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Resistance of common bean (*Phaseolus vulgaris*) cultivars to *Spodoptera frugiperda* (Lepidoptera: Noctuidae)

Resistencia de cultivares de frijol (*Phaseolus vulgaris*) a *Spodoptera frugiperda* (Lepidoptera: Noctuidae)

LÍGIA ALVES DE PAIVA[1], WANESSA DE CARVALHO RESENDE[2], CINTHIA LUZIA TEIXEIRA SILVA[2], ANDRÉ CIRILO DE SOUSA ALMEIDA[3], PAULO CESAR RIBEIRO DA CUNHA[4] and FLÁVIO GONÇALVES DE JESUS[4]

Abstract: *Spodoptera frugiperda* (Lepidoptera: Noctuidae) damages bean crops, resulting in decreased leaf area and destruction of reproductive structures. This study aimed to evaluate the types and levels of resistance of bean cultivars to *S. frugiperda*. The bean cultivars evaluated were: BRS Ametista, Pérola, BRS Notável, BRS Realce, Jalo Precoce, BRS Campeiro, BRS Agreste, BRS Cometa, BRS Executivo and BRS Pitanga, in the Laboratory of Agricultural Entomology of the Goiano Federal Institute, Urutaí Campus, Brazil. Tests to identify levels of antixenosis, in free-choice and no-choice tests, and antibiosis were performed in the laboratory (25 ± 2 °C, 70 ± 10 % R. H. and photophase of 14 h). The cultivars BRS Pitanga, BRS Executivo, BRS Notável and BRS Campeiro presented antixenosis and BRS Realce antibiosis to *S. frugiperda*. However, it is not known whether the levels of resistance exhibited in the laboratory are sufficiently high to be of any economic value to agriculture. Therefore, the next step is to evaluate, under field conditions, the cultivars showing the most resistance in laboratory tests. If field evaluations indicate sufficient levels of resistance to be of practical value, these cultivars may be used as donor sources in the breeding program or may be used directly by farmers.

Key words: Fall armyworm, antibiosis, antixenosis, host plant resistance**.**

Resumen: *Spodoptera frugiperda* (Lepidoptera: Noctuidae) es una plaga que provoca daños en los cultivos de fríjol al reducir el área foliar y destruir las estructuras reproductivas. Este trabajo tuvo como objetivo evaluar los tipos y niveles de resistencia de cultivares de frijol a *S. frugiperda*. Los cultivares evaluados fueron: BRS Ametista, Pérola, BRS Notável, BRS Realce, Jalo Precoce, BRS Campeiro, BRS Agreste, BRS Cometa, BRS Executivo y BRS Pitanga, en el Laboratorio de Entomología Agrícola del Instituto Federal Goiano, Campus de Urataí, Brasil. Antixenosis, a libre y no libre escogencia y antibiosis se evaluaron en laboratorio (25 ± 2 °C, 70 ± 10 % HR y fotoperiodo 14 h). Los cultivares BRS Pitanga, BRS Executivo, BRS Notável y BRS Campeiro presentaron antixenosis y BRS Realce antibiosis a *S. frugiperda*. Sin embargo, no se sabe si los niveles de resistencia, exhibidos en el laboratorio, son suficientemente altos que representen un valor económico de campo para los agricultores. Por lo tanto, el próximo paso es evaluar, en condiciones de campo, los cultivares que mostraron mayor resistencia en las pruebas de laboratorio. Si las evaluaciones de campo indican niveles de resistencia suficientes, para tener un valor práctico, estos cultivares pueden utilizarse como fuentes en el programa de mejoramiento o ser utilizados directamente por los agricultores.

Palabras clave: Cogollero del maíz, antibiosis, antixenosis, resistencia de plantas a insectos.

Introduction

The common bean (*Phaseolus vulgaris* L.) has a high economic and social importance in Brazil, because of its nutritional properties and the labor employed in its cultivation (Pedrosa *et al*. 2015). However, pest insects attacks cause losses in crop productivity (Jesus *et al.* 2010a, b; Janini *et al.* 2011). Among the insect pests attacking common bean, the fall armyworm - *Spodoptera frugiperda* (J. E. Smith, 1797) (Lepidoptera: Noctuidae) is of major importance because the feeding damage results in leaf area reduction and destruction of the reproductive structures.

Spraying of insecticides is the most common means of controlling *S. frugiperda*. However, this practice contributes to unbalanced agroecosystems (Bernardi *et al.* 2012) and the selection of insect resistant populations (Cruz *et al.* 2010). The use of alternative pest control methods, such as plant resistance to insects, is an important component in an integrated pest management (IPM) approach (Jesus *et al.* 2010a, b; Janini *et al.* 2011; Silva *et al.* 2016).

Plant resistance to insects (PRI) is considered an efficient method of pest control. PRI maintains the pest population below the level of economic damage, does not cause adverse effect on the environment, does not incur additional cost and may be compatible with other control methods (Lara 1991; Smith 2005; War *et al.* 2012; Seifi *et al.* 2013).

Plant resistance mechanisms are classified as antixenosis, antibiosis and tolerance. Antixenosis occurs when there is a deterrence of the plant for feeding, oviposition or shelter. Antibiosis is characterized by detrimental effects on insect biology and tolerance is the plant capacity to endure or recover from insect caused damage, through the production of new vegetative or reproductive structures (Gatehouse 2002; Cunningham 2012; War *et al*. 2012; Seifi *et al*. 2013).

[1] M. Sc. Universidade Estadual de Goiás, Campus Ipameri, Rodovia GO 330, Km 241, Setor Universitário - CEP 75780-000, Ipameri, Goiás, Brazil, *ligia.agropaiva@outlook.com.* [2] Agronomy, Instituto Federal Goiano, Campus Urutaí, Goiás, Brazil, *wanessaresende_wr@hotmail.com, cinthiateixeirasilva@hotmail.com*. [3] M. Sc. Instituto Federal Goiano, Campus Urutaí, Rodovia Prof. Geraldo Silva Nascimento, km 2,5 - CEP: 75790-000, Urutaí, Goiás, Brazil, *andre_cirillo@ hotmail.com*. [4] Ph. D. Instituto Federal Goiano, Campus Urutaí, Rodovia Prof. Geraldo Silva Nascimento, km 2,5 - CEP: 75790-000, Urutaí, Goiás, Brazil, *pcdacunha@hotmail.com, fgjagronomia@zipmail.com.br.* Corresponding author: André Cirilo de Sousa Almeida. M. Sc. Instituto Federal Goiano, Campus Urutaí, Rodovia Prof. Geraldo Silva Nascimento, km 2,5 - CEP: 75790-000, Urutaí, Goiás, Brazil, *andre_cirillo@ hotmail.com*.

Several studies to select bean genotypes resistant to stored grain pests have been conducted. However, few studies have examined insects that attack bean plants in the field. Considering the importance of bean crops for food security in Brazil, and the damage caused by defoliating caterpillars that injure reproductive structures, the selection of resistant genotypes is an important IPM strategy (Maldonado *et al*. 1996; Bottega *et al*. 2011; Boiça Júnior *et al*. 2015).

In previous studies the bean genotypes IAC Jabola, Arcelina 1, IAC Boreal, Flor de Mayo and IAC Formoso have been reported to present antixenosis to oviposition, and Arcelina 4, BRS Horizonte, Pérola, H96A102-1-1-1-52, IAC Boreal, IAC Harmonia and IAC Formoso presented antixenosis to feeding by *Chrysodeixis includens* (Walker, 1858) (Lepidoptera: Noctuidae) (Morando *et al*. 2015). Our study was conducted to identify resistance in common bean cultivars to *S. frugiperda.* In this preliminary study, leaves of the common bean were evaluated for antixenosis and antibiosis in the laboratory. Further field evaluations will be based on the results of this study.

Materials and methods

The experiments were conducted in a climate-controlled room (25 ± 1 °C, 70 ± 10 % RH and a 12-h photophase) at the Laboratory of Agricultural Entomology of the Goiano Federal Institute, Urutaí Campus, Brazil. The test varieties were obtained from the germplasm bank of the National Center of Research Rice and Beans - EMBRAPA Rice and Beans, Santo Antonio de Goiás, Goiás, Brazil. The following common bean cultivars were evaluated: BRS Ametista, Pérola, BRS Notável, BRS Realce, Jalo Precoce, BRS Campeiro, BRS Agreste, BRS Cometa, BRS Executivo and BRS Pitanga. These varieties were selected because common bean producers in Brazil currently cultivate them.

To rear *S. frugiperda,* adults collected in the field were placed in cages of polyvinyl chloride (PVC) tubes (10 cm in diameter and 21.5 cm high) covered internally with white paper sheets, which served as oviposition sites (Campos *et al*. 2012; Jesus *et al*. 2014). The newly hatched larvae were placed on artificial diet for rearing (Greene *et al*. 1976). The common bean cultivars were sown in 5 L plastic pots containing soil, manure and sand (2:1:1) mixture as substrate. Following germination, plants were thinned to one plant per pot, and grown in a greenhouse until 30 days after emergence (DAE).

Antixenosis. Attractiveness of the cultivars in a free-choice test was determined by releasing 20 third instar *S. frugiperda* larvae per cultivar. Bean leaves were collected from plants at 30 DAE, washed with distilled water, cut into 2.5 cm^2 leaf disks, and distributed in a circular manner, over moistened filter paper, in a Petri dish (14 cm diameter). A randomized block design, with ten replicates, was used for this bioassay.

The attractiveness in a no-choice test was performed by offering the same cultivars individually. The leaves were collected and prepared as described for the previous test. One leaf disk was placed on moistened filter paper Petri dish (6 cm diameter) and one third instar larva was placed in each petri dish. A completely randomized experimental design was used with 15 replicates.

For both tests the attractiveness of *S. frugiperda* was evaluated at 3, 5, 10, 15 and 30 minutes, as well as at 1, 3, 6 and 12 hours following caterpillar release by counting the number of insects attracted to the leaf disk of each cultivar at each time period. The tests were completed at 12 hours following caterpillar release.

Antibiosis. Newly hatched *S. frugiperda* larvae were placed in Petri dishes (6 cm in diameter) containing moistened filter paper and sealed with polyethylene film. The larvae were fed with a trifoliate leaf collected from the plant apex which were replaced daily or after consumption. Larvae were kept in the Petri dishes until the pupal stage when the leaf supply was terminated. Adults (moths) were not fed.

The following biological parameters were recorded: 13-day-old larva weight (mg), larval and pupal stage duration (days), pupal weight (mg), adult longevity (days), larval and pupal viability (percent that completed the larval and pupal stage respectively), and total life cycle (days). A completely randomized experimental design was used with 25 replicates.

Statistical analysis. The data were subjected to an analysis of variance (ANOVA) and the means were compared using the Tukey's test at 5 % probability in Sisvar 5.3 (Ferreira 2011). A principal component analysis and a cluster analysis test were performed, and dissimilarity was measured using Euclidean distances to identify groups of common bean cultivars with different degrees of resistance (StatSoft 2004).

Results and discussion

The free-choice attractiveness test revealed differences among the common bean cultivars tested to *S. frugiperda* at 5 and 30 minutes, as well as at 3, 6 and 12 hours (Table 1). At 5 min larvae of *S. frugiperda* were not attracted by cultivars BRS Ametista, Pérola, BRS Notável, BRS Agreste, BRS Cometa and BRS Pitanga. BRS Realce and Jalo Precoce were the most attractive at 5 min. At 30 min Pérola, BRS Executivo and BRS Pitanga were not infested and Jalo Precoce and BRS Campeiro were the most attractive cultivars to *S. frugiperda*. At 3 h all genotypes were not infested by *S. frugiperda* except BRS Agreste and BRS Campeiro. At 3 h the cultivar BRS Campeiro showed the most attractiveness to *S. frugiperda*. Overall , the cultivars BRS Pitanga and BRS Executivo were the least attractive to *S. frugiperda*. BRS Campeiro was the most attractive.

The no-choice attractiveness test revealed significant differences between the cultivars at 5, 15 and 30 min. At 5 min BRS Notável, BRS Campeiro, BRS Executivo were not infested and BRS Agreste was the most attractive to *S. frugiperda*. At 15 min Pérola, BRS Notável, BRS Realce, Jalo Precoce, BRS Campeiro and BRS Pitanga were not infested and BRS Agreste was the most attractive and 30 min Pérola had low larval numbers and BRS Agreste again was the most attractive cultivar to *S. frugiperda*. Generally, BRS Notável, BRS Campeiro, BRS Executivo and BRS Pitanga cultivars were the least attractive to *S. frugiperda* and BRS Agreste was the most attractive.

BRS Pitanga, BRS Executivo and BRS Campeiro cultivars showed antixenosis to *S. frugiperda* (Tables 1 and 2). This indicates the presence of chemical compounds and/or morphological leaf characteristics in these cultivars that are repellent to *S. frugiperda* (Cunningham 2012). Few studies have characterized the types of resistance present in common bean cultivars upon defoliating insects. Morando *et al*.

Table 1. Number (± SEM) of third instar *Spodoptera frugiperda* larvae on leaves of different common beans cultivars at a given time in a free-choice test.

Cultivars	Time in minutes			
	5	10	15	30
BRS Ametista	0.00 ± 0.00 b	0.00 ± 0.00	0.20 ± 0.13	0.10 ± 0.10 ab
Pérola	0.00 ± 0.00 b	0.10 ± 0.10	0.10 ± 0.10	0.00 ± 0.00 b
BRS Notável	0.00 ± 0.00 b	0.20 ± 0.13	0.10 ± 0.10	0.20 ± 0.13 ab
BRS Realce	0.50 ± 0.22 a	0.10 ± 0.10	0.30 ± 0.21	0.30 ± 0.15 ab
Jalo Precoce	0.50 ± 0.22 a	0.20 ± 0.13	0.60 ± 0.22	0.70 ± 0.21 a
BRS Campeiro	0.30 ± 0.15 ab	0.10 ± 0.10	0.30 ± 0.21	0.70 ± 0.26 a
BRS Agreste	0.00 ± 0.00 b	0.20 ± 0.13	0.10 ± 0.00	0.10 ± 0.10 ab
BRS Cometa	0.00 ± 0.00 b	0.10 ± 0.10	0.00 ± 0.10	0.10 ± 0.10 ab
BRS Executivo	0.10 ± 0.10 ab	0.10 ± 0.10	0.10 ± 0.10	0.00 ± 0.00 b
BRS Pitanga	0.00 ± 0.00 b	0.00 ± 0.00	0.10 ± 0.10	0.00 ± 0.00 b
F (trat.)	3.14 *	0.57 NS	1.39 NS	4.03 *
C.V (%)	23.34	20.77	27.70	25.12

Cultivars	Time in hours			
	1	3	6	12
BRS Ametista	0.10 ± 0.10	0.00 ± 0.00 b	0.20 ± 0.13 ab	0.20 ± 0.26 ab
Pérola	0.00 ± 0.00	0.00 ± 0.00 b	0.30 ± 0.15 ab	0.30 ± 0.15 ab
BRS Notável	0.00 ± 0.00	0.00 ± 0.00 b	0.70 ± 0.21 ab	0.70 ± 0.29 ab
BRS Realce	0.20 ± 0.13	0.00 ± 0.00 b	0.10 ± 0.10 ab	0.10 ± 0.10 ab
Jalo Precoce	0.30 ± 0.15	0.00 ± 0.00 b	0.20 ± 0.13 ab	0.20 ± 0.00 ab
BRS Campeiro	0.80 ± 0.51	0.80 ± 0.13 a	0.80 ± 0.33 a	0.80 ± 0.27 a
BRS Agreste	0.20 ± 0.13	0.20 ± 0.13 ab	0.40 ± 0.22 ab	0.40 ± 0.22 ab
BRS Cometa	0.00 ± 0.00	0.00 ± 0.00 b	0.30 ± 0.15 ab	0.30 ± 0.15 ab
BRS Executivo	0.00 ± 0.00	0.00 ± 0.00 b	0.10 ± 0.10 ab	0.10 ± 0.10 ab
BRS Pitanga	0.10 ± 0.10	0.00 ± 0.00 b	0.00 ± 0.00 b	0.00 ± 0.00 b
F (trat.)	1.77 NS	16.31 *	2.30 *	3.38 *
C.V. (%)	29.06	13.56	29.91	29.51

[1] Means followed by the same letter are not different by Tukey's test at the 5 % probability level. Data were transformed to (x + 0.5) 1/2) for analysis purposes. * Significant at 5 % probability. NS Non-significant.

(2015) reported antixenosis to *C. includens* in H96A102-1-1-1-52, Flor de Mayo and Arcelina 4 genotypes. Boiça Junior *et al*. (2015) observed antixenosis in IAC Una, IAC Uirapuru, IAC Diplomata and IAC Onix cultivars and tolerance in IAC Onix and IAC Una upon *Diabrotica speciosa* (Germar, 1924) (Coleoptera: Chrysomelidae).

The hierarchical cluster analysis performed for both attractiveness and antixenosis resistance against the third-instar larvae of *S. frugiperda* that were evaluated at different time periods in free-choice and no-choice tests revealed significant differences between the tested cultivars, separating them into groups according to their degree of similarity (Fig. 1). BRS Pitanga, Perola, BRS Ametista and BRS Executivo at Euclidean distance 3.3, 3.5 and 4.7, respectively, were grouped indicating similarity among these cultivars (Fig. 1). The second group was formed by BRS Cometa and BRS Notável at Euclidean distance 4.7, and the third group included Jalo Precoce and BRS Realce at Euclidean distance 4.9. Finally, all the cultivars were grouped at 7.4 (Fig. 1).

Considering a Euclidean distance of 5.0 as the criterion for group division, the tested cultivars were separated according

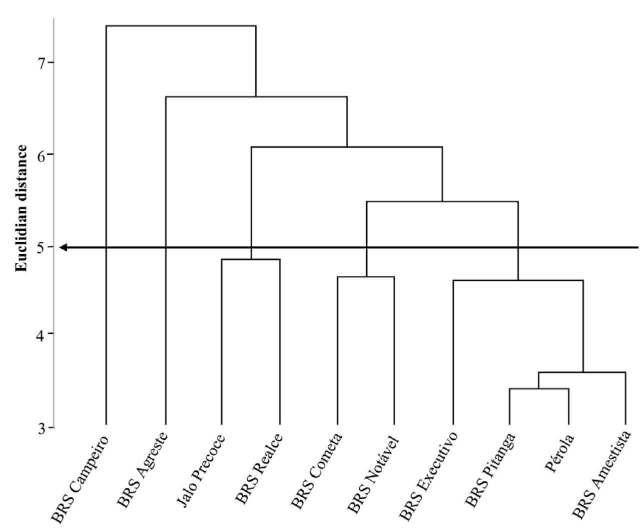

Figure 1. Dendrogram based on attractiveness of third instar *Spodoptera frugiperda* in free and non-choice tests by common bean. The hierarchical cluster analysis was carried out using the Ward's method with the Euclidean distance as dissimilarity measure. The arrow indicates the Euclidean distance used for the separation of groups (phenon line).

Table 2. Number of third instar *Spodoptera frugiperda* larvae (± SEM) on leaves of different common beans cultivars in a no-choice test.

Cultivars	Time in minutes[1]			
	5	10	15	30
BRS Ametista	0.26 ± 0.14 ab	0.20 ± 0.13	0.26 ± 0.14 ab	0.20 ± 0.13 ab
Pérola	0.20 ± 0.13 ab	0.13 ± 0.11	0.06 ± 0.08 b	0.00 ± 0.00 b
BRS Notável	0.06 ± 0.08 b	0.20 ± 0.13	0.13 ± 0.11 b	0.20 ± 0.13 ab
BRS Realce	0.20 ± 0.13 ab	0.13 ± 0.11	0.13 ± 0.11 b	0.13 ± 0.11 ab
Jalo Precoce	0.33 ± 0.15 ab	0.33 ± 0.15	0.13 ± 0.11 b	0.20 ± 0.13 ab
BRS Campeiro	0.06 ± 0.08 b	0.20 ± 0.13	0.06 ± 0.08 b	0.33 ± 0.15 ab
BRS Agreste	0.60 ± 0.16 a	0.53 ± 0.16	0.60 ± 0.16 a	0.53 ± 0.16 a
BRS Cometa	0.33 ± 0.15 ab	0.20 ± 0.13	0.46 ± 0.16 ab	0.33 ± 0.15 ab
BRS Executivo	0.06 ± 0.08 b	0.13 ± 0.11	0.33 ± 0.15 ab	0.46 ± 0.16 ab
BRS Pitanga	0.06 ± 0.08 b	0.06 ± 0.08	0.06 ± 0.08 b	0.13 ± 0.11 ab
F (trat.)	2.86 *	1.61 NS	3.38 *	2.24 *
C.V. (%)	24.84	25.55	24.66	25.99
Cultivars	**Time in hours**			
	1	**3**	**6**	**12**
BRS Ametista	0.13 ± 0.11	0.46 ± 0.16	0.60 ± 0.16	0.73 ± 0.14
Pérola	0.06 ± 0.08	0.26 ± 0.14	0.66 ± 0.15	0.60 ± 0.16
BRS Notável	0.33 ± 0.15	0.26 ± 0.14	0.40 ± 0.16	0.86 ± 0.11
BRS Realce	0.26 ± 0.14	0.13 ± 0.11	0.40 ± 0.16	0.46 ± 0.16
Jalo Precoce	0.26 ± 0.14	0.20 ± 0.13	0.60 ± 0.16	0.80 ± 0.13
BRS Campeiro	0.26 ± 0.14	0.26 ± 0.14	0.46 ± 0.16	0.86 ± 0.11
BRS Agreste	0.33 ± 0.15	0.40 ± 0.16	0.60 ± 0.16	0.73 ± 0.14
BRS Cometa	0.40 ± 0.16	0.26 ± 0.14	0.46 ± 0.16	0.60 ± 0.16
BRS Executivo	0.13 ± 0.11	0.53 ± 0.16	0.86 ± 0.11	0.86 ± 0.11
BRS Pitanga	0.00 ± 0.00	0.26 ± 0.14	0.66 ± 0.15	0.80 ± 0.13
F (trat.)	1.50 NS	1.05 NS	1.29 NS	1.47 NS
C.V. (%)	25.81	27.61	25.36	20.84

[1] Means followed by the same letter are not different by Tukey's test at the 5 % probability level. Data were transformed to ((x + 0.5)1/2) for analysis purposes. * Significant at 5 % probability. NS Non-significant.

Table 3. Larval and pupal period (days) and larval and pupal weight (mg) of *Spodoptera frugiperda* (Lepidoptera: Noctuidae) fed on common bean cultivars.

Cultivars	Larval period	Larval weight	Pupal period	Pupal weight
BRS Ametista	23.6 ± 2.84 ab	0.156 ± 0.03	9.1 ± 0.39 ab	156.0 ± 0.01
Pérola	19.1 ± 0.62 b	0.172 ± 0.04	9.3 ± 0.48 ab	153.0 ± 0.01
BRS Notável	18.7 ± 0.47 b	0.276 ± 0.04	10.3 ± 0.29 ab	163.0 ± 0.01
BRS Realce	27.2 ± 1.24 a	0.104 ± 0.02	14.5 ± 6.26 a	161.0 ± 0.02
Jalo Precoce	19.2 ± 0.63 b	0.217 ± 0.03	7.7 ± 0.28 b	131.0 ± 0.01
BRS Campeiro	18.3 ± 0.76 b	0.222 ± 0.04	10.0 ± 0.17 ab	164.0 ± 0.01
BRS Agreste	20.0 ± 0.79 b	0.777 ± 0.70	9.5 ± 0.34 ab	148.0 ± 0.01
BRS Cometa	19.5 ± 0.99 b	0.179 ± 0.02	10.6 ± 0.48 ab	151.0 ± 0.00
BRS Executivo	22.2 ± 0.80 b	0.333 ± 0.02	10.7 ± 0.28 ab	153.0 ± 0.02
BRS Pitanga	21.1 ± 0.86 b	0.180 ± 0.03	10.2 ± 0.81 ab	143.0 ± 0.00
F (trat.)	4.87 *	1.04 NS	4.41 *	0.76 NS
C.V. (%)	18.00	28.86	36.93	22.04

[1] Means followed by the same letter are not different by Tukey's test at the 5 % probability level. Data were transformed to (x + 0.5)1/2) for analysis purposes. * Significant at 5 % probability. NS Non-significant.

Table 4. Larval and pupal viability (%) (± SEM) and adult longevity (days) of *Spodoptera frugiperda* (Lepidoptera: Noctuidae) fed on common bean cultivars.

Cultivars	Larval viability	Pupal viability	Adult longevity
BRS Ametista	36.00 ± 5.00	32.00 ± 6.00	3,80 ± 0,29 [ab]
Pérola	36.00 ± 5.00	32.00 ± 6.00	3.10 ± 0.15 [b]
BRS Notável	60.00 ± 10.00	56.00 ± 8.00	5.20 ± 0.25 [a]
BRS Realce	48.00 ± 8.00	40.00 ± 8.00	4.20 ± 0.25 [ab]
Jalo Precoce	36.00 ± 5.00	32.00 ± 6.00	3.50 ± 0.38 [ab]
BRS Campeiro	44.00 ± 7.00	36.00 ± 5.00	4.20 ± 0.24 [ab]
BRS Agreste	36.00 ± 5.00	32.00 ± 6.00	4.00 ± 0.29 [ab]
BRS Cometa	48.00 ± 8.00	44.00 ± 8.00	4.50 ± 0.23 [ab]
BRS Executivo	40.00 ± 6.00	36.00 ± 5.00	4.10 ± 0.26 [ab]
BRS Pitanga	48.00 ± 8.00	44.00 ± 8.00	4.20 ± 0.25 [ab]
F (trat.)	1.12 [NS]	1.44 [NS]	4.82 *
C.V. (%)	32.33	30.32	29.32

[1] Means followed by the same letter are not different by Tukey's test at the 5 % probability level. Data were transformed to (x + 0.5)1/2) for analysis purposes. * Significant at 5 % probability. [NS] Non-significant.

to the level of antixenosis resistance as follows: moderately resistant - BRS Campeiro and BRS Agreste; susceptible - Jalo Precoce, BRS Realce, BRS Cometa and BRS Notável; and highly susceptible - BRS Executivo, BRS Pitanga, Pérola and BRS Ametista.

Comparing the results of the hierarchical cluster analysis with those of the free choice and no-choice attractiveness tests, BRS Campeiro was found to be one of the most attractive cultivar to *S. frugiperda* in free-choice test, despite its inclusion in the moderately resistant group (Table 1 and Fig. 1).

The common bean cultivars presented a significant effect on the biological parameters of *S. frugiperda* (Table 3). The larvae fed on cultivar BRS Realce presented a longer larval stage compared to the remaining cultivars, except for BRS Ametista. The larval phase prolongation in *S. frugiperda* caused by BRS Realce is characteristic of antibiosis (Smith 2005; Seifi *et al*. 2013). This data is in agreement with those of Jesus *et al.* (2014) that found antibiosis on cotton cultivar Nuopal to *S. frugiperda* that completed the larval stage in 23.3 days. Paiva *et al.* (2016) observed that *S. frugiperda* completed the same stage in BX 1293 YG antibiosis resistant corn in 31.85 days. Larvae of *S. frugiperda* fed on artificial diet had their larval stage completed in 16 days (Silva *et al*. 2016).

The pupae originating from larvae fed on BRS Realce also presented an extended pupal stage that was 6.8 days longer than those from Jalo Precoce. The adults presented a higher longevity after feeding on BRS Notável compared to Pérola (Table 4). The same authors mentioned previously found extension in the life cycle of *S. frugiperda* when fed on resistant plants. It is important to use as IPM tactic because over time there is a reduction in the population density of the pest (Gatehouse 2002).

The observed extension of the larval and pupal stages on *S. frugiperda* fed on BRS Realce indicates a detrimental effect

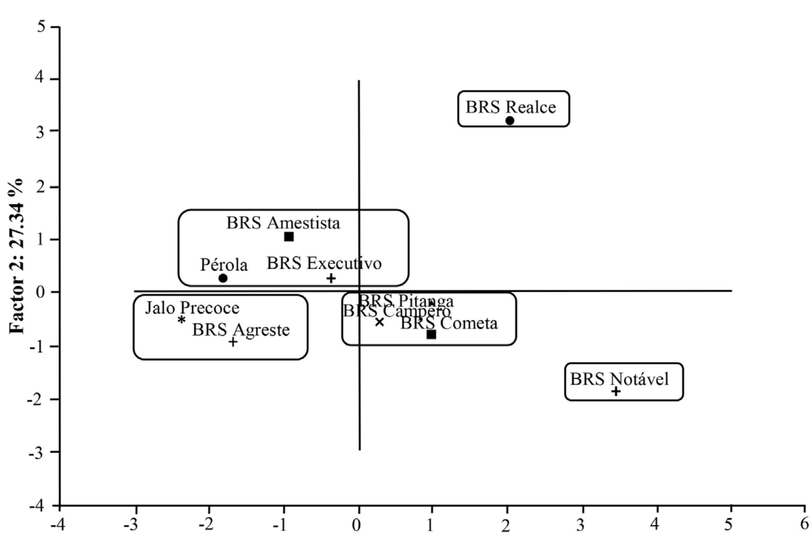

Figure 2. Distribution of the common bean cultivars according to principal component analysis based on biological parameters of *Spodoptera frugiperda*.

of the plant on their biology. *S. frugiperda* needed more time to complete the larval and pupal stages than those feeding on a susceptible cultivar. Delays on *S. frugiperda* development are usually associated with antibiosis. Antibiosis is characterized by an extension on the larval stage when the insect feeds on a resistant host plant. This results in negative effects on initial insect developmental stages, such as high mortality, deformities and decreased body weight (Lara 1991; War *et al*. 2012; Seifi *et al*. 2013).

The principal component analysis separated the bean cultivars into four levels of antibiosis resistance: highly resistant - BRS Notável; moderately resistant - BRS Pitanga, BRS Campeiro, BRS Cometa and BRS Realce; susceptible - BRS Ametista, BRS Executivo and Pérola; and highly susceptible - Jalo Precoce and BRS Agreste (Fig. 2).

Conclusions

The cultivars BRS Pitanga, BRS Executivo, BRS Notável and BRS Campeiro presented antixenosis and BRS Realce antibiosis to *S. frugiperda* under laboratory conditions. However, it is not known whether the levels of resistance, exhibited in the laboratory, are sufficiently high, to be of any economic value in farmers' fields. Therefore, the next step is to evaluate, under field conditions, the cultivars showing the most resistance in the laboratory tests. If field evaluations indicate sufficient levels of resistance, to be of practical value, these cultivars may be used as donor sources in the breeding program or used directly by farmers.

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