Demographic parameters of cowpea aphids on advanced semi-erect cowpea lines

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Abstract – The objective of this work was to evaluate the resistance of advanced semi-erect cowpea (*Vigna unguiculata*) lines, by means of a screening assay for resistance and the elaboration of fertility-life tables of *Aphis craccivora* (Hemiptera: Aphididae). The experiments were carried out in a screenhouse. For the resistance trial, 15 advanced cowpea lines were used, as well as two standard genotypes for resistance and two for susceptibility, which were arranged in six blocks. After resistance was determined, two lines with the highest and lowest resistance were selected for the development of the fertility-life tables which were used to estimate demographic parameters. The MNCO4-762F-03 and MNCO4-762F-09 cowpea lines were classified as resistant, for which cowpea aphids showed the lowest values (in parentheses, respectively) for: net reproductive rate (R_O = 3.0 and 2.5), intrinsic rate of increase (r_m = 0.16 and 0.15), and finite rate of increase (λ = 1.18 and 1.16). The highest values were obtained for the 'Vita-7', MNCO4-795F-168, and 'BRS Tumucumaque' genotypes. The MNCO4-762F-03 and MNCO4-762F-09 lines show antibiosis-type resistance, which directly affects the reproductive potential of the cowpea aphid population.

Index terms: *Aphis craccivora*, *Vigna unguiculata*, fecundity, plant health, plant resistance.

Parâmetros demográficos do pulgão-preto em linhagens avançadas de feijão-caupi de porte semiereto

Resumo – O objetivo deste trabalho foi avaliar a resistência de linhagens avançadas de feijão-caupi (*Vigna unguiculata*) de porte semiereto, por meio de ensaio de resistência e elaboração de tabelas de vida de fertilidade de *Aphis craccivora* (Hemiptera: Aphididae). Os experimentos foram realizados em telado. Para o ensaio de resistência, utilizaram-se 15 linhagens avançadas de feijão-caupi, assim como dois genótipos-padrão de resistência e dois de susceptibilidade, os quais foram distribuídos em seis blocos. Após ter-se determinado a resistência, selecionaram-se as duas linhagens com o maior e o menor grau de resistência, para compor o ensaio destinado à elaboração de tabelas de vida de fertilidade que foram utilizadas para estimar os parâmetros demográficos. As linhagens de feijão-caupi MNCO4-762F-03 e MNCO4-762F-09 foram classificadas como resistentes, nas quais, o pulgão-preto apresentou os menores valores (nos parênteses, respectivamente) de: taxa líquida de reprodução (R_O = 3,0 e 2,5); taxa intrínseca de crescimento (r_m = 0,16 e 0,15); e razão finita de crescimento (λ = 1,18 e 1,16). Os maiores valores foram obtidos nos genótipos 'Vita-7', MNCO4-795F-168 e 'BRS Tumucumaque'. As linhagens MNCO4-762F-03 e MNCO4-762F-09 apresentam resistência do tipo antibiose, o que afeta diretamente o potencial reprodutivo da população de pulgão-preto.

Termos para indexação: *Aphis craccivora*, *Vigna unguiculata*, fecundidade, fitossanidade, resistência de plantas.

Introduction

Cowpea, *Vigna unguiculata* (L.) Walp., is one of the most widely cultivated legumes in tropical and subtropical regions worldwide (Torres et al., 2015). In Brazil, according to Freire Filho et al. (2017), cowpea has been cultivated by small family farmers and also by medium- and large-scale producers in the Brazilian Cerrado soils of the North, Northeast, and Central-West regions, for which the planted area and productivity of cowpea was 40.636 ha and 810 kg ha^{-1}, 980.69 ha and 303 kg ha^{-1}, and 109.27 ha and 982 kg ha^{-1}, respectively, during the period between 2010 and 2014.

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Among the limiting factors of cowpea cultivation is infestation by the cowpea aphid *Aphis craccivora* Koch (Hemiptera: Aphididae), considered a key-crop pest (Moraes & Bleicher, 2007; Huynh et al., 2015) that causes direct injury by sucking sap, and indirect damages through virus transmission (Oliveira et al., 2012).

Cowpea aphid control is carried out using chemical insecticides, although few compounds used against this pest have been registered (Agrofit, 2016). In addition to increasing the cost of production, these pesticides might cause serious unwanted side effects, including insect resistance. A safer alternative for both the environment and producers would be to use crop plants with genetic resistance to this insect.

In this regard, there is a previously report on the *V. unguiculata* resistance to *A. craccivora* (Singh, 1977) whose trial was carried out in a greenhouse, and five genotypes resistant to the aphids were found, among which was TVu 408 P_2. The authors also concluded that antibiosis was the probable cause of resistance, as a severe aphid mortality was observed.

Subsequently, Pathak (1988) reported the occurrence of two dominant and independent genes, Ra_C1 and Ra_C2, controlling the resistance of African *V. unguiculata* genotypes to *A. craccivora*, based on quantitative studies, which was also related to the segregation of populations derived from resistant and susceptible parental crosses. Cowpea resistance to the cowpea aphid is considered a dominant trait controlled by two genes, one poorly and one highly expressed, which has been confirmed by the quantitative trait loci (QTL) analysis (Huynh et al., 2015).

In Brazil, there have been numerous studies for the identification of the resistance sources of *V. unguiculata* to *A. craccivora*, particularly in the last decade (Moraes & Bleicher, 2007; Silva & Bleicher, 2010; Rodrigues et al., 2012; Silva et al., 2012; Bandeira et al., 2015; Melville et al., 2016). These authors have reported a genetic diversity in the cowpea resistance against the cowpea aphid, and sources of resistance to this insect have been observed in both newly imported and landrace varieties.

The incorporation of resistance to cowpea aphid in future cultivars should be a routine criterion in breeding programs. However, the genetics of resistance and insect characteristics, such as thelytokous parthenogenesis, should serve as a warning of the potential for the resistance of genotypes to insect outbreaks, as mentioned by Aliyu & Ishiyaku (2013) and Souleymane et al. (2013). Therefore, the use of methodologies that facilitate the evaluation of a large number of genotypes, with greater scientific rigor and which are of low cost, are necessary to identify resistant genotypes and resistance break down.

However, cowpea breeding programs in Brazil have not evaluated advanced lines for resistance to this important pest, which should be included in the value for cultivation and use (VCU) testing required to launch a new cultivar. This implies the serious risk of launching a more susceptible cultivar in the market than the existing ones, which could result in additional costs to producers and the environment.

The objective of this work was to evaluate the resistance of advanced semi-erect *V. unguiculata* lines, by means of a resistance screening assay, and the elaboration of fertility-life tables of *A. craccivora*.

Materials and Methods

The study was carried out at Centro de Ciências Agrárias of Universidade Federal do Ceará, located in the municipality of Fortaleza, in the state of Ceará, Brazil (3°40'24"S, 38°34'32"W, at 12 m altitude). The experiments were performed at room temperature in a screenhouse, with side walls covered with an anti-aphid screen and the upper part with 200-µ thick plastic.

For the research, two screenings were performed. In the first, insect resistance was screened to verify the resistance or susceptibility of advanced cowpea lines. In the second, the aim of the screening was to develop fertility-life tables for estimating the aphid's demographic parameters.

The initial assay included the screening of 15 advanced semi-erect cowpea lines and four genotypes used as control groups: two cultivars, standard susceptible genotypes (BR – 17 Gurguéia and VITA 7), one cultivar and one standard resistant genotype ('BRS Guariba' and TVu 408 P_2) with respect to *A. craccivora* (Singh, 1977; Moraes & Bleicher, 2007; Silva & Bleicher, 2010), totaling 19 sample materials (Table 1). These samples were provided by the genetic breeding program of Embrapa Meio Norte.

Cowpea plants were grown in 300 mL polyethylene pots with three holes in the base. These pots were filled with a substrate composed of subsoil soil, earthworm

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humus, and vermiculite in a 6:3:1 ratio. A completely randomized block statistical design with six replicates was used, and each plant of a particular treatment was considered a plot.

For experimental purposes, the age of aphid breeding colony was standardized before infestation, so that all insects ranked into the same age group. To achieve age synchronization, fourteen-day-old plants of cowpea 'Vita-7' were infested with adult aphids, which were removed after 24 hours. The nymphs produced during this period were used in the treatments when they reached the adult stage.

Planting was carried out with two seeds sown per pot; plants were thinned five days later, and only one seedling was left in each pot. On the 12th day after planting, the plants were infested with the age-synchronized aphids. Five apterous, shiny black, six-day-old adult females from the breeding colony were deposited on each plant. After infestation, the pots of each treatment were placed on benches to form the blocks that were equidistantly separated and covered with a 1.0x1.0x0.5 m cage.

Resistance was evaluated in two steps, one at 48 hours after infestation, during which the number of live adults was recorded, followed by their removal from the plants. The second one was performed 96 hours after infestation, at which time the number of live nymphs was counted.

To assess the resistance between treatments, the numbers of adults and nymphs were transformed using the formula $(X + 0.5)^{0.5}$, then subjected to the analysis of variance, in which the averages were grouped by applying the Scott-Knott test. The use of the Scott-Knott test allows of the formation of homogeneous groups of treatments and avoids ambiguity in the interpretation of the results (Silva, 2007). The averages were ranked according to the methodology proposed by Mulamba & Mock (1978), and the lowest score or rank was assigned to the average of greatest interest for the study, that is, the highest degree of resistance. The rank sum corresponding to the number of adults and nymphs provides the effective resistance (ER), which represents the joint action of the genotype on adult insects and nymphs. In free-choice screening tests, the infestation of adult insects can cause several reactions, including their escape to or the attraction of infesting insects of other plants, which characterizes nonpreference resistance (antixenosis) and preference,

Table 1. Treatments, lines, and genotypes of semi-erect cowpea (*Vigna unguiculata*), with their respective parents or origin.

Treatment	Line/genotype	Parent/origin
1	MNCO4-762F-03	(TE96-282-22G x (TE96-282-22G x VITA 7))
2	MNCO4-762F-09	(TE96-282-22G x (TE96-282-22G x VITA 7))
3	MNCO4-769F-30	(CE-315 x TE97-304G-12)
4	MNCO4-769F-48	(CE-315 x TE97-304G-12)
5	MNCO4-769F-62	(CE-315 x TE97-304G-12)
6	MNCO4-782F-104	((TE97-309G-24 x TE96-406-2E-28-2) x TE97-309G-24)
7	MNCO4-792F-143	(MNCOO-553-8-1-2-3 x TVx5058-09C)
8	MNCO4-792F-144	(MNCOO-553-8-1-2-3 x TVx5058-09C)
9	MNCO4-792F-146	(MNCOO-553D-8-1-2-3 x TVx5058-09C)
10	MNCO4-792F-148	(MNCOO-553-8-1-2-3 x TVx5058-09C)
11	MNCO4-795F-153	(MNC99-518G-2 x IT92KD-279-3)
12	MNCO4-795F-154	(MNC99-518G-2 x IT92KD-279-3)
13	MNCO4-795F-155	(MNC99-518G-2 x IT92KD-279-3)
14	MNCO4-795F-159	(MNC99-518G-2 x IT92KD-279-3)
15	MNCO4-795F-168	(MNC99-518G-2 x IT92KD-279-3)
16	BR 17 – Gurguéia(1)	(BR 10-Piauí x CE-315 (TVu 2331))
17	BRS Guariba (TE96-282-22G)(2)	(IT85-2687 x TE87-98-8G)
18	Vita-7(1)	(International Institute of Tropical Agriculture)
19	TVu 408 P_2(2)	(International Institute of Tropical Agriculture)

(1)Standard susceptible genotype. (2)Standard resistant genotype.

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respectively (Silva & Bleicher, 2010). Another reaction would be the death of the insects, which characterizes antibiosis. Therefore, it can be assumed that the effective resistance mentioned here would represent a simulation of the insect-plant interaction under field conditions.

The results of the effective resistance were also ranked. Using the rank of the three observed parameters, we performed an analysis of variance, which provided the mean rank variable (Xr), the result of which represents the expression of the genotype in relation to the aphid. The means were grouped using the Scott-Knott test. The mean score data were then analyzed for normality and homogeneity of variances of residues by applying the tests of Shapiro & Wilk (1965) and Bartlett (1937).

Using the results of the initial screening of insect resistance to the different cowpea genotypes, the second stage of the research, which corresponds to the estimation of demographic parameters, was carried out. On the basis of the data obtained from the genetic resistance screening assay for *A. craccivora*, MNCO4-762F-03 and MNCO4-762F-09, and MNCO4-769F-30 and MNCO4-795F-168 were respectively selected as resistant and susceptible lines. The cultivar Vita-7 (a standard susceptible genotype) and one commercial semi-erect cultivar (BRS Tumucumaque), which was recently launched on the market, were also used.

In this experiment, the type of pot, planting, thinning, and standardization of the breeding colony age were the same as those used in the resistance screening assay. Treatment for infestation was performed on the 12th day after sowing, by depositing five adult aphids on each plant. Infested plants were arranged on benches, such that neighboring plants were not in direct contact with one another, and covered with 1.0x1.0x0.50 m cages covered with an anti-aphid screen.

Approximately 4 hours after infestation, adult insects and nymphs were removed from the treated plants, leaving only two nymphs on each plant for a period of 24 hours. After this period, a cohort with ten individuals was formed using one nymph per plant. The same procedure was carried out for each of the six genotypes studied. These individuals were observed daily until their death, and, in the course of their life, the number of living individuals, number of descendants (which were then withdrawn), and the longevity of the cohort insects were recorded.

Using the daily number of offsprings produced and survival in each age group, fertility-life tables were produced. For these parameters, the following was observed: the survival at the time of first offspring production (S 1st O), which assesses the chances of nymphs reaching adulthood and breeding; the gross reproduction rate (GRR), which represents the total average number of nymphs produced per female during their lifetime (Hoque et al., 2008); and the R_O/GRR ratio, for which values closer to 1.0 indicate that there is a greater degree of adaptation to the plant genotype as insect food. The demographic parameters of cowpea aphid were estimated using the jackknife method, according to the routine described by Maia et al. (2000), through the statistical software SAS (SAS Institute, Inc., Cary, NC, USA). The following parameters were also determined: net reproduction rate (R_O), average interval between generations (T), time to the doubling of the population (T_D), intrinsic rate of increase (r_m), and finite rate of increase *(*λ).

After obtaining the results of the demographic parameters, the means were grouped according to Mulamba & Mock (1978), in order to favor resistance, by which the lowest score was attributed to the mean of greatest interest in the study (the highest degree of resistance). For each assessed genotype, data for ranking corresponding to the evaluated parameters were added, yielding the rank sum (∑r), which represents the joint action of the genotype on the insect population parameters.

Results and Discussion

In the first resistance-screening assay, the analyses of variance indicated that there were significant differences for both variables, with the formation of three distinct groups for number of adults and number of nymphs (resistant, intermediate, and susceptible) (Table 2). Lines MNCO4-762F-03 and MNCO4-762F-09 did not differ from the standard resistant genotypes for the number of adults, and showed a lower number of individuals. As to the number of nymphs, none of these lines differed from the resistant 'BRS Guariba' genotype (Table 2).

According to the protocol used, the variable number of adults on a plant may discriminate between antibiosis, or nonpreference resistance (Silva & Bleicher, 2010), whereas a production decrease of the offsprings is indicative of an antibiosis resistance

(Laamari et al., 2008; Obopile & Ositile, 2010). On the basis of this assumption, there was an effect of the plant on the insect reproduction among the evaluated genotypes in the present work, since there were lower numbers of adults and nymphs from the breeding on plants of the 'BRS Guariba', MNCO4-762F-03, and MNCO4-762F-09 genotypes.

When ranked, the mean ranks of the variable number of adults, nymphs, and effective resistance provided an assessment of the resistance potential of these genotypes against cowpea aphid attack (Table 2).

The MNCO4-762F-03 and MNCO4-762F-09 lines might be considered as resistant, as they performed similarly to the standard resistant genotypes 'BRS Guariba' and TVu 408 P_2 (p>0.05). In the second group, the MNCO4-795F-146, MNCO4-795F-155, MNCO4-769F-62, MNCO4-792F-144, and MNCO4-792F-143 lines showed intermediate levels of resistance, differing from the standard genotypes of resistance and susceptibility (Table 2).

The parental line of MNCO4-762F-03 and MNCO4-762F-09 is the same as that of TE96-282-22G, that was launched on the market as 'BRS Guariba', obtained from the breeding of the IT85F-2687 line introduced by the International Institute of Tropical Agriculture with the TE87-98-8G line. Melville et al. (2016) and Paz (2016) verified that the cowpea 'BRS Cauamé', derived from the female TE93-210-13F and male TE96-282-22G parental lines (Vilarinho et al., 2008), is resistant to the cowpea aphid. Therefore, it is assumed that the resistance of the lines used in the present work is related to their common parental line TE96-282-22G (BRS Guariba), which consequently transferred the gene to these lines conferring to them the resistance to the cowpea aphid.

The results indicate that the resistance mechanism involved is antibiosis, as confirmed by Paz (2016) for

Table 2. Genotypes, average number of adults (NA), number of nymphs (NN), effective resistance (ER), and rank average (Xr) of *Aphis craccivora* on semi-erect cowpea (*Vigna unguiculata*) genotypes.

Genotype[(1)]	NA	Rank[(2)]	NN	Rank[(2)]	ER	Rank[(2)]	Xr[(3)]
BRS Guariba	0.17 a[(4)]	1	6.67 a[(4)]	1	2	1	1.00 a
MNCO4-762F-03	0.33 a	2	9.67 a	2	4	2	2.00 a
MNCO4-762F-09	0.33 a	2	15.17 a	3	5	3	2.67 a
TVu 408 P_2	1.00 a	3	30.50 b	4	7	4	3.67 a
MNCO4-792F-146	3.67 b	7	75.50 c	5	12	5	5.66 b
MNCO4-795F-155	3.17 b	5	80.17 c	7	12	5	5.66 b
MNCO4-769F-62	2.83 b	4	86.33 c	10	14	6	6.67 b
MNCO4-792F-144	3.33 b	6	83.00 c	9	15	7	7.33 b
MNCO4-792F-143	3.83 b	8	81.67 c	8	16	8	8.00 b
BR 17 – Gurguéia	4.50 c	12	80.00 c	6	18	9	9.00 c
MNCO4-795F-153	3.17 b	5	94.67 c	14	19	10	9.66 c
MNCO4-782F-104	3.67 b	7	94.33 c	13	20	11	10.33 c
MNCO4-795F-154	4.00 c	9	92.00 c	12	21	12	11.00 c
MNCO4-769F-48	5.00 c	14	90.17 c	11	25	13	12.66 d
MNCO4-795F-159	4.33 c	11	99.50 c	16	27	14	13.66 d
MNCO4-792F-148	4.33 c	11	100.67 c	17	28	15	14.33 d
MNCO4-795F-168	4.17 c	10	105.33 c	18	28	15	14.33 d
VITA 7	5.00 c	14	96.67 c	15	29	16	15.00 d
MNCO4-769F-30	4.67 c	13	107.67 c	19	32	17	16.33 d
Snedecor's F-test	25.71**		30.18**				16.98**
Coefficient of variation (%)	13.52		13.76				12.11

[(1)]Means followed by equal letters, in the columns, do not differ significantly by the Scott-Knott test, at 5% probability. [(2)]Rank occupied according to the observed variable. [(3)]Rank average of Mulamba & Mock (1978). [(4)]Data referring to the number of adults and nymphs that have been transformed using the equation $(X + 0.5)^{0.5}$. **Significant at 1% probability.

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'BRS Guariba', in which the cultivar would transfer the resistance gene to its progeny. According to Babura & Mustapha (2012), when crossbreeding of cowpea varieties susceptible to the cowpea aphid is carried out with resistant materials, it is possible to produce highly resistant progenies, implying that the transmission of the gene conferring cowpea resistance to *A. craccivora* is heritable.

Silva et al. (2012) evaluated the genetic diversity between cowpea genotypes with resistance to the cowpea aphid, and the best combinations among resistant genotypes, and confirmed that 'BRS Guariba' is favorable to genetic combinations and suitable for breeding programs as a source of resistance to the aphid.

In subgroup 1, among the genotypes considered susceptible to the cowpea aphid are 'BR 17-Gurguéia', MNCO4-795F-153, MNCO4-782F-104, and MNCO4-795F-154 (Table 2). In this genotype group, 'BR 17-Gurguéia' has been recognized as susceptible to the cowpea aphid by several authors (Moraes & Bleicher, 2007; Silva & Bleicher, 2010). In subgroup 2, the genotypes MNCO4-769F-48, MNCO4-795F-159, MNCO4-792F-148, MNCO4-795F-168, 'Vita-7', and MNCO4-769F-30 are considered highly susceptible to the cowpea aphid (Table 2).

The production of fertility-life tables enabled us to estimate the demographic parameters of *A. craccivora*. Accordingly, in the present work, the survival at the time of first offspring production (S 1^{st} O) was affected when aphids were bred on the MNCO4-762F-03 and MNCO4-762F-09 lines. In contrast, with the 100% survival on other genotypes, the survival on lines MNCO4-762F-03 and MNCO4-762F-09 was only 30% (Table 3). Therefore, when developing on MNCO4-762F-03 and MNCO4-762F-09, cowpea aphid nymphs have a considerably lower likelihood of reaching adulthood and breeding, compared with those infesting other genotypes. The high-mortality rates on MNCO4-762F-03 and MNCO4-762F-09 indicate antibiosis as the resistance mechanism of these plants, which is presumably due to the production of certain antibiotic compounds that are toxic to the insect.

In the present study, the gross reproduction rate (GRR) of *A. craccivora* varied from 16.50 to 63.93 produced nymphs. When bred on the MNCO4-762F-09 and MNCO4-762F-03 lines, the reproductive capacity of the species was low (16.50 and 17.50 nymphs), in comparison with those on lines supporting a high-gross rate of reproduction (Table 3). According to Panizzi & Parra (2009), a decrease of the reproductive capacity of the insect may be related to the presence of secondary metabolites and plant nutritional factors, which could directly affect the fecundity of the pest.

There were significant differences between the plant genotypes for the net reproduction rate (R_O) of cowpea aphid. The highest values of R_O were observed for aphids on 'Vita-7' and 'BRS Tumucumaque' (61.6 and 48.7, respectively), and the lowest values for aphids on MNCO4-762F-09 and MNCO4-762F-03 (2.5 and 3.0, respectively) (Table 3). There was a decrease of the reproductive potential of *A. craccivora* when bred on MNCO4-762F-09 and MNCO4-762F-03, indicating that these lines were less suitable hosts for insect reproduction than 'Vita-7' and 'BRS Tumucumaque'.

Similarly, for the (R_O)/(GRR) ratio, the genotypes 'Vita-7' (0.96) and 'BRS Tumucumaque' (0.86) were the more favorable hosts for insect feeding, whereas the MNCO4-762F-09 and MNCO4-762F-03 lines were the least favorable ones (0.15 and 0.17) (Table 3). The lower preference for these latter two lines led to decreased consumption, as the plants presumably contain certain compounds that render the host unfavorable to the insect. The presence of secondary compounds such as alkaloids, limonoids, and cucurbitacins tends to reduce palatability, thereby making plants a less preferred host food source for insects (Aoyama & Labinas, 2012).

The mean interval between generations (T) and the time to doubling the population (T_D) did not differ between the genotypes (Table 3). According to Machacha et al. (2012), the higher the resistance of the genotype to the pest attack, the higher are the values for T and T_D. *Aphis craccivora* takes, on average, from six to nine days to complete one generation. Although the values observed in the present work were within this range, the insect mortality occurring on the MNCO4-762F-09 and MNCO4-762F-03 lines increased the coefficient of variation, affecting the result of the analysis.

Significant differences among the treatments were observed for the intrinsic rate of increase (r_m), whose values varied from 0.15 to 0.63 (Table 3). The insects feeding on the MNCO4-762F-09 and MNCO4-762F-03 lines showed a reduced performance. However, when bred on other genotypes, their performance was satisfactory, particularly when feeding on the 'Vita-

Table 3. Demographic parameters: survival at production of the first offspring (S 1st O), gross reproduction rate (GRR), net reproduction rate (R_O), R_O/GRR ratio, average interval between generations (T), time to the doubling of the population (T_D), intrinsic rate of increase (r_m), finite rate of increase (λ), and rank sum (∑r) of *Aphis craccivora* on semi-erect cowpea (*Vigna unguiculata*) genotypes[1].

Genotype	Demographic parameters																
	1st (%)	R[2]	GRR	R	R_O	R	R_O/GRR	R	T	R	T_D	R	r_m	R	λ	R	∑r[3]
Vita-7	100	2	63.93	6	61.6a (53.2-70.0)	6	0.96	6	6.44a (6.21-6.67)	5	1.08a (1.03-1.13)	6	0.63a (0.60-0.66)	6	1.89a (1.83-1.95)	6	43.00
MNCO4-795F-168	100	2	62.01	5	47.0ab (33.5-60.5)	4	0.76	4	6.40a (5.88-6.91)	6	1.14a (1.09-1.20)	5	0.60ab (0.57-0.63)	5	1.82ab (1.77-1.88)	5	36.00
MNCO4-769F-30	100	2	50.58	3	33.8b (20.7-46.8)	3	0.67	3	6.53a (6.04-7.01)	4	1.27a (1.18-1.37)	3	0.54b (0.49-0.58)	3	1.71b (1.64-1.79)	3	24.00
MNCO4-762F-03	30	1	17.50	2	3.0c (-1.6-7.6)	2	0.17	1	6.84a (5.0-8.6)	1	3.58a (-3.2-10.4)	1	0.16c (-0.05-0.4)	2	1.18c (0.92-1.4)	2	12.00
MNCO4-762F-09	30	1	16.50	1	2.5c (-1.80-6.8)	1	0.15	2	6.77a (5.8-7.7)	2	2.17a (-1.7-21.4)	2	0.15c (-0.13-0.4)	1	1.16c (0.84-1.48)	1	11.00
BRS Tumucumaque	100	2	56.59	4	48.7ab (39.7-57.6)	5	0.86	5	6.61a (6.19-7.04)	3	1.17a (1.13-1.22)	4	0.58ab (0.56-0.60)	4	1.79ab (1.76-1.84)	4	31.00

(1)Means followed by equal letters, in the columns, do not differ significantly by means of two-to-two treatment comparisons, through a 95% confidence interval, after estimating the errors by applying the jackknife method using the t-test. (2)Rank occupied by the variables observed. (3)The lower the rank sum, the more promising is the genotype resistance, when considering the eight parameters evaluated.

7' and MNCO4-795F-168 genotypes, which are more suitable hosts for the development and reproduction of *A. craccivora* (Table 3). Therefore, due to their low r_m values, resulting from a decreased reproductive capacity, populations of cowpea aphids could not increase satisfactorily if feeding only on the MNCO4-762F-09 and MNCO4-762F-03 lines, as a consequence of the antibiosis mechanism of these plants (Laamari et al., 2008; Obopile & Ositile, 2010).

The r_m values, obtained for the genotypes considered as susceptible in the present work, corroborate the finding one by De La Pava & Sepúlveda-Cano (2015), who described the demographic parameters of *A. craccivora* on cowpea, and obtained r_m of 0.51, which confirmed that this plant is susceptible to the pest. Similarly, Obopile & Ositile (2010) described the genotype IT835-720-20 as resistant to cowpea aphid, with an r_m value of (0.13), which is close to the values obtained for the MNCO4-762F-09 and MNCO4-762F-03 lines evaluated in the present work.

As to the finite rate of increase variable (λ), significant differences were observed among the genotypes. The lowest values were obtained for aphids on MNCO4-762F-09 and MNCO4-762F-03 (1.16 and 1.18, respectively), whereas the highest values were obtained for aphids on 'Vita-7', MNCO4-795F-168, 'BRS Tumucumaque', and MNCO4-769F-30 (1.89, 1.82, 1.79, and 1.71, respectively) (Table 3). According to Hafiz (2006), the ideal condition for the development of aphids on a host occurs when the insects have a finite rate of increase that is greater than 1.2, and a positive intrinsic rate of increase, as obtained in the present work for aphids bred on 'Vita-7', MNCO4-795F-168, 'BRS Tumucumaque', and MNCO4-769F-30. In this case, aphid populations would breed well on the aforementioned genotypes, without major host effect, such as resistance mechanisms. In contrast, insect population outbreaks of this species would rarely occur on the MNCO4-762F-09 and MNCO4-762F-03 lines.

Using the methodology by Mulamba & Mock (1978), it was observed that the lines MNCO4-762F-09 and MNCO4-762F-03 showed the lowest value for the rank sum (∑r) (Table 3). This analysis is a more accurate confirmation of resistance, highlighting that these two lines are the most promising materials based on the parameters evaluated. These lines are highly resistant to cowpea aphid, as they can significantly reduce the reproductive potential of the insect, and increase its mortality during the nymphal phase. This high mortality and low fertility confirms an antibiosis mechanism of resistance (Obopile & Ositile, 2010; Kamphuis et al., 2013).

On the basis of the preliminary preference/ resistance screening and estimation of the demographic parameters of *A. craccivora* presented here, it was possible to confirm, to a greater degree of precision, the genotypes that are more resistant or susceptible to cowpea aphid.

It is important to mention that the screening of a large numbers of genotypes allowed an adequate separation of the genotypes by groups of susceptibility to *A. craccivora*, when associated with the methodology of Mulamba & Mock (1978) for the number of live adults, live nymphs, effective resistance, and their analysis using the Scott-Knott test.

The development of fertility-life tables, and their use to estimate demographic parameters of pest insects on different host plant genotypes, enables the prediction of risks related to the launch of new cultivars, for both financial and environmental costs, if the genotypes are planted under conditions favorable to the cowpea aphid. Therefore, it is imperative to incorporate this methodology in *V. unguiculata* breeding programs.

Conclusions

1. The MNCO4-762F-03 and MNCO4-762F-09 cowpea (*Vigna unguiculata*) lines are resistant to *Aphis craccivora* and show an antibiosis mechanism of resistance against this insect pest.

2. The cowpea genotypes 'Vita-7', MNCO4-795F-168, and MNCO4-769F-30 are suitable hosts for the development and population increase of *A. craccivora*.

3. Under favorable conditions, the cultivation of 'BRS Tumucumaque' may lead to *A. craccivora* outbreaks.

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