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Original Article

Population density of phytophagous insects associated with early-and late-period cultivated beans

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ABSTRACT

In order to make an inventory of phytophagous insects of the bean crop on two planting dates and to determine their population density in the Bat-304 bean variety, an investigation was carried out at "San Miguel" farm on two planting dates, the first on September 5th, 2015 and the second on February 18th, 2016. Sampling was carried out 15 days after sowing the crop, performing 6 double diagonal samplings. Samples were taken from 15 plants at random in each sampling, taking one leaf from each level. The samples taken were taken to the Entomology Laboratory for quantification and identification of the different species. The phytophagous insects detected in the bean crop on the two planting dates were: *Empoasca kraemeri* Ross and Moore; *Bemisia tabaci* Gennadius; *Liriomyza trifolii* Burgess; *Thrips palmi* Karny; *Diabrotica* balteata Leconte and *Cerotoma ruficornis* Olivier. The mean population density of *B. tabaci* was higher at the lower level of the plant, while the remaining species (*E. kraemeri*; *L. trifolii* and *T. palmi*) did not show a preference for a particular level. The intensity of chrysomelid damage was higher at the early planting date and at the middle and lower levels for both planting dates. *E. kraemeri* showed a higher mean population density at the late sowing date; while *T. palmi* showed a tendency towards a higher mean population density at the early sowing date.

Key words: *Phaseolus vulgaris*, pest, sowing dates.

INTRODUCTION

The common bean (*Phaseolus vulgaris* L.) is native to the Americas, but is intensively cultivated throughout the tropical and some temperate regions of the world. It is one of the oldest foods known to man; it has been an important part of the human diet for thousands of years, and it is among the first domesticated and then cultivated food plants [(1)]. In Cuba, it constitutes one of main dishes in the Cuban menu, where together with rice (*Oryza sativa* L.) it forms part of the basic food, particularly black beans that make up the typical food of the population. However, the country has been importing about 60 thousand tons of beans per year to meet market demand, a figure that at the current average price is equivalent to more than 52 million dollars, which puts population food security of the at risk due to the expenditure of a large amount of foreign currency [(2)].

In Cuba, beans are of great importance; they are a food of high popular demand, so they are grown throughout the country. It covers an area of approximately 104,500 ha, which includes the state and non-state sector. The average yield of national production is 0.72 t ha^{-1} , so it is not able to meet consumption needs and country imports annually about 110 000 tons to meet the 25 kg per year average required per consumer [(3)]. However, domestic production continues to fail to meet demands of the population, and although production has increased, it is necessary to import around 114 400 tons of this grain annually [(4)].

Despite its importance and the fact that it is a traditional crop, its yield is affected by the incidence of various pests. Among the most harmful phytophagous insects that feed on beans are the white fly, *Bemisia tabaci* Gennadius; the leafhopper, *Empoasca kraemeri* Ross and Moore, which causes curling of the foliage; the chrysomelids *Diabrotica balteata* Leconte and *Cerotoma ruficornis* Oliver, which cause leaf punctures and transmit yellow mottle and cowpea mosaic viruses; the leafminer *Liriomyza trifolii* Burgess; the thysanoptera complex; and the stored grain weevils *Acanthoscelides obtectus* Say and *Zabrotes subfaciatu* Boheman [(5)].

Chemical control has remained, for about seven decades, as the main method of pest controls (arthropods, weeds and pathogens). Throughout this time, sufficient evidence has accumulated of the risks posed by the use of chemical pesticides to the environment and health, risks that also compromise the sustainability of agricultural systems. Despite public concerns about the damage they cause, in recent years there has been an increase in their use, but losses caused by pest attacks on crops have not decreased; on a global scale, these can reach values of more than 50 %. This situation makes it necessary to implement pest management strategies that do not affect the environment and that do not involve expenditure of economic resources with a view to increasing average annual yields, since they are well below national demand [(6)].

Cultural measures are agronomic practices that have been in use for a long time and constitute an example of methods applied with the aim of preventing pests. Cultural control constitutes a method that is the basis of any Integrated Pest Management strategy, which consists of the implementation of practices through which changes are produced in the environment that make it less favorable for the development of pests and that directly or indirectly benefit their natural enemies; the application of the method implies knowledge of pests and crops, their characteristics, and the relationships established between them (7).

The choice of an appropriate planting date is a cultural measure to reduce population densities of certain harmful organisms. By advancing or delaying the sowing or harvesting of annual crops, a strong pest attack can be avoided by sowing at times of the year when pests are absent, or by sowing in such a way that the most susceptible stage of the crop coincides with the time of the year when the pest is less abundant.

In Cuba, when evaluating different measures of integrated pest management in the cultivation of beans in several provinces of the country (8), it was reported the incidence of insect pests of this crop at different planting dates; however, climate change has caused variations in the behavior of these harmful organisms. On the other hand, in the Tumba Cuatro Council, no research has been carried out on the incidence of phytophagous insects that concur with the bean crop at different planting dates. Taking into consideration the above mentioned, in the present work it was proposed to determine the population density of phytophagous insect community associated to the bean crop by levels of the plant and sowing dates.

MATERIALS AND METHODS

List of phytophagous insects associated with the bean crop on two planting dates; as well as the determination of their population density by plant levels and planting dates.

The present research was carried out at San Miguel Farm, belonging to the CCSF "Niceto Pérez" located in Jaruco municipality, Mayabeque province, on two sowing dates, the first on September 5th, 2015 (early) and the second on February 18th, 2016 (late). The bean variety used in the research was Bat-304, sown on a Brown carbonate soil (9), at a sowing distance of 0.70 m between rows and 0.07 m between plants, for both sowing dates. The experimental area was 0.6 ha.

To list phytophagous insects associated with the bean crop on the two sowing dates under investigation, 15 plants were sampled at random in each sample, starting 15 days after sowing the crop. A total of six samplings were made with a weekly frequency in double diagonal. In each plant, one leaf from each level (upper, middle and lower) was sampled and the organisms were observed with the aid of a magnifying glass. The samples taken (leaves from each level) were placed in a nylon bag previously labeled with the date of sampling and the corresponding plant level. Subsequently, they were taken to the Entomology laboratory belonging to the Faculty of Agronomy of the Agrarian University of Havana, for quantification and identification of the different species, using the keys corresponding to each of these. The species of adult thrips detected were mounted with the help of the NOVEL stereoscopic microscope up to 1.5 magnification.

The data of the populations of the different species of phytophagous insects were transformed using the expression $\sqrt{x+1}$ and subjected to a factorial variance analysis, through the Statgraphics 5.1 program. Means were compared using Duncan's Multiple Range for 5 % significance.

The intensity of chrysomelid damage for both planting dates was determined using the lesion method and a scale of degrees was used.

Finally, damage intensity (I) expressed as a percentage was calculated using the formula:

$$I = (\Sigma (a\ b)) / 4N * 100$$

where:

a: degree of the scale

b: number of leaves of each grade

N: total number of leaves evaluated

4: last grade of the scale

RESULTS AND DISCUSSION

List of phytophagous insects associated with the bean crop on two planting dates, as well as the determination of their population density by plant level and planting dates.

Table 1 shows that insect species belonging to four orders and five families were associated with the bean crop on two planting dates under investigation. The order of insects with the highest incidence was the order Hemiptera, with two families (Cicadellidae and Aleyrodidae), which represented 40 % of families detected. These insects are the most frequent in bean cultivation in Cuba and in several countries [5,10,11].

Table 1. List of phytophagous insect species associated with the bean crop on two planting dates

Species	Order	Family
Empoasca kraemeri Ross & Moore	Hemiptera	Cicadellidae
Bemisia tabaci Gennadius	Hemiptera	Aleyrodidae
Liriomyza trifolii Burgess	Diptera	Agromizidae
Thrips palmi Karny	Thysanoptera	Thripidae
Diabrotica balteata Leconte	Coleoptera	Chrysomelid
Cerotoma ruficornis Olivier	Coleoptera	Chrysomelid

Regarding the determination of the mean population density of phytophagous insects associated with the bean crop by plant levels and sowing dates, results of the statistical analysis showed significant differences for these factors separately, as shown in Table 2. In the case of the interaction between both factors, no significant differences were obtained as a result of the statistical analysis.

Table 2. Mean population density of phytophagous insects associated with the bean crop by plant level

Level of the plant	***E. kraemeri* (nymphs/leaves)**		***B. tabaci* (nymphs/leaves)**		***L. trifolii* (larvae/leaves)**		***T. palmi* (larvae/leaf)**	
	$\bar{x}$ orig	$\bar{x}$ tranf	$\bar{x}$ orig	$\bar{x}$ tranf	$\bar{x}$ orig	$\bar{x}$ tranf	$\bar{x}$ orig	$\bar{x}$ tranf
Superior	12	3,38 a	4,92	2,32 b	0,75	1,29 a	17,83	3,72 a
Middle	12,25	3,38 a	6,33	2,63 b	0,83	1,30 a	15,33	3,34 a
Upper	15	3,61 a	14,42	3,76 a	1,25	1,45 a	8,00	2,47 a
S.E $\bar{x}$	0,29		0,25		0,11		0,61	

Means with equal letters in the same column do not differ significantly according to Duncan for p≤0.05

In the case of *E. kraemeri*; *L. trifolii* and *T. palmi,* no significant differences were obtained between three levels of the plant with respect to the mean population density of these phytophagous insects. The mean population density of *B. tabaci* was higher at the lower level of the plant, with significant differences between the middle and upper levels, but not between the latter. A significantly higher level of this insect was observed in the lower stratum of the plant with respect to the middle and upper stratum in the months of February to March for the bell pepper crop. Whitefly pupae and other immature stages (eggs and nymphs) are located on the underside of lower leaves [(12)].

The mean population density of *E. kraemeri* in the bean crop did not differ statistically for the three levels of the plant, which does not correspond with the results obtained by other researchers, who found that 89 % of the individuals of this cicadellid were located in the lower stratum and 6.15 % were located in the upper level [(13)]. It is important to note that there was a tendency towards a higher average population density of this cicadellid in the lower level of the plant from the biological point of view.

For the leafminer, no significant differences were obtained between plant levels in terms of mean population density, although there was a tendency toward a higher mean population density of *L. trifolii* in the lower level of the plant from the biological point of view, results that correspond with those reported by other authors [(14)], who when studying the effect of the levels of the plant on the feeding and oviposition behavior of *Liriomyza huidobrensis* (Blanchard) (*Diptera*: *Agromyzidae*), in varieties of *Solanum tuberosum* L. obtained that females of *L. huidobrensis* made a greater number of feeding bites and laid a greater number of eggs on the leaves of the lower stratum compared to the middle and upper stratum. The first mines made by *L. trifolii* become visible three or four days after oviposition and that apparently the females avoid the developing leaves, therefore the mines generally appear in the leaves of the lower or central part of the plant in the form of sinuous and whitish galleries [(15)].

Regarding the average population density of *T. palmi*; no significant differences were obtained between the levels of the plant, but it was possible to verify that there was a tendency from the biological point of view to higher average population densities of this thrips in the upper and middle levels of the plant, coinciding with the results obtained in other investigations, when describing the spatial pattern of *Thrips palmi* Karny in potato and bean crops, respectively, they reported that this was aggregated or contagious, being more accentuated in the larvae, which are more frequently located in the middle stratum of the plant, while adults are located in the upper stratum (16).

The fact that thrips larvae are found more frequently in the middle stratum of the plant is understandable if it is considered that in the middle stratum the individuals have better living conditions because they are less exposed to the action of natural enemies and solar radiation, besides being at this level, leaves, which due to their age, could be more adequate to guarantee food for this biological stage. In the case of adults, they predominated in the upper stratum, where the leaves are younger, which facilitates oviposition in the leaf tissue and allows them greater mobility (17).

These results correspond with those obtained by the National Service of Health, Safety and Food Quality of Mexico (18), which refers that this species shows a random spatial distribution in adults and aggregated in nymphs. In the case of low-growing crops, it has been observed that the distribution of populations at different levels of the plant shows significant differences, with the largest populations of nymphs in the middle and lower strata, while adults have a preference for the upper stratum of the plant.

The intensity of damage by chrysomelids at planting date 1 (early) was higher in relation to planting date 2 (late), where at the first date the values ranged between 6.11 % for the upper plant level and 11.9 % for the middle level. The plant levels most affected by these chrysomelid species were the middle and lower for both planting dates (Table 3).

Table 3. Damage intensity of chrysomelids (*D. balteata* and *C.* ruficornis) by plant level at two planting dates (%)

Level of the plant	Date 1(5/09/2015)	Date 2 (18/02/2016)
Upper	6,11	2,77
Middle	11,9	4,44
Inferior	9,44	3,61

In sowing date 1 (early) the higher intensity of damage by chrysomelids could be due to the abundant rainfall in September, which corresponds with other researches (19), whose authors refer that these chrysomelids are present in all the national territory causing important damages in early phenologies of the crop, associating their higher appearances to rainy seasons.

The fact that the intensity of damage by chrysomelids was greater on the leaves of the middle and lower levels may be related to certain physiological or morphological characteristics of the host plants. This preference for the leaves of the middle and lower levels may be due to the fact that these coleopterans prefer leaves with a certain degree of physiological maturity for feeding.

It is important to point out that in none of the two sowing dates under investigation the chrysomelids exceeded the economic threshold (25 % infestation), reported by the National Center of Plant Health in Cuba (CNSV), coinciding with other results (20), where when determining the ethology of these chrysomelids associated to three varieties of common bean in intermediate sowing time in Encrucijada municipality, in Villa Clara province, obtained in the most affected varieties of bean, CC 25-9 (white and red testa) infestation percentages below 25 %, while the variety of black testa was more tolerant to the attack of this insect.

As shown in Table 4, regarding the mean population density of phytophagous insects of the bean crop on the two planting dates, statistically significant differences were only obtained between the two planting dates for *E. kraemeri*. Regarding the mean population density of *B. tabaci*; *L. trifolii* and T. *palmi*, no significant differences were recorded for these phytophagous insects between the two sowing dates under investigation. However, it is important to point out that the mean population density of *T. palmi* on sowing date 1 was higher from the biological point of view, reaching values above the economic threshold defined for this insect (15 thrips/leaf) [(21)].

Table 4. Average population density of phytophagous insects of the bean crop at two planting dates

Dates	*E. kraemeri*		*B. tabaci*		*L. trifolii*		*T. palmi*	
	x̄ orig	**x̄ tranf**	**x̄ orig**	**x̄ tranf**	**x̄ orig**	**x̄ tranf**	**x̄ orig**	**x̄ tranf**
1 (5 /09 /2015)	4,55	2,27 b	7,50	2,08 a	0,83	1,29 a	20,27	3,74a
2 (18/02/2016)	21,65	4,64 a	9,61	3,00 a	1,05	1,40 a	7,16	2,61a
S. E x̄	0,24		0,20		0,09		0,49	

Means with equal letters in the same column do not differ significantly according to Duncan for p≤0.05

orig: original; tranf: transformed

The bean leafhopper *E. kraemeri* in sowing date 2 (late) showed a higher average population density compared to sowing date 1 (early), which could be due to the fact that in this period of growth and development of the crop, rainfall was scarce. It corresponds with what was exposed by the National Center of Plant Health [(21)], which states that in dry periods, the biological cycle of E. kraemeri is completed in a short time and its damages are intensified. In addition, on colder or rainy days, the intensity of flight is notably reduced.

The optimal sowing date for beans in Cuba is between October 15 and November 30, although there is an early date from the first of September and a late one until January 30 [(22)]. In research carried out in Holguin, it was found that the incidence of bean crop pests was maintained with lower indexes of leafhoppers, white fly, leafminer and white mite in September than in February [(8)].

It is of great value and importance to note that the average population density of E. kraemeri for both planting dates was high, with values above the economic threshold (one to two insects/leaf).

Table 4 shows that on sowing date 1 (early) there was a tendency towards a higher average population density of *T. palmi* from the biological point of view, which could be due to the temperature during the period under investigation, which ranged between 24-26 ºC. In this regard, it has been suggested that in tropical regions T. palmi finds favorable conditions to develop throughout the year; but its populations are lower in winter than in summer and the optimum temperature for the development of this species of thysanoptera is 25 ºC [23].

The damage potentials of *T. palmi* increase during dry seasons and its growth is favored by high temperatures [5]. It is recommended as cultural practices for the management of *T. palmi* the sowing date. For some localities, this can be an important preventive tactic, either because the sowing date can be managed favoring periods of higher rainfall for its effect on the pest, or taking into account the susceptibility or infestation levels of the crops or crop campaigns that were previously sowed [24].

In the case of *B. tabaci*, Table 4 shows a tendency from the biological point of view towards a higher average population density of this insect on sowing date 2, which could be due to the fact that in this period rainfall was scarce and the temperature oscillated between 20-24 ºC which is favorable for the development of this species. The most favorable temperatures for the development of this insect are between 24 and 30 ºC and that rainfall has a suppressive effect on whitefly populations [25]. The results obtained regarding the higher average population density of the whitefly on sowing date 2 (late) agree with other studies [26], where it is pointed out that the management of pest infestation foci and the arrangement of crop dates are determinant for the definition of the phytosanitary status of the pest.

The average population density of *L. trifolii* for planting date 2 (late) reached the economic threshold defined by the National Center for Plant Health [21], which is one live larva per leaf. For this phytophagous insect, the mean population density on both planting dates was very similar, with no significant differences between the two.

CONCLUSIONS

- The phytophagous insects detected in the bean crop on the two planting dates were: *Empoasca kraemeri* Ross and Moore; *Bemisia tabaci* Gennadius; *Liriomyza trifolii* Burgess; *Thrips palmi* Karny; *Diabrotica balteata* Leconte and *Cerotoma ruficornis* Olivier.
- The mean population density of *B. tabaci* was higher at the lower level of the plant, while the remaining species (*E. kraemeri; L. trifolii and T. palmi*) did not show a preference for a particular level.
- The intensity of chrysomelid damage was higher at planting date 1 (early) and at the middle and lower levels for both planting dates.
- *E. kraemeri* showed a higher mean population density at sowing date 2 (late); while *T. palmi* showed a tendency towards a higher mean population density at sowing date 1 (early).

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