

*Full Length Research Paper*

## **Correlation of climatic factors between the development of tomato cultivars (*Solanum lycopersicum* L., Solanaceae) with adults of two key pests**

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The tomato (*Solanum lycopersicum* L., Solanaceae) is a crop that has suffered from insect attacks and environmental factors. The objective of this work was to evaluate the correlations of climatic factors and two key pests at the development of cultivars. The study was conducted in Alagoas, Northeastern Brazil, monitored from September 2016 to August 2017. The experiment was randomized with five treatments and twelve replicates. Collection of adult insects was performed with Delta® traps with *Tuta absoluta* pheromone and *Bemisia tabaci* Genn. through manual harvesting. Data were analyzed by Pearson correlation and climatic factors. Data were subjected to analysis of variance, and the means were compared by the Tukey test at the 5% probability. In numbers of flower buds, the cultivars Santa Cruz and Rio Grande gave the highest values, 9.65 and 13.6, respectively. In numbers of fruits, the cultivar Cereja gave higher yields, with a mean value of 6.91. For fruit diameter, the cultivars Santa Clara, Caline IPA 6 and Santa Cruz produced fruits whose diameter was 2.93 cm, 2.95 cm and 3.22 cm, respectively. In terms of fruit weight, the cultivars Caline IPA 6 and Santa Cruz gave averages of 29.14 g and 38.9 g, respectively, both superior to those of the other cultivars studied. The correlations of precipitation, radiation, temperature and wind were climatic factors contributing to the development of tomato varieties in protected crops and caused damage to the physiology of the plant, and acted as environmental indicators for the planning of integrated pest management.

**Keywords:** vegetable production, productivity, agriculture, abiotic factors.

### **INTRODUCTION**

Tomato *Solanum lycopersicum* L., is one of the most cultivated vegetables in the world. It is cultivated in fields,

in protected environments with or without soil, with various levels of cultural management and with several climatic variations (Dorais et al., 2011).

The growth and development of the tomato plant depends on environmental variables and appropriate management for the crop integrity; the fruits produced are used in agroindustries that depend on its production in the field (Horowitz et al., 2005; Silva et al., 2007).

The whitefly (*Bemisia tabaci* Genn. [Hemiptera: Aleyrodidae]) is capable of causing both direct and indirect damage to the tomato crop. It causes direct damage by sucking plant sap, and indirect damage from toxins excreted in its saliva during feeding. The management of *B. tabaci* has been a challenge for farmers (Baldin et al., 2005; Silva et al., 2009).

The moth *Tuta absoluta* (Meyrick, 1917) (Lepidoptera: Gelechiidae), is a key pest causing damage and low yield in tomatoes, both in the field and in closed crops (Bacci, 2006; Desneux et al., 2010; Guedes and Picanço, 2012).

Climatic factors including radiation, relative humidity, temperature, precipitation and wind interfere in tomato development and productivity. Increased radiation increases the production of photoassimilates that can contribute to the growth of the tomato, while excess hinders stomatal conductance and photosynthesis (Andriolo, 2000).

Relative humidity exerts an effect on tomato development, in which high humidity allows for emergence of diseases, and low rates cause evapotranspiration, favoring water deficiency, reducing the photosynthetic rate and consequently decreasing crop production (Kalungu, 2008).

Temperature has a strong influence on the adaptation of the tomato crop; low temperatures slow down growth, while high temperatures affect flowering, fruiting and fruit development, giving rise to deformed fruits that do not have nutrients when climatic conditions are not adequate (Silva et al., 2006).

Rainfall is important during the phenological cycle, participating in vital plant processes, including germination and flowering. However, water availability limits growth and alters productivity as well as promoting the emergence of diseases (Farias, 2007).

Wind indirectly affects crop development, renewing the CO<sub>2</sub> supply for photosynthesis and maintaining transpiration. Excess wind inhibits plant development via mechanical damage (e.g., falling leaves and branches) (Pereira et al., 2002).

An association of climatic variables in the development of tomato cultivars with the presence of two key pests was proposed in the study. The objective of this study was to evaluate the correlation of climatic factors on

development of five tomato cultivars (Santa Clara, Caline IPA 6, Santa Cruz, Rio Grande, Cereja) in a protected environment, to assist with the planning of integrated pest management.

## MATERIALS AND METHODS

The study was conducted in a greenhouse with a 50% shaded environment, located in the municipality of Arapiraca, Alagoas, Northeast Brazil, at geographic coordinates: 9° 75' 25" S latitude 36° 60' 11" W longitude. The municipality gave edaphic conditions as follows: Temperature 28°C; average annual rainfall 550 mm (Alagoas-Semarah-dmet, 2017); the climate of the region is As' type, that is, a tropical and hot climate according to the classification of Köppen and Geiger.

The study was carried out with five tomato (*S. lycopersicum*) varieties, cultivated from September 2016 to August 2017. The design was completely randomized with five treatments (Santa Clara, Caline IPA 6, Rio Grande, Santa Cruz and Cereja cultivars) and twelve replicates.

The data were recorded weekly in a spreadsheet with the evaluated varieties from the phases of post-transplant and opening of the flower bud until fruit formation. The following parameters were recorded: Height (cm), branches (U), flower buds (U), number of fruits (U), fruit diameter (cm) and fruit weight (g).

Climatic evaluations were recorded using monthly data for precipitation (mm), relative humidity (%), temperature (°C), wind and solar radiation, provided by the National Institute of Meteorology (INMET), for the periods 2016 to 2017.

The insects were collected using the Delta® trapping strategy with IscalureTuta® pheromone, for moth (*T. absoluta*) and for whitefly (*B. tabaci*), using a paintbrush on each plant in the pot. Insects were taken to the laboratory for classification verification with the aid of identification keys. For insect analysis, the design was completely randomized with two treatments and fifteen replicates. For the Pearson correlation coefficient (r) of the phenological variables with climatic factors, *Action Stat* software, a statistical system developed by the Estatcamp Team (2014) was used. Data were subjected to analysis of variance and the means were compared by the Tukey test at the 5% probability level, using the statistics package, Assisat - Statistical Analysis System (Silva et al., 2016).

## RESULTS AND DISCUSSION

### Evaluation of tomato cultivar development

The variables height (H), branches (B), flower buds (FB), fruit number (FN), fruit diameter (FD) and fruit weight (FW) analyzed among the cultivars (Santa Clara, Caline Ipa 6, Santa Cruz, Rio Grande and Cereja), differed significantly from one another (Table 1). Gracia (2016) studied fruit production of the Salada group in planting season, giving significant values for numbers of fruit. Shirahige (2010) found significant differences among cultivars such as Santa Cruz and Italiano in terms

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**Table 1.** Average data and standard deviation of the development of *Solanum lycopersicum* L with *Tuta absoluta* and *Bemisia tabaci*.

Mean and standard deviation of insects and phenological variables of tomato plants								
Cultivar	<i>Tuta absoluta</i>	<i>Bemisia tabaci</i>	Height (cm)	Branches (U)	FB(U)	NF(U)	DF(cm)	WF(g)
Santa Clara	67±7.8 <sup>a</sup>	56±3.4 <sup>a</sup>	77.49±3.44 <sup>a</sup>	18.74±1.32 <sup>a</sup>	7.27±1.1 <sup>b</sup>	3.16±0.93 <sup>c</sup>	2.93±0.59 <sup>a</sup>	20.68±3.95 <sup>b</sup>
Caline Ipa 6	47±3.2 <sup>b</sup>	39±1.8 <sup>b</sup>	64.92±5.30 <sup>a</sup>	10.39±0.56 <sup>b</sup>	5.2±0.99 <sup>b</sup>	2.12±0.50 <sup>c</sup>	2.95±0.38 <sup>a</sup>	29.14±4.41 <sup>a</sup>
Santa Cruz	54±2.3 <sup>a</sup>	41±2.1 <sup>b</sup>	77.01±1.85 <sup>a</sup>	13.23±0.51 <sup>b</sup>	9.65±0.87 <sup>a</sup>	3.54±0.39 <sup>b</sup>	3.22±0.31 <sup>a</sup>	38.9±4.97 <sup>a</sup>
Rio Grande	55±1.4 <sup>a</sup>	52±2.5 <sup>a</sup>	60.44±1.40 <sup>b</sup>	11.32±0.31 <sup>b</sup>	13.6±0.73 <sup>a</sup>	4.41±1.41 <sup>b</sup>	2.03±0.48 <sup>b</sup>	2.03±0.48 <sup>c</sup>
Cereja	14±0.8 <sup>c</sup>	13±0.5 <sup>c</sup>	72.51±1.54 <sup>a</sup>	22.74±1.16 <sup>a</sup>	7.22±0.70 <sup>b</sup>	6.91±2.62 <sup>a</sup>	1.45±0.24 <sup>b</sup>	5.4±1.10 <sup>c</sup>

Means followed by the same letter in the column and in the row did not differ significantly by the Tukey test at 5% probability. A = height; B = branches; FB = flower buds; NF = number of fruits; DF = fruit diameter; PF = fruit weight.

of productivity and quality of these tomato hybrids, as well as data on yield, number of fruits per plant, fruit number per flower head, length and width of the fruit.

Due to the significant differences identified for tomato height, it was observed that only the Rio Grande cultivar showed less development (mean and standard deviation 60.44 ± 1.40). Soares (2011), in a study of tomato growth rates, observed significant differences between the phenological phases, with higher rates of relative and absolute growth in diameters in stressed plants in the reproductive phase, but they did not verify differences in growth rates related to height.

The Santa Clara and Cereja cultivars showed higher values for branches than Caline Ipa 6, Santa Cruz and Rio Grande. Silva (2008) studied hybrid tomato cultivation in two different environments and found that the number of lateral branches emitted per plant did not differ in terms of dry mass. The comparison of the means of the flower buds variable of the cultivars showed that the cultivar Santa Cruz and Rio Grande gave the highest values, with means of 9.65 and 13.6 flower buds per plant, respectively.

The cultivar Cereja showed higher production in terms of characteristic number of fruits (6.91 ± 2.62) than did the other cultivars. Among the analyzed cultivars, the cultivars Santa Clara and Caline Ipa 6 gave lower performance, with fruit numbers 3.16 ± 0.93 and 2.12 ± 0.50, respectively. Melo et al. (2009) evaluated the performance of tomato cultivars in an organic system under protected cultivation and reported a number of fruits between 32.2 and 68.9 fruits per plant. Similar results were found by Silva et al. (2013), who reported an average of 37.4 fruits per plant in protected environment cultivation.

The cultivars Santa Clara, Caline Ipa 6 and Santa Cruz gave fruits with greater diameter than did the other cultivars. Shirahige (2009) found greater fruit diameters in the Santa Cruz hybrids THX-02 and THX-03, 6.1 and 6.6 cm, respectively, in plants grown in experimentally protected environments.

The cultivars Caline, Ipa 6 and Santa Cruz showed higher average fruit weights than did the other cultivars. In a similar study by Libânio (2010), the cultivar Santa

Clara showed the higher average fruit weights than did other cultivars, with 21.33 g.

Among the cultivars, the differences in attacks by key pests (*Tuta absoluta* and *Bemisia tabaci*) were significant among the five tomato varieties. Santa Clara was the most susceptible and Cereja was least susceptible, or most resistant, to attacks by two key pests.

Baldin et al. (2007) and Togni et al. (2009) obtained similar results, in controlled studies using extracts of plants in a greenhouse. Oliveira et al. (2008), in a study of *T. absoluta*, obtained significant results, corroborating this study in terms of climatic variables.

### Analysis of climatic factors

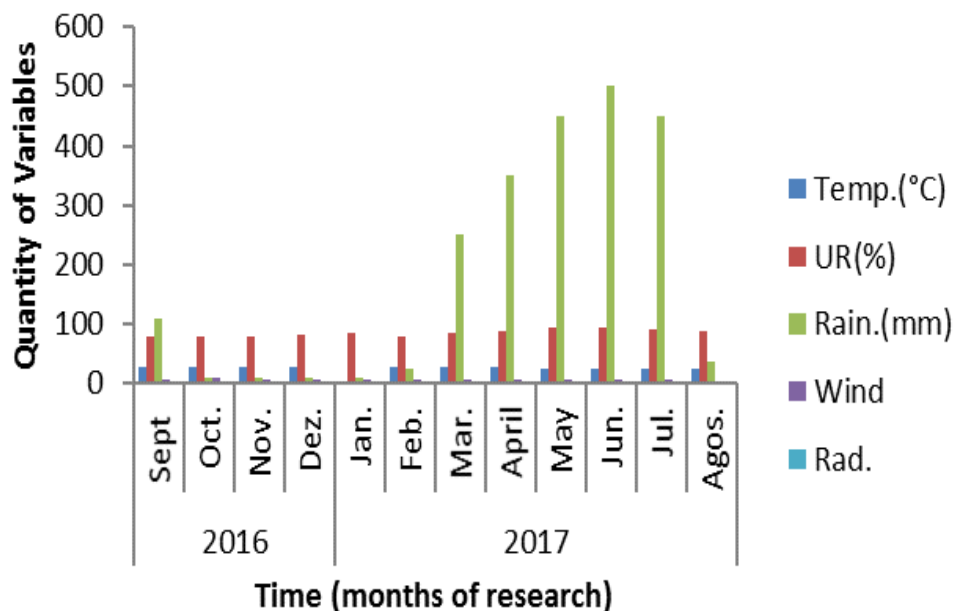
There were no variations among the average values of the climatic variables, relative humidity, temperature, wind and radiation. However, there was variation in terms of rainfall, with the months of March to July 2017 being having with the highest rainfall (Figure 1).

Various climatic conditions are determinant factors for the productivity of the tomato crop, with precipitation, relative humidity, temperature, wind and radiation modulating crop performance.

Wind, rainfall and relative humidity were the climatic factors that most modified the performance of tomato plants, since wind assists in the growth of tomatoes, contributing to photosynthesis by increasing concentrations of CO<sub>2</sub>. This process produces biochemical energy to perform physiological activities, in addition to participating in the transpiration processes, allowing water present in the tomato plants to escape through the stomata, regulating plant temperature, and inhibiting wilting (Gravena and Benvenga, 2003).

Rainfall participates in several physiological and biochemical processes in tomato plants, allowing the absorption and transport of nutrients throughout the plant. Relative humidity prevents the absorption of nutrients, in addition to keeping the leaves of the tomato moist for long periods, favoring the appearance of diseases caused mainly by fungi and bacteria (Barbosa et al., 2016).

In onion production, wind had a strong influence on



**Figure 1.** Climatic variables of the rural region of Alagoas, Northeast Brazil, during the period of the research (2016–2017).  
Source. Research Data.

plant growth, contributing to transpiration, increasing CO<sub>2</sub> absorption and consequently increasing the photosynthetic rate, as well as exerting substantial mechanical effects on onion leaves (Oliveira et al., 2014). In beet cultivation, high rainfall favored infestation of invasive plants, limited the development of the crop, increased the occurrence of diseases causing physiological disturbances and reduced productivity (Costa, 2014).

#### Evaluation of the correlations of adult key pests and explanatory variables

Tables 2 to 6 display the Pearson correlation coefficients of the phenological variables of the cultivars (Santa Clara, Caline Ipa 6, Santa Cruz, Rio Grande and Cereja) with climatic variables (precipitation, relative humidity, temperature, wind and radiation). There were positive and negative correlations for the climatic variables and the phenological variables of the tomato plants with the monitoring of the adult pest insects. Correlations between *T. absoluta* and *B. tabaci* were negative for each cultivar. The populations of these insects were inversely proportional, that is, while one grows the other one diminishes during the culture cycle.

Fernandes et al. (2009), in a study of *Leucoptera coffeella* (Guérin-Mèneville, 1842) (Lepidoptera: Lyonetiidae) in coffee plants, observed that in correlation studies and trail analysis, the environmental variables that most influenced the intensity of the attack of this pest were rainfall ( $r = 0.69$ ), air temperature ( $r = -0.40$ ) and

solar radiation ( $r = -0.44$ ).

According to Oliveira et al. (2011), the principal meteorological elements that provided energy for evaporation and removal of water vapor from evaporating surfaces were solar radiation, air temperature, relative humidity, wind speed and vapor pressure deficit. In this study, solar radiation was the most important element for the evaporative demand of the atmosphere (Tables 1 and 2).

The study of simple correlations between the variables allowed only measurement of association to verify their magnitude, direction and intensity (Coimbra et al., 2005; Vieira et al., 2007)

The data collected from the cultivars and the climatic dynamics in the tomato growing region correlated with explanatory variables, following the hypothesis raised for the association of the endemic presence of the key pests *T. absoluta* and *B. tabaci*. These environmental indicators could aid the planning of integrated pest management - IPM.

#### Evaluation of correlations of phenological variables with climatic factors

The pest insects studied cause damage to the crop and damage is associated with presence during seasonality and climatic variables. In the case of rainy days, the application of chemical control is not effective (Guimarães et al., 2007). The data presented on the correlations were significant at  $p < 0.01$  level of

**Table 2.** Pearson's correlation coefficient between the agronomic performance variables of the Santa Clara cultivar with the climatic variables and the pest insects.

Cultivar Santa Clara													
	<i>T. absoluta</i>	<i>B. tabaci</i>	Heig.	Bran.	FB	NF	DF	WF	Rain.	UR	Temp.	Win.	Rad.
<i>T. absoluta</i>	-	-0.25	-										
<i>B. tabaci</i>	-0.25	-											
Heig.	0.74	0.67	-										
Bran.	0.67	0.63	0.11	-									
FB	0.55	0.73	-0.06	-0.59	-								
NF	0.57	0.74	-0.58	-0.13	0.12	-							
DF	0.33	0.47	-0.15	-0.33	0.85	0.30	-						
WF	0.35	0.36	-0.24	-0.25	0.53	0.46	0.77	-					
Rain.	0.82	0.56	-0.06	-0.04	-0.32	-0.50	-0.54	-0.44	-				
UR	0.53	0.46	-0.11	0.30	-0.69	-0.02	-0.74	-0.55	0.46	-			
Temp.	-0.19	-0.17	0.04	-0.36	0.49	0.12	0.53	0.35	-0.29	-0.59	-		
Wind	-0.42	-0.38	-0.29	-0.25	0.37	0.49	0.64	0.53	-0.42	-0.42	0.72	-	
Rad.	0.44	0.46	0.07	-0.43	0.19	-0.42	-0.08	-0.23	0.37	-0.03	0.55	0.06	-

Heig. = Height; Bran. = Branches; FB = Flower buds; NF = Number of fruits; DF = Fruit diameter; WF = Fruit weight; Rain. = Rainfall U.R = Relative humidity; Temp = Temperature; Wind = Winds; Rad. = Sun radiation.

significance. These positive (+) and or negative (-) correlations are important because they are directly proportional or inversely proportional, in intensity and direction in relation to explanatory variables. Magnitudes were defined as follows: Weak ( $0.20 < |r| < 0.40$ ), moderate ( $0.40 < |r| < 0.60$ ), strong ( $0.60 < |r| < 0.80$ ) and very strong ( $|r| > 0.80$ ); these parameters are corroborated by the publication of Franzblau (1958).

Flower buds of the tomato cultivars had positive and negative correlations, depending on the cultivar, with a greater number of climatic variables. Under the conditions studied, precipitation, temperature, relative humidity, wind and radiation modulated the performance of tomato plants (Table 2).

In cultivar Santa Clara, the correlations between fruit diameter and temperature ( $r = 0.53$ ), and fruit diameter ( $r = 0.64$ ), fruit weight ( $r = 0.53$ ) with wind, were positive at a level of  $p < 0.01$ . In this cultivar there was also a negative correlation between precipitation and fruit diameter ( $r = -0.54$ ), as well as between relative humidity with flower buds ( $r = -0.69$ ), fruit diameter ( $r = -0.74$ ) and fruit weight ( $r = -0.55$ ). These results show that flowering and fruit quality increased when there was a lower level of precipitation and relative humidity (Table 2).

These data suggest that fruit quality was associated with climatic variables when the crop was in the field. Carmo et al. (2010) found that temperature directly participated in growth phases, limiting cultivation, becoming the climatic factor of greatest importance for the tomato crop. Guimarães et al. (2007) found that high humidity levels interfered with pollination of the flowers and caused abortion, as well as reducing the transpiration process of the plant because it interfered with the absorption of nutrients.

In cultivar Caline Ipa 6, there was a significant positive correlation between flower buds and rainfall ( $r = 0.51$ ), suggesting that increased rainfall correlated with greater flowering of the tomato in the field. The negative correlation ( $r = -0.76$ ) between flower buds and wind was desirable because lower air velocity contributes to flower bud performance, increasing tomato production in crops without control of the variables (Table 3).

Although tomato is a demanding species in terms of water requirements, excess rainfall limited cultivation, favored disease occurrence, and impaired fruit quality, causing a reduction in soluble solids content ( $^{\circ}$ Brix) (Silva et al., 2006).

For Santa Cruz there was a positive correlation between precipitation and flower buds ( $r = 0.70$ ), suggesting that higher rainfall gives rise to greater development of flower buds. Solar radiation positively correlated with flower buds ( $r = 0.65$ ), directly contributing to increased tomato productivity (Table 4).

In the tomatoes used in the study of Fabbri (2009) on radiation, they observed that tomatoes exposure to radiation for over fifteen days caused a delay in fruit ripening, with fruits remaining greenish in color. Holcman (2009), in a study of Cereja tomato fruits, found large fruit numbers were obtained with larger amounts of solar radiation.

In cultivar Rio Grande, there was a negative correlation between flower buds and relative humidity ( $r = -0.65$ ). This result demonstrates that at lower relative humidity there was a greater emission of flower buds. The other phenological variables did not show significant correlations (Table 5).

High rates of relative humidity modulate the development of lettuce, leading to the emergence of

**Table 3.** Pearson's correlation coefficient between the agronomic performance variables of the Caline Ipa 6 cultivar with the climatic variables and the pest insects.

Caline Ipa 6													
	<i>T. absoluta</i>	<i>B. tabaci</i>	Heig.	Bran.	FB	NF	DF	WF	Rain.	UR	Temp.	Win.	Rad.
<i>T. absoluta</i>	-	-0.21	-										
<i>B. tabaci</i>	-0.21	-											
Heig.	0.77	0.67	-										
Bran.	0.66	0.63	0.09	-									
FB	0.58	0.70	-0.14	-0.06	-								
NF	0.56	0.71	0.46	-0.01	-0.43	-							
DF	0.34	0.44	0.58	0.40	-0.37	-0.02	-						
WF	0.33	0.36	0.55	0.44	-0.31	-0.06	0.96	-					
Rain.	0.81	0.55	0.19	-0.45	0.51	-0.08	-0.06	0.02	-				
UR	0.53	0.44	0.02	-0.36	0.36	0.13	-0.27	-0.21	0.46	-			
Temp.	-0.18	-0.19	0.12	0.23	-0.36	0.12	0.12	0.12	-0.29	-0.59	-		
Wind	-0.42	-0.37	-0.06	-0.05	-0.76	0.34	0.08	-0.01	-0.42	-0.42	0.72	-	
Rad.	0.43	0.44	0.35	0.02	0.14	0.17	0.06	0.19	0.37	-0.03	0.55	0.06	-

Heig. = Height; Branc. = Branches; FB = Flower buds; NF = Number of fruits; DF = Fruit diameter; WF = Fruit weight; Rain. = Rainfall U.R = Relative humidity; Temp = Temperature; Wind = Winds; Rad. = Sun radiation.

**Table 4.** Pearson's correlation coefficient between the agronomic performance variables of the Santa Cruz cultivar with the climatic variables and the pest insects.

Santa Cruz													
	<i>T. absoluta</i>	<i>B. tabaci</i>	Heig.	Bran.	FB	NF	DF	WF	Rain.	UR	Temp.	Win.	Rad.
<i>T. absoluta</i>	-	-0.24	-										
<i>B. tabaci</i>	-0.24	-											
Heig.	0.75	0.67	-										
Bran.	0.66	0.64	-0.18	-									
FB	0.56	0.69	-0.30	0.54	-								
NF	0.54	0.72	-0.09	0.33	-0.01	-							
DF	0.33	0.45	0.08	-0.08	0.16	0.24	-						
WF	0.35	0.36	0.23	-0.32	-0.01	0.17	0.95	-					
Rain.	0.81	0.57	-0.39	0.41	0.70	0.18	-0.01	-0.21	-				
UR	0.51	0.47	0.22	0.04	0.24	0.11	-0.36	-0.32	0.46	-			
Temp.	-0.18	-0.16	-0.36	0.01	0.03	0.07	0.30	0.34	-0.29	-0.59	-		
Wind	-0.42	-0.39	-0.37	-0.38	-0.29	-0.19	0.18	0.26	-0.42	-0.42	0.72	-	
Rad.	0.46	0.48	-0.47	0.39	0.65	0.36	0.09	0.02	0.37	-0.03	0.55	0.06	-

Heig. = Height; Branc. = Branches; FB = Flower buds; NF = Number of fruits; DF = Fruit diameter; WF = Fruit weight; Rain. = Rainfall U.R = Relative humidity; Temp = Temperature; Wind = Winds; Rad. = Sun radiation.

diseases, and low indices of relative humidity facilitated dehydration of the plant more frequently (Tibiriçá et al., 2004).

Cultivar Cereja did not present significant correlations at the level of  $p < 0.01$  between climatic and phenological variables. It was observed that this cultivar grew without regard to climatic variations in the study area. In this study, the plants irrigated daily in a protected environment with 50% shade, these factors aided in the phenology of tomato plants (Table 6).

## Conclusion

Tomato cultivation in protected environments was influenced by climatic variables in terms of the phenological development of the cultivars used and was correlated with the presence of two key pests. The correlations of phenological and climatic variables were significant for the presence of *T. absoluta* and *B. tabaci* in cultivars of tomatoes cultivated in pots, establishing the endemism of these two key pests in the tomato growing

**Table 5.** Pearson's correlation coefficient between the agronomic performance variables of the Rio Grande cultivar with the climatic variables and the pest insects.

Rio Grande													
	<i>T. absoluta</i>	<i>B. tabaci</i>	Heig.	Bran.	FB	NF	DF	WF	Rain	UR	Temp.	Win.	Rad.
<i>T. absoluta</i>	-	-0.22	-										
<i>B. tabaci</i>	-0.22	-											
Heig.	0.75	0.68	-										
Bran.	0.64	0.63	0.51	-									
FB	0.55	0.70	0.11	0.65	-								
NF	0.53	0.71	0.58	-0.03	0.06	-							
DF	0.32	0.44	0.41	-0.09	0.02	0.60	-						
WF	0.33	0.35	0.41	-0.09	0.02	0.60	0.99	-					
Rain.	0.81	0.55	-0.44	-0.30	-0.34	0.05	-0.37	-0.37	-				
UR	0.55	0.42	-0.01	-0.36	-0.65	-0.01	-0.15	-0.15	0.46	-			
Temp.	-0.17	-0.16	0.40	0.35	0.17	0.29	0.33	0.33	-0.29	-0.59	-		
Wind	-0.41	-0.35	0.34	0.48	0.43	0.14	0.47	0.47	-0.42	-0.42	0.72	-	
Rad.	0.44	0.43	0.28	0.24	-0.25	0.16	-0.28	-0.28	0.37	-0.03	0.55	0.06	-

Heig. = Height; Bran. = Branches; FB = Flower buds; NF = Number of fruits; DF = Fruit diameter; WF = Fruit weight; Rain = Rainfall U.R = Relative humidity; Temp = Temperature; Wind = Winds; Rad. = Sun radiation.

**Table 6.** Pearson's correlation coefficient between the agronomic performance variables of the Cereja cultivar with the climatic variables and the pest insects.

Cereja													
	<i>T. absoluta</i>	<i>B. tabaci</i>	Heig.	Bran	FB	NF	DF	WF	Rain	UR	Temp	Win.	Rad
<i>T. absoluta</i>	-	-0.23	-										
<i>B. tabaci</i>	-0.23	-											
Heig.	0.76	0.69	-										
Bran.	0.67	0.65	0.62	-									
FB	0.57	0.71	0.69	0.47	-								
NF	0.55	0.73	0.14	0.12	0.57	-							
DF	0.34	0.45	0.40	0.41	0.69	0.37	-						
WF	0.34	0.37	0.42	0.37	0.69	0.36	0.99	-					
Rain.	0.83	0.56	0.10	-0.39	-0.07	-0.44	-0.07	0.01	-				
UR	0.52	0.45	-0.04	-0.04	-0.22	-0.46	0.13	0.20	0.46	-			
Temp.	-0.19	-0.17	-0.17	-0.04	0.03	0.29	-0.15	-0.19	-0.29	-0.59	-		
Wind	-0.43	-0.39	0.06	0.45	0.23	0.42	-0.01	-0.06	-0.42	-0.42	0.72	-	
Rad.	0.45	0.47	-0.02	-0.27	-0.13	-0.13	-0.09	-0.06	0.37	-0.03	0.55	0.06	-

Heig. = Height; Bran. = Branches; FB = Flower buds; NF = Number of fruits; DF = Fruit diameter; WF = Fruit weight; Rain = Rainfall U.R = Relative humidity; Temp = Temperature; Wind = Winds; Rad. = Sun radiation.

regions, although no economic damage was done. It was observed that climatic factors including precipitation, radiation, temperature and wind were environmental factors that contributed to the development of tomatoes cultivated in fields or protected environments, and to the monitoring of pests for planning integrated pest management – IPM.

## CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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