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INFLUENCE OF THE PHENOLOGICAL PHASE OF TWO PEPPER CULTIVARS ON THE BEHAVIOUR OF *Polyphagotarsonemus latus* (BANKS)

H. Rodríguez*[1], A. Montoya, Ileana Miranda*, Yaritza Rodríguez***, Mayra Ramos******

** Grupo Plagas Agrícolas, Dirección de Protección de Plantas. Centro Nacional de Sanidad Agropecuaria (CENSA). Carretera de Jamaica y Autopista Nacional. Apdo. 10, San José de las Lajas, Mayabeque, Cuba. Correo electrónico: morell_66@isch.edu.cu, ** Facultad Agroforestal de Montaña (FAM). Centro Universitario de Guantánamo (CUG). El Salvador, Guantánamo, Cuba, *** Instituto de Investigaciones Hortícolas «Liliana Dimitrova» (IIHLD). Carretera Bejucal-Quivicán, km 33½, Quivicán, Mayabeque, Cuba, **** Departamento de Medio Ambiente. Facultad de Gestión de la Ciencia, la Tecnología y el Medio Ambiente, Instituto Superior de Tecnologías y Ciencias Aplicadas (InSTEC). Carlos III y Luaces, Plaza de la Revolución, La Habana, Cuba*

***ABSTRACT*: The severity of the damages caused by *Polyphagotarsonemus latus* (Banks) in the protected production of pepper have been related to the phenological phases of the crop. The influence of the phenological phases on the damages produced by *P. latus* on two Cuban pepper cultivars is evaluated in the present work. Groups of eight pots were formed with plants of each of the cultivars. The treatments consisted in the infestation of the apical zone of the plants with ten females of the broad mite at 5, 7, 10 and 14 weeks of seed germination, time periods corresponding to the different phenological phases. A group of eight plants of both cultivars were left uninfested as controls. After infestation, one leaf was collected from the apical zone of each plant every seven days for eight weeks to determine the number of mites. In addition, the leaf fresh and dry weights and the leaf area were determined. The trial was concluded after 22 weeks, when the height and the fresh and dry weights of the plants were determined. The number of mites present in each of the pepper phenological phases was statistically different in both cultivars. Both cultivars showed significant differences in the plant height and fresh and dry weights in relation to the remaining treatments and the control only when the mite was released at the vegetative growth phase. These results suggest that the pepper crop is more vulnerable to the attack of the broad mite at the initial life cycle phases of the crop. Therefore, it is when the crop must be protected with greater emphasis.**

*(Key words: **Capsicum annuum**; damage; broad mite; Tarsonemidae; injury levels)*

INFLUENCIA DE LA FASE FENOLÓGICA DE DOS CULTIVARES DE PIMIENTO EN EL COMPORTAMIENTO DE *Polyphagotarsonemus latus* (BANKS)

***RESUMEN*: La severidad de los daños que produce *Polyphagotarsonemus latus* (Banks) en la producción protegida de pimiento ha sido relacionada con las fases fenológicas del cultivo. En el presente trabajo se evalúa la influencia de las mismas en los daños producidos por *P. latus* sobre dos cultivares cubanos de pimiento. Con las plantas de cada cultivar se formaron grupos de ocho macetas. Los tratamientos consistieron en infestar las plantas en la zona apical con 10 hembras del ácaro blanco a las 5, 7, 10 y 14 semanas de germinadas las semillas, periodos que se corresponden con las diferentes fases fenológicas. Se dispuso de un grupo de ocho plantas como control que no**

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[1]**Current address**: Departamento Biología-Sanidad Vegetal. Facultad de Agronomía. Universidad Agraria de La Habana (UNAH). Carretera de Tapaste. San José de las Lajas, Mayabeque. CP 32 700. Correo electrónico: morell_66@isch.edu.cu

fueron infestadas, para ambos cultivares. A partir de la infestación, se extrajo una hoja de cada planta de la zona apical cada siete días, para determinar la cantidad de ácaros presentes por espacio de ocho semanas. A cada hoja se le determinó además, la masa fresca y seca y el área foliar. A las 22 semanas, cuando se dio por concluido el experimento, se midió la altura de las plantas, su masa fresca y seca. El número de ácaros presentes en cada una de las fases fenológicas del pimiento fueron estadísticamente diferentes, en ambos cultivares. Para los indicadores altura, masa fresca y seca de la planta, solo se observaron diferencias significativas cuando el ácaro fue liberado en la fase de crecimiento vegetativo con relación al resto de los tratamientos y el control, para ambos cultivares. Estos resultados sugieren que el cultivo del pimiento es más vulnerable al ataque de ácaro blanco en las fases iniciales del cultivo. Por tanto, este es el momento en que el cultivo debe ser protegido con mayor énfasis.

*(Palabras clave: **Capsicum annuum**; daño; ácaro blanco; Tarsonemidae; nivel de daño)*

INTRODUCTION

Nowadays, the protected agriculture system is worldwide recognized as an advanced agricultural technology that can have an effective influence on the production of fresh vegetable around all the year. The importance of this system has come increasing as the producer has mastered the technology and reached satisfactory results (1).

The conditions offered to the crop in these systems are also suitable for the development of new pests and the rise of others to levels that may be incompatible with the achievement of acceptable yields. In this context, an increase of the affectations by nematodes, insects and mites has occurred, and the latter have been the cause of considerable losses in some horticultural species grown under these systems (2,3).

The broad mite, *Polyphagotarsonemus latus* (Banks) (Acari: Tarsonemidae) is considered one of the major pests in the pepper crop (*Capsicum annuum* L.) (4,5,6,7,8,9), which causes the decrease of the plantation useful time and yields. Monitoring of this pest starts with the pepper seedlings and is maintained during the whole cycle of the crop (1). However, it is unnoticed very often and its presence is detected when the damage is irreversible.

Pepper production has assumed new challenges in Cuba giving priority to the domestic consumption (population and tourism); and in the search of solutions, the use of pepper hybrids (F_1) has been increased for their exploitation in protected crops and in the open field as well. These hybrids offer the possibility of showing the effect of heterosis, mainly under stress conditions; of accumulating dominant genes of resistance to several pathogens and of conserving the fruits in shelves; in addition of permitting the varietal protection and the profitability of the selection work, as well as a better adaptation to adverse conditions (10).

With this purpose, plant improvers have worked on obtaining multiresistant lines to diseases, mainly to viruses. The material derived from the improving process has been assessed and promising results has been reached with the cultivars HIRAM F_1 and LPD-5 F_1, which are the hybrids mostly used in the protected pepper production in Cuba at present (11). However, their behaviour when attacked by *P. latus* is unknown. Bearing all these facts in mind, this work was aimed to know the damages caused by *P. latus* and its relationship with the phenological phases of the two pepper hybrids in greenhouses.

MATERIAL AND METHODS

The experiments were carried out in a greenhouse of the Centro Nacional de Sanidad Agropecuaria (CENSA, Mayabeque) with net walls and roof of plexiglass from November 2007 to April 2008. The pepper cultivars used were HIRAM F_1 and LPD-5 F_1. After one month of germinated, the seedlings were transplanted to 5 L plastic pots containing Compacted Red Ferralitic soil (12) and organic matter (cattle manure) in a 3:1 proportion. Eight pots/hybrids/ treatment were used, which were the repetitions of the experiment. The temperature and the relative humidity were maintained at 26.63 ± 6.5°C and 64.08 ± 5.1%, respectively, measured with a digital thermo-hygrometer (Testo 608-H2).

Five groups with eight plants were formed of each cultivar. The treatments consisted in the infestation of the plants with the broad mite at 5, 7, 10 and 14 weeks after seed germination. Those time periods correspond with the plant phases: vegetative growth, blossoming, early fruiting and late fruiting, respectively.

At each infestation time, 10 broad mite females were released on the apical zone of each plant. The females were taken with a paintbrush (00); they were placed with an entomological pin on two pepper leaves (five on each leaf). For both cultivars, a group of eight plants were left uninfested as a control.

After plant infestation, they were sampled weekly during eight weeks. In each sampling, the number of mites present on one leaf collected from the apical zone of each plant was determined under a Zeiss Stemi SV-6 stereomicroscope. The area and the dry and fresh weights of these leaves were also determined.

Each leaf image was digitised with a NIKON D 200 digital camera at life-size and the same distance between the lens and the leaf (0.5 m). The leaf area was determined with these images using the Image Tool version 3 program .Then, the leaf fresh weight was determined with a Sartorius electronic balance and the dry weight determined after the leaves were placed in an ECOCELL stove at 70 ºC for seven days until constant weights were reached.

After 22 weeks, when the experiment was considered concluded, the plant height was determined in cm, as well as the plant fresh and dry weights. Prior to plant removal, the pots were abundantly watered to avoid damages to the root system. The roots were washed with water and wiped with absorbent paper. Thereafter, a procedure similar to the above described for the leaves was followed.

With the data recorded and taking account of the phenological phases of the pepper crop for each cultivar separately, the influence of the broad mite on each of the parameter assessed was determined by Simple Analysis of Variance and means compared by Duncan's Test.

RESULTS AND DISCUSSION

In both cultivars, the broad mite populations were preferably localized on the leaf underside. But when the population levels increased, they could also be found on the leaf upperside, mainly the females, which was the stage that migrated more easily. This is the habitual behaviour of this phytophagous, which prefers the most protected places of the young leaf underside for its development (4,5,13). A similar behaviour was shown by both cultivars; the population levels of the broad mite increased from the first to the third sampling, and then began to decrease gradually until minimum values in the eighth sampling (Fig. 1-2). It is known that when the leaves show severe symptoms, they become unsuitable for the normal development of the pest and it tends to migrate towards more favourable zones (5).

Table 1 shows that the numbers of mites present in each of the pepper phenological phases were statistically different. If the total population of the phytophagous is considered, the highest population levels were reached by both cultivars when the plants were infested at the vegetative growth phase, with values that differed significantly from the remaining treatments The plants infested at the blossoming phase were placed in a second group, although the population levels did not exceed the 40% of the population observed in the vegetative growth phase. The lowest population levels, with no significant difference among them, were observed when the plants were infested at the early and late fruiting phases.

This result is not entirely consistent with that informed by de Coss-Romero and Pena (4) in Florida. The highest mite levels were observed by these authors in the early fruiting phase, what does not agree with the results of the present study, while the lowest values were similarly detected in the late fruiting phase. It is

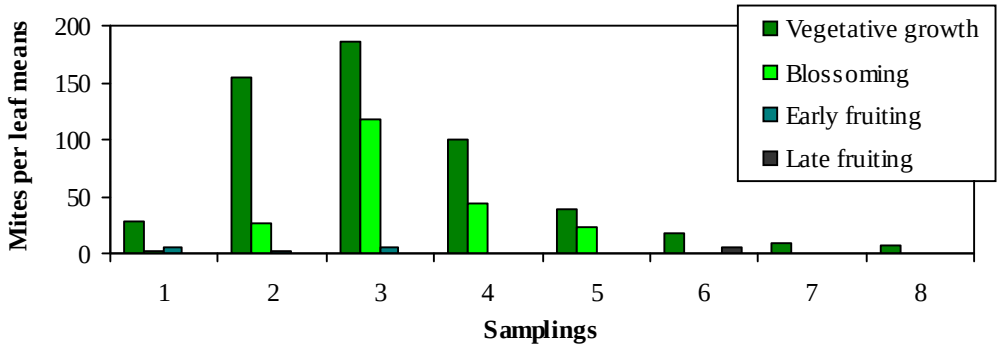

FIGURE 1. Population density of *Poplyphagotarsonemus latus* in the different phenological phases of the pepper crop *Capsicum annuum* cv. HIRAM F_1./ *Densidad poblacional de* ***Polyphagotarsonemus latus*** *en las diferentes fases fenológicas del cultivo del pimiento* ***Capsicum annuum*** *cv. HIRAM* F_1.

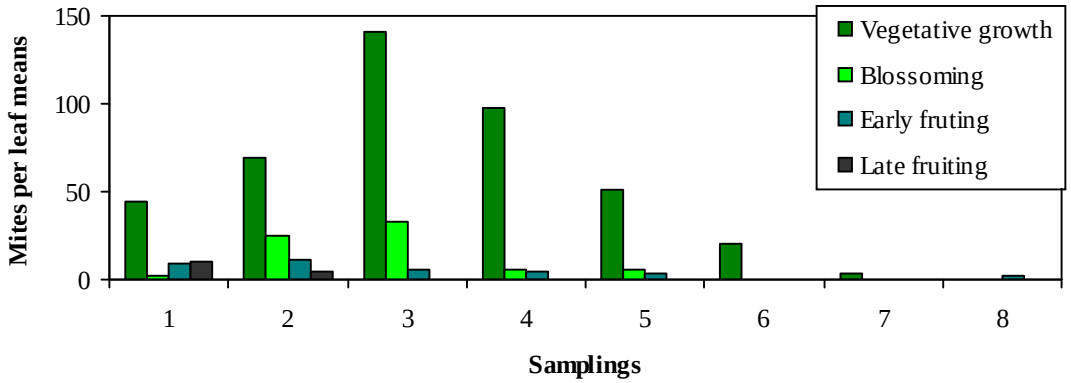

FIGURE 2. Population density of *Polyphagotarsonemus latus* in the different phenological phases of the pepper crop *Capsicum annuum* cv. LPD-5 F_1./ *Densidad poblacional de* ***Polyphagotarsonemus latus*** *en las diferentes fases fenológicas del cultivo del pimiento* ***Capsicum annuum*** *cv. LPD-5* F_1.

TABLE 1. Population mean of *Polyphagotarsonemus latus* stages in the different phenological phases of the pepper crop *Capsicum annuum* cv. HIRAM F_1 and LPD-5 F_1./ *Media poblacional de las fases de* ***Polyphagotarsonemus latus*** *en las diferentes fases fenológicas del cultivo del pimiento* ***Capsicum annuum*** *cv. HIRAM* F_1 *y LPD-5* F_1.

Phase	Female Mean±SE	Male Mean±SE	Nymph Mean±SE	Egg Mean±SE	Total Population Mean±SE
HIRAM F_1					
Vegetative growth	5.40±0.78a	4.03±0.67a	30.20±6.45a	29.95±7.23a	69.59±14.12a
Blossoming	2.01±0.35b	1.54±0.37b	11.29±2.67b	9.20±2.12b	24.06±5.17b
Early fruiting	0.20±0.13c	0.07±0.04c	0.62±0.29c	0.39±0.21b	1.29±0.63c
Late fruiting	0.06±0.04c	0.03±0.03c	0.37±0.35c	0.14±0.12b	0.60±0.56c
LPD-5 F_1					
Vegetative growth	6.57±1.05a	5.15±0.80a	26.71±4.44a	20.98±4.25a	59.43±9.12a
Blossoming	1.54±0.28b	1.04±0.24b	9.15±0.31b	11.35±3.45b	23.10±5.72b
Early fruiting	0.75±0.20b	0.70±0.37b	2.93±1.04bc	3.25±0.73c	6.95±2.02c
Late fruiting	0.12±0.07b	0.09±0.05b	0.59±0.24c	0.84±0.37c	1.64±0.69c

Means followed by different letters, in column, differ significantly ($p<0.05$)

known that, due to the characteristic of their oral parts, the tarsonemids are less capable of penetrating the lignified tissues (14), what is likely to happen with the l4 week-old pepper plants. Both de Coss-Romero and Pena (4) and Echer *et al*. (5) pointed out that it was a valuable result for the programs evaluating pepper resistance to the broad mite, suggesting that this evaluation could be carried out in early growth stages of the crop.

The leaf area values observed for the phenological phases of vegetative growth and blossoming demonstrate that they are the phases more affected by *P. latus* feeding since these values are significantly different from those of the uninfested control in both cultivars. All the phases showed a similar behaviour for the fresh and dry weight evaluations as these were not significantly different excepting the fresh and dry weights for the early fruiting phase in the cultivar HIRAM F_1 and for the fresh weight in the late fruiting phase in the cultivar LPD-5 F_1 (Table 2).

When the influence of *P. latus* on plant height and plant fresh and dry weights was analysed, significant differences in plant height could only be observed in both cultivars when the mite was released at the vegetative growth phase in relation to the remaining treatments and the control. In the LPD-1 F_1 cultivar, the fresh and dry weights showed a similar behaviour, as it was expected; the lowest value was observed when the plants were infested with the mite at the vegetative growth phase, which differed significantly from the remaining treatments. In this cultivar, significant differences were not detected between the

TABLE 2. Comparison of the mean plant heigh and the fresh and dry weights of the pepper crop *Capsicum annuum* cv. HIRAM F_1 and LPD-5 F_1 infested with *Polyphagotarsonemus latus* at the different phenological phases./ *Comparación de la altura media y la masa fresca y seca del cultivo del pimiento* ***Capsicum annuum*** *cv. HIRAM* F_1 *y LPD-5* F_1 *infestadas con* ***Polyphagotarsonemus latus*** *en las diferentes fases fenológicas*

Phase	Height (cm) Mean ± SE	Fresh weight (g) Mean ± SE	Dry weight (g) Mean ± SE
HIRAM F_1			
Control	76.00±5.04a	112.66±11.9b	17.93±1.39b
Vegetative growth	57.00±5.30b	81.45±9.49c	10.01±2.10c
Blossoming	76.87±4.21a	124.57±6.32b	20.78±1.93b
Early fruiting	86.37±3.30a	157.87±6.45a	25.62±1.60a
Late fruiting	88.50±5.40a	102.02±5.96b	16.26± 0.14b
LPD-5 F_1			
Control	98.75±6.80a	192.81±15.55a	26.93±2.08a
Vegetative growth	56.50±6.41b	53.98±8.53c	6.47±0.92c
Blossoming	80.25±7.71a	108.05±10.59b	16.58±1.79b
Early fruting	93.25±6.52a	119.03±11.32b	18.80±2.07b
Late fruiting	98.25±6.07a	137.28±7.78b	20.73±1.21b

Means followed by different letters, in column, differ significantly ($p<0.05$)

control and the blossoming and late fruiting phases, whereas the highest value was shown by the early fruiting phase (Table 3). Significant differences among the treatments were found for the LPD-5 F_1 cultivar. The lowest value was observed in the vegetative growth phase; blossoming and early and late fruiting phases showed medium values and with no significant differences among them and the highest value was for the uninfested control.

The high stress levels induced by *P. latus* feeding provoke a reduction in the fruit quantity and quality, vegetative growth and differentiated blossoming development, due to some anatomical, physiological or biochemical differences among the plants in vegetative growth or reproductive stages. This reduction is caused by the systematic feeding on leaf young tissues, which are more susceptible than the plants with a higher number of mature leaves (4).

TABLE 3. Comparison of the mean leaf area and leaf fresh and dry weights of the pepper crop *Capsicum annuum* cv. HIRAM F_1 and LPD-5 F_1 infested with *Polyphagotarsonemus latus* at the different phenological phases./ *Comparación del área foliar media y la masa fresca y seca del cultivo del pimiento* ***Capsicum annuum*** *cv. HIRAM* F_1 *y LPD-5* F_1 *infestados con* ***Polyphagotarsonemus latus*** *en las diferentes fases fenológicas*

Phase	Leaf area (cm^2) Mean ± SE		Fresh weight (g) Mean ± SE		Dry weight (g) Mean ± SE	
HIRAM F_1						
Phenological moment	Infested	Control	Infested	Control	Infested	Control
Vegetative growth	501.98±40.32b	879.36±56.83a	0.10±0.010a	0.08±0.005a	0.01±0.0008a	0.01± 0.0006a
Blossoming	460.53±35.50b	613.60±41.45a	0.06±0.005a	0.05±0.003a	0.01±0.0010a	0.007±0.0004b
Early fruiting	612.25±50.98a	492.92±28.30b	0.07±0.008a	0.04±0.003b	0.009±0.0007a	0.007±0.0005b
Late fruiting	593.14±36.41a	410.30±23.92b	0.06±0.009a	0.04±0.003a	0.01±0.0020a	0.006±0.0004a
LPD-5 F_1						
Phenological moment	Infested	Control	Infested	Control	Infested	Control
Vegetative growth	370.67±31.01b	844.29±54.82a	0.08±0.010a	0.08±0.007a	0.01±0.001a	0.01±0.001a
Blossoming	467.19±33.42b	610.02±47.22a	0.05±0.004a	0.06±0.007a	0.008±0.0007a	0.01±0.001a
Early fruiting	549.95±31.40a	529.51±26.39a	0.05±0.004a	0.05±0.009a	0.00±0.0005a	0.01±0.001a
Late fruiting	591.09±38.27a	495.15±27.94b	0.05±0.003a	0.04±0.002b	0.008±0.0005a	0.009±0.001a

Means followed by different letters, in column, differ significantly ($p<0.05$)

TABLE 4. Comparison of the mean number of the fruits and weight of the pepper crop *Capsicum annuum* cv. HIRAM F_1 and LPD-5 F_1 infested with *Polyphagotarsonemus latus* at the different phenological phases./ *Comparación del número y masa promedio de los frutos del cultivo del pimiento* ***Capsicum annuum*** *cv. HIRAM* F_1 *y LPD-5* F_1 *infestados con* ***Polyphagotarsonemus latus*** *en las diferentes fases fenológicas*

Phase	Number fruits by plant Mean ± SE	Fruit weight by plant(g) Mean ± SE
HIRAM F_1		
Control	3.14±0.34a	91.09±5.52 a
Vegetative growth	1.12±0.29b	53.27±10.52b
Blossoming	2.62±0.49a	92.87±15.85a
Early fruiting	2.37±0.37a	93.21±8.13 a
Late fruiting	2.50±0.42a	99.20±13.73a
LPD-5 F_1		
Control	2.71±0.28a	84.70±6.40ab
Vegetative growth	1.37±0.26a	26.76±3.76 c
Blossoming	2.12±0.39a	74.73±4.90ab
Early fruiting	2.12±0.51a	66.45±14.65b
Late fruting	2.37±0.53a	96.59±5.36 a

Means followed by different letters, in column, differ significantly ($p<0.05$)

This population behaviour and the affectations of the normal plant development that they mean were evident in the number and mean weight of fruits per plant (Table 4). In the LPD-1 F_1 cultivar, significant differences were only observed between the vegetative growth phase, with the lowest values, and the remaining phases and the control. This result is in agreement with that previously described for this hybrid. In the case of the LPD-5 F_1 cultivar, no differences were found in the mean of fruits per plant, but they were in the fruit weight. For this parameter, the lowest value was found in the vegetative growth phase differing from the remaining ones.

Regardless of the existence or not of statistical differences among the treatments evaluated, it is observed a clear tendency indicating that in the same extent in which the mite delays its arrival at the pepper plant, the affectations it produces are lesser. These results suggest that the pepper crop is more vulnerable to the attack of the broad mite at the initial life cycle phases of the crop. Therefore, it is when the crop must be protected with greater emphasis.

The understanding of *P. latus* population behaviour in response to the phenological phases of these two pepper cultivars contributes to improve the monitoring programs and to the design of more effective management strategies.

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