Vol. 14(10), pp. 582-587, 7 March, 2019
DOI: 10.5897/AJAR2018.13780
Article Number: CEBA70E60427
ISSN: 1991-637X
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http://www.academicjournals.org/AJAR

African Journal of Agricultural Research

Full Length Research Paper

Correlation of climatic elements with phases of the lace bug *Vatiga illudens* (Hemiptera: Tingidae) in two cassava cultivars (*Manihot esculenta* Crantz, Euphorbiaceae)

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Received 30 November, 2018; Accepted 7 February, 2019

Cassava (*Manihot esculenta* Crantz) is subject to various disease problems and insect attacks. The aim of this study was to evaluate the correlations of climatic elements on the phases of the lacebug, *Vatiga illudens* in two cultivars of cassava. The study was carried out in a greenhouse using the 'Sergipana' and 'Campina' cultivars. Data were analyzed using the Pearson index for linear correlations. Comparisons between the cultivars and the insect population were performed using boxplot tests, with 95% confidence intervals. Data were subjected to analysis of variance and were compared using the Tukey test at 5% probability. In cassava phenological stages, height and number of branches were different between the cultivars of. The greatest number of individual lace bugs was found in the 'Campina' cultivar, with an increase in the population during August. Nymphs and adults of *V. illudens* populations varied monthly in 'Sergipana' cultivar with a peak in June and August. There was a significant correlation between the phenological stages of the cassava cultivars and the climatic elements on lace bug population fluctuations in a greenhouse.

Key words: Abiotic factors, lacebug, *Manihot esculenta*, plant production.

INTRODUCTION

Cassava (*Manihot esculenta* Crantz, Euphorbiaceae) is a fruit with various usages, from human and animal food production to industrial uses, serving as an energy base for populations with low human development indices in tropical and subtropical countries (Albuquerque et al., 2009).

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Nevertheless, pests and diseases can significantly compromise the final yield of the crop (El-sharkawy, 2003). About 200 species of arthropods are associated with cassava cultivation, and some insects are specific and resistant to the host plant; however, not all get to the status of pests (Bellotti et al., 2000).

Insects cause injuries in cassava (Bellotti et al., 2012). The protoplasm-sucking species and those that consume the leaves reduce leaf area, decreasing the photosynthetic rate (Farias and Bellotti, 2006). Other pests suck the phloem and xylem contents, weakening the plant (Bellotti and Arias, 2001; Calatayud and Le Rü, 2006). Nevertheless, there are those that attack stems and roots, creating a gateway for diseases (Pietrowski et al., 2010). Therefore, these insects cause reduction of yield and root quality of the cassava (Farias and Bellotti, 2006; Bellotti et al., 2012).

In Brazil, particular pests are the lace bugs *Vatiga manihotae* or *Vatiga illudens* (Hemiptera: Tingidae); the whiteflies Bemisia tuberculata and *Aleurothrixus aepim* (Hemiptera: Aleyrodidae); the mites *Mononychellus tanajoa* and *Tetranychus urticae* (Acari: Tetranychidae); the thrips *Frankliniella williamsi* and *Scirtothrips manihoti* (Thysanoptera: Thripidae); and the beetle *Migdolus fryanus* (Coleoptera: Cerambycidae) (Pietrowski et al., 2010; Bellotti et al., 2012; Wengrat et al., 2015; Embrapa, 2016). Among the pests cited above, the lace bug (Hemiptera: Tingidae) was highlighted which in recent years has been showing visible population growth on cassava plantations (Pietrowski, 2009). It was hypothesized that there is influence of climatic elements on the population dynamics of the lace bug *V. illudens* in cassava cultivars. The objective of this study was to evaluate the correlation of the climatic elements on the population fluctuation of *V. illudens* in two cultivars of cassava in greenhouse conditions.

MATERIALS AND METHODS

The study was carried out in the city of Arapiraca, Alagoas, Northeast of Brazil, with the following geographical coordinates: Latitude 9° 75´ 25´´S and Longitude 36° 60´ 11´´W. The municipality presents edaphoclimatic conditions, with average temperature 28°C; average annual rainfall of 470 mm; the climate of the region is type As', presenting as tropical and hot according to the classification of Köppen and Geiger (Alagoas-Semarh-dmet, 2017).

The experiment was conducted from July/2017 to January/2018. Two cultivars of cassava 'Sergipana' and 'Campina' were grown in a greenhouse with 50% shaded environment. After 15 days, there was seedling emergence (reproduction by cutting). After two months, the lace bug V. illudens was collected. The insects were kept in the greenhouse on the plants and monitored weekly. The experimental design was completely randomized with two treatments (cultivars) and twelve replications.

To monitor insect developmental period, no control method was used against *V. illudens*. Data were recorded weekly in spreadsheets, including the number of nymphs and adults of bedbug per leaf, plant height, number of leaflets, ramifications and stem diameter, variables measured in the experiments, end to evaluation of the phenological development of the two cultivars. The climatic evaluations were recorded using monthly data of precipitation (mm), relative humidity (%), and temperature (°C), provided by the 'Instituto Nacional de Metereologia' (INMET) for 2017 and 2018. The population fluctuation was analyzed by the Pearson index to obtain linear correlations between the numbers of nymphs and adults of *V. illudens*, and for the phenology data of the cultivars and the climatic elements. Boxplots were used to compare the data between the two cultivars and to evaluate the dispersion of the data. The comparison between the cultivars and the sampled populations was performed using boxplot tests with 95% confidence intervals. The data were subjected to analysis of variance and the means were compared by the Tukey test at 5% of probability, using the Assistat - Statistical Analysis System (Silva et al., 2016).

RESULTS AND DISCUSSION

Evaluation of the phenological development of the two cultivars

The phenological development of plants grown in pots in greenhouse conditions showed significant differences in terms of height and branches. The analysis of variance of the cultivars data showed a significant difference by the F = 9.3807 * test at the 1% probability level ($p < 0.05$) (Table 1). Vidigal Filho et al. (2000), working with cultivated data in the field, compared the height of cultivars IAC 12, IAC 13, IAC 14, Fécula Branca, Espeto, Branca de Santa Catarina, and Fibra. The cultivar that presented the highest growth in height during the evaluated period was IAC 14, with height estimated at 20 cm, at 80 DAP, reaching an estimated height of 272 cm, at 320 DAP, making it the largest cultivar at 135 days.

The two cultivars showed no significant difference in terms of leaf numbers and stem diameters. According to Beraldo et al. (2011), the number of leaves on the main stem was associated with the beginning of starch accumulation in the roots. Schons et al. (2007) verified that the cultivar of cassava RS 13 started this accumulation when its stem had 21 leaves very visible, independent of the planting season.

Characteristic branching also influences the mechanization of the crop. Varieties that do not present branching are more amenable to mechanized planting to facilitate crop management (RÓS et al., 2011). According to Beraldo et al. (2011), cultivars with stem and branch can present lower yields in denser spacings, because they require more space to develop their branches and, consequently, to express the potential of photoassimilate production.

Population fluctuations of the lace bug in cultivars

The month of December showed the lowest variability, indicating that the distribution of lace bugs within the greenhouse was low in relation to the months observed (June/2017 and January/2018). Oliveira and Malaguido (2004) found similar data regarding adults and nymphs of various instars of lace bugs found throughout the year,

Table 1. Average data of the phenological development of the two cultivars.

Variety	PH (cm)	L(u)	SD (cm)	B(u)
Sergipana	40.36[a]	14.31[a]	0.76[a]	1.33[a]
Campina	35.05[b]	16.38[a]	0.74[a]	0.54[b]
C.V.%		15.42		

Legend: PH = plant height; L= leaflets; SD= stem diameter; B= Branches. C.V= correlation coefficient. Means followed by the same letter in the column and in the row did not differ significantly by the Tukey test at 5% probability.

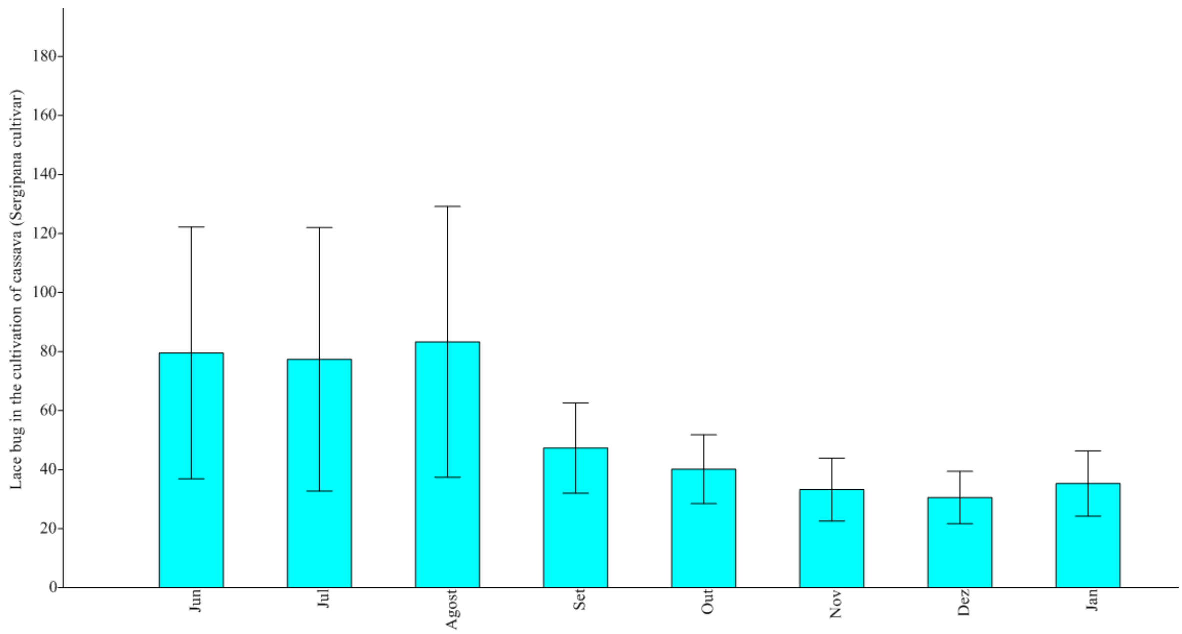

Figure 1. Population monitoring of the income bug during the research (June / 2017-January / 2018) (Sergipana cultivar).
Source: Research data.

although in the drier periods the adult population was lower. The results showed that the population of nymphs and adults of *V. illudens* in the cultivar Sergipana varied throughout the analyzed months, with a peak between June and August (Figure 1).

Although there are still few studies that determine the population fluctuation of the lace bug, studies carried out in various locations with several cassava cultivars in commercial plantations have shown that the population peaks of this pest insect can occur between the months of November to July (Vitório et al., 2005; Rohden et al., 2005; Martinazzo et al., 2007; Rheinheimer et al., 2012).

In the western region of Paraná, the population is recorded in the crops from November, presenting higher population peaks between January and March (Martinazzo et al., 2007); whereas for the Federal District, (Oliveira et al., 2001) and in Bahia, the peak occurs between September and October (Farias et al., 2007).

The boxplot for the month of October (Figure 2) showed lower variability in the Campina cultivar, indicating that lace bug distribution was relatively low in relation to the months observed. The highest number of individuals of lace bugs in the Campina cultivar was in August. According to Martinazzo et al. (2007), the behavior of the lace bug in this winter period remains unknown, and it is unclear whether the insect enters diapause in the cultural remnant of the area or if there is a migration to refuge areas. A factor that can also be related to these differences of attack of *V. illudens* among the cultivars are the contents of cyanogenic compounds in plants, a fact verified by Santos et al. (2008) who observed that the higher the hydrocyanic acid content (HCN) in cassava roots, the lower the incidence of nymphs and adults of *V. illudens*. Nevertheless, in the present work, the cyanogenic contents of the studied materials were not assessed.

According to Bellon (2013) in the first cycle of cassava, the population of nymphs had its peak population in the

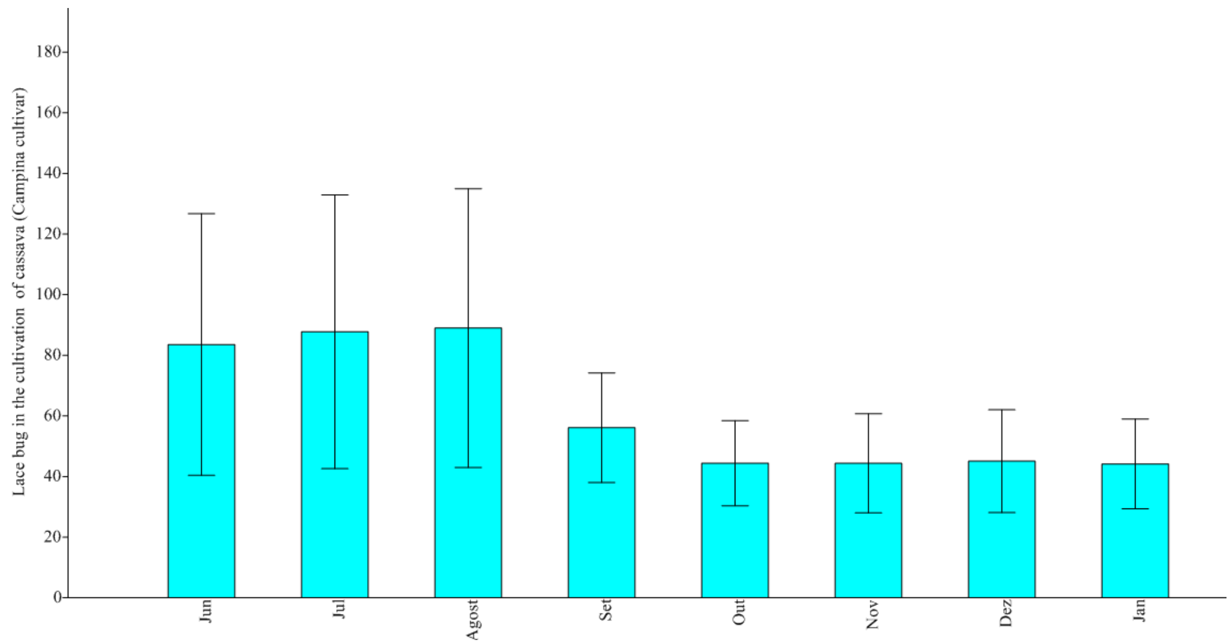

Figure 2. Population monitoring of the income bug during the research (June / 2017-January / 2018) (Campina cultivar). Source: Research data.

months of March, April and May. For the second cycle, the population began to increase in November, reaching its population peaks from December to February and again in April.

Martinazzo et al. (2007) determining the population fluctuations in *V. manihotae*, also reported a higher incidence of these insects in the second cassava cycle. According to these authors, the higher incidence may be related to the formation of a more intense foliar mass in the regrowth of the plant, with greater food availability, allowing the insect to complete a larger number of generations in that period and consequently to increase its population.

Evaluation of the correlations of climatic elements and phenological variables on insect phases

The estimates of correlations between the phenological variables, insect phases and climatic factors in the Campina and Sergipana varieties are shown in Table 2. The data presented for the correlations were significant ($p < 0.01$). The magnitudes are defined as follows: weak ($0.20 < |r| < 0.40$), moderate ($0.40 < |r| < 0.60$) and strong ($0.60 < |r| < 0.80$); these parameters are corroborated by the publication of Franzblau (1958).

Pearson indices in the two correlation matrices, between the biotic and abiotic variables, were within the weak-to-moderate range in the two cassava cultivars. The adult variables and nymphs had negative correlations with the others; the exception was the positive correlation between biotic (nymphs) ($r = 0.15$) and abiotic (precipitation) ($r = 0.24$). If the correlations are positive, the benefits are mutual; however, if one is positive and another is negative, the effects move in opposite directions. For the two cultivars, this phenomenon was observed.

Similar results were obtained by Fialho et al. (2009) who found a negative correlation for *V. illudens* nymphs and adults with cassava root and shoot yield in three years of evaluation. Uemura-Lima (2017) stated that the maximum, average and minimum temperatures positively affected the population of *V. illudens* nymphs (Drake, 1922). It was discovered that the correlation between leaves ($r = 0.66$) and height ($r = 0.63$) of the plant showed higher positive correlations. The temperature and relative humidity of the air are other abiotic factors that influence in the development of the plant and the insects hosted there. They then become limiting in distinct environments in cassava cultivation, a plant that is very sensitive to these variations and may present variable responses (El-sharkawy, 2003; Long, 2006; El-sharkawy et al., 2012).

Uemura-Lima (2017) evaluated the interaction between temperature, relative humidity and precipitation, and observed that the number of eggs of *Vatiga* spp. increased as temperature increases; however, the opposite occurs if the increase is for humidity and precipitation. According to Uemura-Lima (2017), in general, the leaf of the cassava plant is able to withstand damage caused by the lace bug, even at high population numbers, when the insect remains for a short time in the plant, both for cultures in the first and the second cycle. Nevertheless, as the feeding time of the insects increases

Table 2. Pearson's index of linear correlations in cassava cultivars.

Variable	Campina								
	Adults	**Nymphs**	**Height**	**Leaves**	**Stem**	**Branches**	**Rh**	**Temp.**	**Rain.**
Adults	-	-0.41							
Nymphs	-0.30	-							
Height	0.33	-0.00	-						
Leaves	0.66	-0.23	0.63	-					
Stem	0.54	-0.30	0.03	0.41	-				
Branches	-0.36	-0.16	0.25	0.22	0.17	-			
Rh	0.45	-0.51	0.09	0.42	0.00	-0.01	-		
Temp.	-0.23	-0.32	0.70	-0.90	0.56	0.46	0.26	-	
Rain.	0.24	0.15	0.54	0.45	-0.40	-0.55	-0.42	-0.64	-
	Sergipana								
Adults	-	-0.27							
Nymphs	-0.30	-							
Height	0.50	-0.21	-						
Leaves	0.49	0.19	0.73	-					
Stem	0.14	-0.03	0.46	0.73	-				
Branches	0.02	-0.35	0.58	0.47	0.80	-			
Rh	-0.37	0.00	0.28	-0.08	-0.35	-0.09	-		
Temp.	0.23	0.35	0.74	-0.91	0.57	0.38	0.26	-	
Rain.	0.24	0.15	0.54	0.45	-0.40	-0.55	-0.42	-0.64	-

Legend: Rh = Relative humidity. Temp. = temperature and Rain. = rainfall.

in the leaf, the damage increases, regardless of the population present in the leaf.

Fialho et al. (2009) described a decrease of the phenological growth of the plant due to the number of adult and nymph lace bugs, possibly related to the damage that the insect causes to the leaves. The other species *V. illudens*, in the adult and nymph phases, causes damage to the plant (Bellotti et al., 2012). Another form of damage is the drop of the aerial part of the plant, an injury caused by the lace bug that triggers senescence and loss of leaves (Alves and Stter, 2004). Sucking insects reduce the photosynthetic rate in several ways, with reduced stomatal conductance and changes in water transport being the main causes of this reduction (Bellon et al., 2017; Nabity et al., 2009; Zvereva et al., 2010).

It is important to point out that research on population fluctuation of a pest and its relation to climatic factors presents different results from one region to another. That is, a factor that presents significant correlations in one region may not be relevant in another region; suggesting that the fluctuation population is specific to each assessed site (Portela et al., 2010).

Conclusion

Cassava cultivation in protected environments can be influenced by climatic elements, causing lower phenological development of the cultivars that correlated with the presence of lace bugs. The correlations of the climatic elements with the phenological variables on the phases of the lace bug in cassava cultivars grown in a greenhouse indicate that they are related. Further studies of the occurrence and population fluctuations of *V. illudens* in the study region are required.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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