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Falling of asparagus flowers (*Asparagus officinalis* Linneo.) for the handling of *Prodiplosis longifila* Gagné in the irrigation of the Chavimochic project

Caída de flores del espárrago (*Asparagus officinalis* Linneo.) para el manejo de *Prodiplosis longifila* Gagné en la irrigación Chavimochic

Prado, S.[1*], Castillo, J.[2], Rodriguez, S.[3].

* Corresponding author. joracava@lamolina.edu.pe

Abstract

The asparagus, a dioecious plant, usually includes plants of both sexes, though also hermaphrodite ones. The male inflorescences are frequented by adult *Prodiplosis longifila*, who lay such large amounts of eggs on them that its populations can reach millions of individuals over a lapse of 20 to 30 days, which is the plant regular flowering period. The field investigation took place in two locations: (i) the Irrigation Research Unit of the Universidad Nacional Agraria La Molina (UNALM) and (ii) properties of the Agricultural Society of Virú (SAVSA). The number of fallen flowers and larvae per bud after applying multiple treatments on asparagus plots of the two locations was counted to determine the best concentration and application time of various fertilizers to induce the highest percentage of flower fall to manage *P. longifila* populations. In the UNALM the fertilizer B Dose 2 generated the highest percentage of fallen flowers, 82.1 % ± 14.85 %, and the fertilizer C Dose 1 caused 74.94 % ± 13.78 %. In SAVSA the fertilizer B Dose 3 made a percentage of fallen flowers of 50.6 % ± 21.56 % and fertilizer B Dose 2, 49.85 % ± 16.28 %. The average number of *P. longifila* 2nd-stage larvae, evaluated on fifteen flowers and in three moments was 3.9 larvae. Foliar fertilizers applications affected both male and female flowers almost equally in all treatments, percentage-wise. Foliar fertilizers promote asparagus flowers falling, consequently contribute to a significative reduction of *P. longifila* populations, due to a larvae exposition to rapid desiccation under the sun.

Key words: *Management, Prodiplosis, Asparagus*

Resumen

El espárrago, planta dioica, generalmente comprende plantas para ambos sexos, aunque también plantas hermafroditas. Las influorescencias masculinas son frecuentadas por adultos de *Prodiplosis longifila* oviponiendo en las mismas**,** poblaciones que pueden alcanzar a millones de individuos en un lapso de tiempo de 20 a 30 días, período regular que dura la floración. La investigación se realizó en condiciones de campo en dos localidades, en la (i) Unidad de Investigación en Riegos de la Universidad Nacional Agraria la Molina (UNALM) y en el (ii) fundo Sociedad Agrícola Virú (SAVSA) para determinar niveles y momentos de aplicación de diversos fertilizantes foliares para generar el mayor porcentaje de caída de flores para el manejo de poblaciones de *P. longifila*; se determinó el promedio de larvas por cada flor. En la UNALM el fertilizante B Dosis 2 generó el mayor porcentaje de caída de flores de 82.1% ± 14.85 y el fertilizante C Dosis 1 generó un porcentaje de caída de flores de 74.94% ± 13.78 En SAVSA el Fertilizante B Dosis 3 generó un porcentaje de caída de flores de 50.6% ± 21.56 y el Fertilizante B Dosis 2 generó una caída de flores de 49.85 % ± 16.28. El promedio de larvas de II estadio de *P. longifila*, evaluadas en quince flores y tres momentos fue de 3.9 larvas. Tanto las flores masculinas y femeninas son afectadas por la aplicación de los fertilizantes foliares casi en el mismo porcentaje en todos los tratamientos. Se concluye que la aplicación de fertilizantes foliares promueve la caída de flores del espárrago y con ello una significativa reducción de las poblaciones de *P. longifila*, debido a que las larvas quedan expuestas a la desecación o al sol y rápidamente muere.

Palabras claves: *Manejo, Prodiplosis, Espárrago*

[1]Thesis to opt for the degree of agricultural engineer of the Faculty of Agronomy. Universidad Nacional Agraria La Molina.
[2]Professor of the Entomology Department of the Faculty of Agronomy. Universidad Nacional Agraria La Molina.
[3]Professor of the Plant Breeding Department of the Faculty of Agronomy. Universidad Nacional Agraria La Molina

Introduction

Prodiplosis longifila Gagné is the most significant pest in asparagus cultivation (*Asparagus officinalis* Linneo), specifically in Northern Peru; the larvae of this dipteran are located in the tender sprouts and apexes of green shoots causing injuries and malformations, which can lead to the sprout death. (Castillo, 2006; Delgado de la Flor *et al*., 1993).

The asparagus is a dioecious plant, though there also exist hermaphrodite plants. The inflorescences are frequented by adult female *P. longifila*, which lay eggs on them, thus generating populations of adult insects that can reach millions of individuals in a time lapse of 20 to 30 days, flowering period of the plants.

This pest population originated in flowering crops, can have three destinations: 1st, settle on the same field, attacking sprouts of the second sprouting; 2nd, invade neighboring fields in their first sprouting; and 3rd, attack fields during harvest, these attacks are so aggressive that they raise productions costs considerably. In all cases, there is a gradual carbohydrate reduction in the crown, only perceived over time. (Castillo, 2006).

Velasco (2015) carried out a study of *Prodiplosis longifila* populations on a molecular level based on altitude distribution, finding that there are not any groups attributable to high or low regions, there is no populational differentiation, populations can maintain a genetic flow despite environmental variation, this partly explains the wide range of geographic distribution.

A way to handle populations of this insect is by inducing a premature falling of the asparagus flowers, avoiding the adult females laying eggs on them, and thus decreasing the larvae number that could develop on the inflorescences and consequently reduce the emerging adult number. The present investigation studied the flowers falling due to foliar fertilization with different macro and microelements.

Foliar fertilization based on the absorption of nutrients through the foliar tissue is more effective when the solution stays more time in the form of a thin layer on the foliar surface, however, if salt accumulates on the foliar surface without being absorbed, could cause burning and wrinkling. Consequently, foliar spraying should be applied in doses from 2 to 5 percent. (Mengel & Kirkby, 2000).

The investigation establishes several objectives: to determine the effects of foliar fertilizers on the falling of asparagus flowers to handle *P. longifila*; to find which fertilizer produces the highest percentage of fall of flowers, and to establish the average number of larvae per flower.

Materials and methods

For the present investigation, we used commercial products, as shown in Table 1 with their respective concentrations.

The field work was carried in two localities: Lima and La Libertad. In Lima, it took place in the Irrigation Research Unit of the Universidad Nacional Agraria La Molina (UNALM) (November and December) and in La Libertad, in the district of Virú in properties of the Agricultural Society of Virú (SAVSA) (April and May).

In both cases, we applied One-way tests with factorial arrangements, where the factors were the levels of fertilization and the moments of application.

Table 1. Fertilizers used and their components in percentage.

	Concentration of elements (%)									
Fertilizers	**Mo**	**Mn**	**Mg**	**Fe**	**Cu**	**Co**	**Zn**	**B**	**S**	**N**
A		3		4	3		3	0.65		
B	0.05	3	2	4	0.5	0.005	4		2.8	
C										46
D	0.1	9	traces	7.2	0.3		0.6	0.4		
E	0.3		3.5	7.5	0.28		0.7	0.65		

La Molina, Lima-Perú. (UNALM).

We used the asparagus variety Atlas, in its ninth campaign, with thirteen treatments; each treatment had three plots, and the experimental unit was an asparagus plant, with twelve repetitions. The total area of the experiment was 485.44 m^2. For each treatment we made, three applications of fertilizers in the same doses, with the following phenologies: 30% of phylloclade opening (30th of November), 20% of flowering (7th of December) and 50% of flowering (15th of December).

Before applying the fertilizers, we chose the sample plants per each plot, and marked their 10th branch, starting to count from the first inferior branch of the plant. We used four fertilizer products in three different doses, as shown in Table 2, with their respective concentrations in Table 3. The fertilizers were applied with the help of a backpack sprayer.

Table 2. Fertilizers and their respective doses in the UNALM – La Molina. Lima-Perú, November -December.

	Doses (Kg/cil or Lt/cil*)		
Fertilizers	**D1****	**D2**	**D3**
A	1	0.5	1.5
B	1	0.5	1.5
C	2	4	6
D	0.25	0.35	0.5
Control	0	0	0

* Cylinder of 200 lt
** Doses

Virú, La Libertad- Perú. SAVSA.

For SAVSA we used the asparagus variety UC-157 F1 in its ninth campaign, with sixteen treatments. Each treatment had two different plots, and the experimental unit was an asparagus plant with ten repetitions. The total area of the experiment was 5832 m2. For each treatment, we made four applications in the same doses to the following phenologies: 50% of ramification (30th of April), 20% of phylloclade opening (05th of May), 20% of flowering (9th of May) and 30% of flowering (15th of May).

Before the application, we chose the plants per each plot and marked the 12th branch, starting to count from the first inferior branch of the plant. We applied the fertilizers by addition of surfactants and adherents to the solution, to favor the use of the foliar fertilizer (Leece, 1976). This way, the amount of falling flowers is increased. We used five different products in three separate doses along watered controls as shown in Table 3.

Table 3. Fertilizers used with their respective levels in SAVSA. Virú, La Libertad - Perú, May - June.

	Doses (Kg/cil or Lt/cil*)		
Fertilizers	D1**	D2	D3
A	0.4	0.5	0.6
B	0.5	0.6	0.7
C	2	2.5	3
D	0.5	0.6	0.7
E	0.5	0.6	0.7
Control	0	0	0

* Cylinder of 200 lt
** Doses

To determine the percentage of fallen flowers per plant, we compared the number of flower buds and flowers of the first and last evaluations; we also counted the number of larvae present on the flower.

One hundred flowers were evaluated at three times. From 10 rows, one meter/row and 10 male flowers/meter were evaluated and collected in the field.

Only the second larval stage was considered since the first stage is difficult to see and susceptible to dry, the third stage falls off the flower to the ground.

Results

Experimental work in UNALM

Significative statistical differences of the percentage of fallen flowers were observed for the parameters levels of fertilization and application moments of foliar fertilizers ($p < 0.001$); but not in their interaction. The treatments which caused the highest falling of flowers were Treatment B Dose 2 with 82.11 % + 14.85 % and C with 79.94 % + 13.78 % of fallen flowers; being both treatments statistically equal. ($p < 0$ .05). (Figure 1).

Experimental work in SAVSA

Statistical differences were observed concerning the percentage of fallen flowers for the factors levels of fertilization and moments of application and with their interaction ($p < 0.001$). The treatments which caused the highest falling of flowers were B Dose 3 (50.6 % ± 21.56 %), B Dose 2 (49.85 % ± 16.28 %), E Dose 1 (48.60 % ± 20.98 %), E Dose D3 (47.81 % ± 1.72 %) and E Dose 2 (45.09 % ± 23.42 %). All these treatments were statistically equal ($p < 0.05$). All the treatments had numerically more falling flowers than those of the control (Figure 2).

Falling of flowers in female and male plants

After comparing the average percentage of fallen flowers for male plants, all treatments produced more falling of flowers than the absolute control, with treatments B and E being the ones to stand out with 48.60 % ± 7.97 % and 46.56 % ± 8.63 % respectively, and treatments B, E, C, D, and A being statistically equal. ($p < .05$). (Figure 3).

After comparing the average percentage of fallen flowers for female plants, all treatments produced more falling flowers than the absolute control, with treatments B and E being the ones to stand out with 54.03 % ± 5.97 % and 48.1 % ± 6.1 %, and treatments B, E, C being statistically equal. ($p < 0.05$) (Figure 4).

The average number of *P. longifila* larvae per affected flower was 3.9 ± 1.68, with infestations from 1 to 7 larvae per flower. Figure 5.

Discussion

From the experiment that took place in La Molina, treatments B Dose 2 and treatment C Dose 1 were the ones that had the highest percentages of fallen flowers with 82.11 % + 14.85 % and 79.94 % + 13.78 %, respectively; unlike in Virú, the most top records treatments were B Dose 3 and B Dose 2 with 50.6 % ± 21.56 % and 49.85 % ± 16.28 %, respectively. (Figures 1 and 2).

These differences could be explained by various factors like the varietal and locality aspect, opportunity of application and others, since in La Molina the Atlas variety was used and in SAVSA the UC-157 F1 variety; the localities are 500 km apart and each one of them has unique climatic variables. Additionally, the fertilizers were applied differently.

All these observed differences could interfere with the results. As Fuentes (1999), and Trinidad & Aguilar (2000) explain, the factors which influence foliar fertilization are the plant (species, stage of cultivation, state of nutrition,

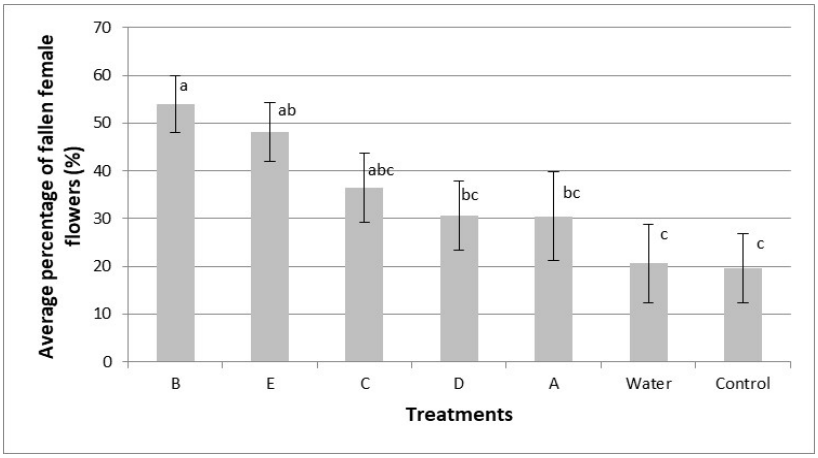

Figure 1. Average percentage of fallen flowers, standard error and Tukey test for the different treatments. La Molina, Lima-Perú. 2008.

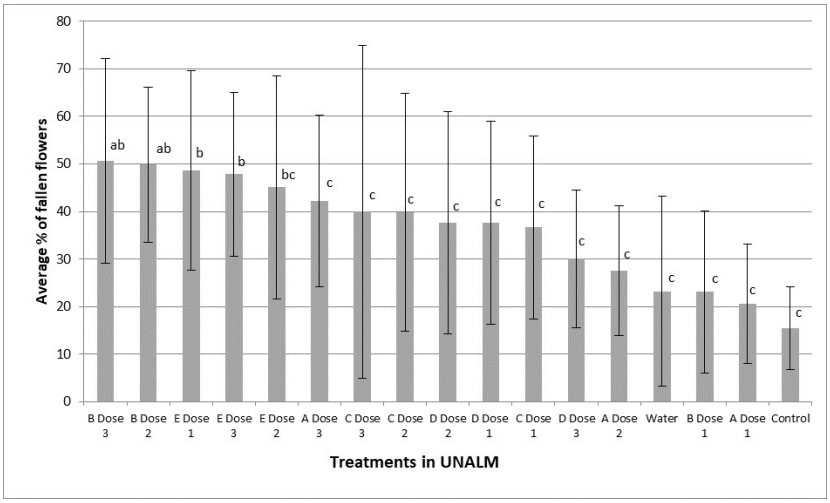

Figure 2. Average percentage of fallen flowers, standard error and Tukey test for the different treatments. Virú. La Libertad. Perú, May- June. 2008.

etc.), the solution used (concentration, pH, synergistic or antagonistic, hygroscopicity, dose, etc.) and environmental conditions (temperature, light, humidity, luminosity, etc.).

Observations of Claudinei de Almeida *et al*. (2000) reinforce this assessment, in a study of the foliar application of urea on bean crops, where variations depended on the time of the day the application took place.

The foliar applications of fertilizers were able to produce the falling of flowers in varying degrees, depending on their concentrations. Approximately, about the 50 % of flowers fell in both types of flowers, without differences between them. All treatments caused premature flowers falling, higher than the control. (Figures 3 and 4).

Flowers falling is caused by dehydration due to the concentration of soluble salts on its external surface, which leads to the decompensation of nutrient concentration with osmotic effects (Marschner, 1997). Application of foliar nutrients can produce levels of salt on leaves higher than those found in the soil; which is why biggest concern of foliar spraying is the leaves sensitivity to high concentrations of salt.

The salts act in a corrosive manner on a foliar level, since they provoke the extraction of water (Alcanter & Trejo-Trellez, 2007). In the same way Mengel & Kirkby (2000) state that on warm days when evaporation is high, the water from a foliar pulverization can evaporate rapidly with the salts staying on the foliar surface without being absorbed, which can lead to burning and wrinkling of the leaves.

The insect could infest some male flowers. In the present experiment, *P. longifila* adults plagued 35% of the total male flowers. Likewise, in the field flowers infested with *P. longifila* 2nd-stage larvae, stayed closed, with a

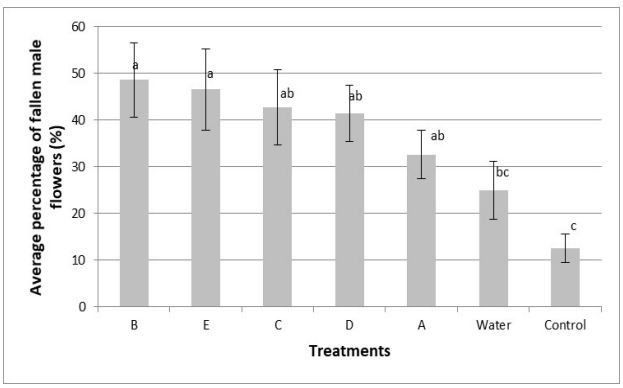

Figure 3. Average percentage of fallen flowers in male plants, standard error and Tukey test for the different treatments. Virú. La Libertad. Perú, May-June. 2008.

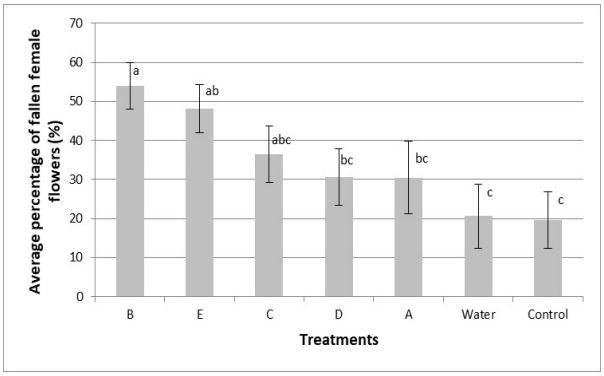

Figure 4. The average percentage of fallen flowers in female plants, standard error and Tukey test for the different treatments. Virú. La Libertad. Perú, May-June. 2008.

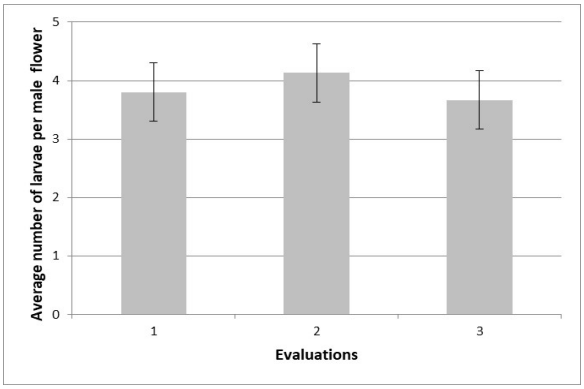

Figure 5. The average number of larvae of *Prodiplosis longifila* (in 2nd-stage) evaluated in male asparagus flowers. Virú, La Libertad - Perú, May-June. 2008.

red-violet coloration, generating a humid microclimate that facilitated the survival of the larvae. The larvae scraped internal surfaces while feeding, damages similar to those described by Rodríguez (1992) of *P. longifila* larvae in tomato crops.

Once the larva hatches from the egg, needs space for developing, and the male plants equipped only with stamens have enough space to accommodate them. In the case of female flowers is reduced their available area when is fertilized the ovary and fruit starts developing, and the corolla opens, showing conditions not ideal for the larval development. When is exposed the larva and the nutrients to the sun both present desiccation and the larva dries and dies quickly, as described by Castillo (2006) in a study on *P. longifila* damages in asparagus.

During asparagus flowering, the *P. longifila* adults lay eggs on the flowers. When the percentage of flowering decreases, the emergence of adults starts in high numbers (García, 2006). According to the average number of larvae per flower (3.9) and percentages of male inflorescences infested (32.2% and 37.8%, respectively) has been calculated that adult populations can reach over 70 million of individuals per hectare during a flowering period over a period of 20 to 25 days. (Castillo, 2006).

The effect of foliar fertilizers application produces the falling of flowers of asparagus plants and, at the same time, a significative reduction of the insect population, since the larvae do not complete their biological cycle. The early fall of flowers in the furrows, where there is no shadow, dries the flower; consequently, the larvae die, or it is unable to leave the bud and find shelter under the plant to complete the larval stage.

Cuya (2011) concludes that within the components of integrated management of *P. longifila,* cultural control is essential as well as handling of irrigation and fertilization, but to the soil and not directly onto the foliage.

The treatments applied during this experiment were made to cause an early fall of the inflorescent since they are the favorite places of *P. longifila* to lay their eggs and where their larvae can complete a full cycle and generate new populations that infest other fields.

Conclusions

Under the conditions the experiment was conducted, can be concluded that:

The foliar fertilizer application on asparagus plants produced a higher fall of flowers than in controls.

The different responses in the two localities can be due to various causes, environmental, moments and number of applications or composition of the foliar fertilizers.

In the UNALM (La Molina, Lima-Perú), the fertilizer that generated the highest number of fallen flowers in the Atlas variety, was the fertilizer B, with a dose of 0.5 Kg/200 liters of water, accumulating 1.5 Kg on the three applications and reaching an average percentage of fallen flowers of 82.1 %.

In SAVSA (Virú, La Libertad-Perú), the fertilizer that generated the highest number of falling flowers in the UC-157 F1 variety was the fertilizer B, with a dose of 0.6 Kg/200 liters of water (D3), accumulating 2.4kg on 4 opportunities and reaching an average percentage of fallen flowers of 50.6 %.

The percentage of infested male flowers by *Prodiplosis longifila* was 35 %.

The average number of 2nd-stage larvae of *Prodiplosis longifila* evaluated on affected flowers was 3.9.

By generating a premature falling of the male flowers, the larvae did not reach adulthood, and thus the number of individuals in the *Prodiplosis longifila* populations was reduced.

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