasons. Nevertheless, a negative correlation between grain yield and web blight severity was significant in 2006/2007. Despite the fact that the number of cultivars is too small to generalize responses on escape to web blight, results evidenced that choice of plant architecture is a useful strategy for web blight management.

1. Introduction

Web blight, caused by the soilborne fungus *Thanatephorus cucumeris* Frank (Donk) (anamorph = *Rhizoctonia solani* Kuhn), is a major disease on common beans (*Phaseolus vulgaris* L.) grown in several Brazilian warm and humid regions. The disease is also a limiting factor in other regions of Latin America, the Caribbean and Africa, as effective management is hardly achieved due to the pathogen's wide host range, long-lasting soilborne inoculum and high aggressiveness (Allen, 1987; Schwartz, 2005).

The disease has been a major limiting factor for sustainable yields especially at small scale farming. In the lowlands of the North and Mid-West Brazilian Regions, where web blight is endemic, yield losses can reach 100%. Even though disease conditions are not optimal, it still causes low productivity when it occurs together with other biotic and abiotic sources of plant stress, such as poor quality seeds (Paula et al., 1996).

There are some reports of resistant *P. vulgaris* genotypes and some breeding strategies for web blight tolerance or partial resistance, such as reduction in lesion size (Beaver et al., 2008, 2012; Montoya, 1997). However, according to Poltronieri and Oliveira (1990) all genotypes bred for resistance to web blight in other Latin American regions performed as highly susceptible in the Brazilian humid tropics. Pathogen variability and quantitative resistance are considered major impediments for achieving high levels of disease resistance (Godoy-Lutz et al., 2003; Gonzáles et al., 2012; Takegami et al., 2004). Consequently, to this date, no effective resistance to web blight has been incorporated into commercial cultivars (Takegami and Beaver, 2000).

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Disease avoidance by upright plant and open canopy architecture have been noted (Singh and Schwartz, 2010; Takegami and Beaver, 2000) as options for disease management, but have not been clearly demonstrated in the field. Moreover, even moderate decrease in disease levels based on architectural traits could be beneficial, when combined with other management strategies such as no-tillage cropping and fungicide sprays (Costa-Coelho et al., 2012; Galindo et al., 1983a).

Traditional Brazilian common bean cultivars in general exhibit indeterminate growth, with prostrate or semi-prostrate plants. Among them, those with the "Carioca" grain type (beige grains with dark brown stripes), of the Mesoamerican race of *P. vulgaris*, are preferred by consumers in most parts of the country accounting for approximately 70% of the domestic market. Therefore, those cultivars are responsible for most of the 3.1 million tons of common beans harvested annually in approximately 3.0 million ha, which places Brazil as the world's largest producer and consumer of *Phaseolus* beans. Despite the appreciation for cultivars with traditional plant architecture, all relevant domestic breeding programs are currently focused on releasing cultivars with upright architecture, to facilitate mechanical harvest.

Considering that web blight epidemics are influenced by long periods of leaf wetness, dense canopies and plant-to-plant infection through mycelial bridges (Schwartz, 2005), genotypes with upright architecture may induce a less favorable environment for the disease, in comparison to those of prostrate growth. To date, no detailed field study on the performance of common bean cultivars with distinct architecture and their reaction to web blight has been done. Given the lack of information on the subject, our objective was to estimate the progress of web blight epidemics and yield in 10 cultivars of the Carioca type of determinate bush, indeterminate bush and indeterminate prostrate habit, for three consecutive rainy seasons in an area endemic to the disease.

2. Materials and methods

Field trials were carried out in the 2004/05, 2005/06 and 2006/07 growing seasons in an area naturally infested by *T. cucumeris*, at the National Research Centre for Rice and Beans, in Santo Antônio de Goiás, GO, Brazil. The experimental field (16° 28′ 60″ S, 49° 7′ 00″ W, altitude of 823 m) had a total area of 3600 m^2 surrounded by native forest, where weeds, such as *Acanthospermum australe*, were commonly found infected by *T. cucumeris* (Costa et al., 2007).

Ten common bean cultivars of the Carioca type differing in growth habit and including one cultivar with an early crop cycle, were assessed. Cultivars were assigned to three groups according to Laing et al. (1984). Group I gathered cultivars of upright plants or "determinate bush": cvs. Iapar 81, BRS Horizonte and FT Magnífico; Group II assembled semi-prostrate or "indeterminate bush" cultivars: cvs. Pérola and BRS Pontal; and Group III, included indeterminate prostrate cultivars: cvs. Aporé, BRS Requinte, BRSMG Talismã, Carioca, and Carioca Precoce (an early cycle genotype). The experimental plots consisted of four 5 m rows, spaced 0.45 m apart, at an average density of 15 plants per meter after emergence. The experimental design was a randomized complete block with four replicates.

Fertilization at planting consisted of 500 kg ha^{-1} of NPK 03-17-00 + Zn. Potassium fertilizer was dispensed superficially, at 80 kg ha^{-1} with KCl, immediately after planting, and nitrogen topdressing was done at a rate of 100 kg ha^{-1} of urea, equally divided at 15 and 30 days after planting (DAP). Seeds were treated just before planting with imidacloprid (200 g 100 kg^{-1} of seeds), carbendazim + thiram (300 mL 100 kg^{-1} of seeds) and pencicuron (300 mL 100 kg^{-1} seed).

Crops were sown yearly in the third week of December when rain frequency was almost daily, in order to match crop development to weather conditions that favor rapid disease development. Crops were harvested manually in late February, and yields were estimated after adjustment of grain moisture to 13%. The experimental field remained under fallow in between planting seasons.

Web blight severity was recorded weekly with a disease scale, where 1 = no disease symptoms, 3 = up to 30% of diseased leaf area, 5 = 31–60% of diseased leaf area, 7 = 61–80% of diseased leaf area and 9 = over 80% of diseased leaf area (Van Schoonhoven and Pastor-Corrales, 1987). Following the method recommended by Madden et al. (2007), disease scale records were back transformed to mid-point percentage values for the estimation of the area under disease progress curve (AUDPC). AUDPCs were estimated according to Shaner and Finney (1977) and compared through analysis of variance by the GLM procedure and the Tukey test at $P = 0.05$ for mean separation, using the SAS 9.1 statistical package (SAS Institute, Cary, NC).

Combined web blight progress curves for each season were adjusted to logistic and monomolecular models, where regression residues and R^2 values were used to determine the best fit for the disease curves. Models were then linearized and the respective intercepts and disease progress rates were compared by analysis of covariance, with the REG and MIXED procedures, as suggested by Madden et al. (2007). Climate variables (number of rainy days, rainfall and averages of maximum temperatures) were recorded by an automatic weather station, located 500 m from the experimental field.

3. Results and discussion

Severe to very severe web blight epidemics developed in all cultivars and all three planting seasons, benefited by the wide distribution of local primary inoculum and weather favorable for disease development (Fig. 1, Table 1). Typical web blight symptoms were observed in all plots, with water-soaked symptoms developing from discrete lesions or from mycelial bridges, followed by abundant microsclerotia production and plant defoliation. Highest disease progress rates were associated with heavy rainfall (above 20 mm) during the flowering/pod filling stages (Table 1). In that stage, secondary infections were common, as a consequence of rain splash dispersal of microsclerotia formed on earlier diseased plants (Galindo et al., 1983b). Such pattern was also reported by Yang et al. (1990) for soybean (*Glycine max* (L.) Merr.), where profuse formation of microsclerotia was observed in frequent rainfall periods. According to Prabhu et al. (1983), web blight incidence may occur at any plant developmental stage, but it is usually observed in the field after blossom, reaching highest intensity at the full flowering and pod filling stages. In the present case, disease progress was also favored by a plant population that formed closed rows after flowering, in all treatments.

In 2004/05 (Fig. 1A), first web blight symptoms were recorded at 43 DAP. In the second and third seasons (Fig. 1B, C), the disease became visible soon after the primary leaves were set, at 7 DAP, but remained stable at low severity levels until 57 and 50 DAP, respectively, probably due to much drier and somewhat warmer conditions at late vegetative and flowering stages (Table 1). Sparser canopy during the early phenological stages in the second and third seasons may also have played a role in reducing web blight levels. Disease severity was higher in the first season than in the two subsequent seasons ($p < 0.0001$). Overall, a more frequent distribution of rainfall during 2004/05 may explain the higher disease severities recorded in this season, with fastest disease progress rates and, ultimately, the total collapse of almost all indeterminate-prostrate plants at 65 DAP.