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ESTIMATION OF THE ENVIRONMENTAL IMPACT COEFFICIENT IN TREATMENTS FOR THE CONTROL OF FOLIAR DISEASES IN POTATO

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ABSTRACT

The environmental impact (EI) is a measuring device to estimate the risk caused by the use of pesticides on different crops, to the people who use them, to the environment and to those ones who consume them. This research objective was to quantify the environmental impact produced by phytosanitary strategies used in the treatments of fungicides. They were carried out to combat foliar diseases at the Potato Variety Garden, planted in the Research Institute of Tropical Roots and Tuber Crops (INIVIT), through the use of the Environmental Impact Coefficient (EIQ) indicator. As a result, an environmental impact per hectare was achieved, equivalent to **432.68** in the phytosanitary program established for potato in the Ministry of Agriculture of Cuba. However, when applying the IPM Program, this value turned out to be **332.74**, which allowed a reduction of **99.94** units of the EI/ha. This showed the urgency of using the phytosanitary control and accurate diagnosis as effective means to prevent the environmental impact caused by fungicides, aspects that will help assume successful provisions on the protection of plants.

Keywords: fungicides, environmental impact, potato

ESTIMACIÓN DEL COEFICIENTE DE IMPACTO AMBIENTAL EN TRATAMIENTOS PARA EL CONTROL DE ENFERMEDADES FOLIARES EN PAPA

RESUMEN

El impacto ambiental (EI, por sus siglas en inglés) es un indicador que sirve para valorar el riesgo potencial causado por el uso de los plaguicidas en cultivos agrícolas a los agricultores que los aplican, a los consumidores y al componente ecológico. Este trabajo se desarrolló con el objetivo de cuantificar el impacto ambiental producido por estrategias fitosanitarias empleadas en los tratamientos de fungicidas, realizados para el combate de enfermedades foliares, al Jardín de Variedades de Papa ubicado en el INIVIT, mediante el uso del indicador Coeficiente de Impacto Ambiental (EIQ, por sus siglas en inglés). Como resultado, se alcanzó un impacto ambiental por hectárea equivalente a **432.68** en el programa fitosanitario establecido para la papa en el MINAG, sin embargo, al aplicar el Programa MIP, este valor resultó ser **332.74**, lo que permitió una reducción de **99.94** unidades del EI/ha. Esto evidencia la necesidad de la incorporación de herramientas predictivas del impacto ambiental de los fungicidas como instrumentos de apoyo a la toma de decisiones para el manejo de plagas.

Palabras clave: fungicidas, impacto ambiental, papa

INTRODUCTION

The high priority that has been given to the cultivation of potato in Cuba for decades, for its nutritional value and its acceptance by the population. It as an important product in the Cuban diet, it is necessary to adapt its production to the current demands of rationality, incorporating to the experience accumulated by technicians and producers, the results of science and technological innovation applicable to this crop during these years. To ensure the productive success of the crop, the program of phytosanitary defense of potato in Cuba includes 15 applications of fungicides, depending on the environmental conditions (MINAG, 2018).

The methodology for the evaluation of the Environmental Impact Coefficient and the Environmental Impact were developed by Cornell University (Kovach *et al.,* 1992; Kovach *et al.,* 2004). The environmental impact (EI) is a measuring device to estimate the risk caused by the use of pesticides on different crops, to the people who use them, to the environment and to those ones who consume them. This is a methodology that requires a primary information, which may include the chemical type and common name of the active ingredient, trade name, dosage used and number of applications. These data offer the possibility of evaluating the environmental impact coefficient generated when applying Integrated Pest Management (IPM) programs, which can be calculated before and after the project implementation (PRIICA, 2017). In many cases, although this information is traditionally and easily managed (Carrizo *et al.*, 2015), such programs do not estimate the environmental impact of pesticides use (Guillén, 2015).

It is a current trend, both in Cuba and in the rest of the world, that the fungoresistance phenomenon occurs, despite the fact that there are several chemical fungicides that are easily applied, but bad applications are generated and these fungal resistance events emerge, such as: the chemical control of *Phytophthora infestans* (Mont.) de Bary, which causes late blight in potato (Folgueras *et al.*, 2020b).

These problems have led to the search of new control alternatives, which are feasible to be integrated into a management plan for this disease. The use of biological control through the use of microorganisms to combat the late blight and other foliar diseases, is recognized as an efficient choice for its management. Chemical fungicides are capable of inhibiting pathogenic microorganisms, constituting an environmental hazard. However, certain microbes known as plant growth promoters help in sensitizing and preparing the plant's immune defense arsenal to overcome invading pathogens (Enebe and Babalola, 2019).

For this reason, the objective of this work was to quantify and compare the environmental impact produced by phytosanitary strategies used in the treatments of fungicides, carried out to combat foliar diseases at the Potato Variety Garden, located in the INIVIT through the use of the EIQ indicator.

MATERIALS AND METHODS

The work was carried out in the Research Institute of Tropical Roots and Tuber Crops (INIVIT), located at 22º35' N, 80º18' W and 40 meters above sea level, in the municipality of Santo Domingo, Villa Clara province, Cuba.

The environmental impact of two phytosanitary programs for disease control was evaluated: Early blight, caused by *Alternaria solani* Sorauer and Late blight, caused by *Phytophthora infestans* (Mont.) de Bary. These consisted of:

1. Phytosanitary program established for potato in the Ministry of Agriculture of Cuba (Technical Instruction) (**Traditional Program,** MINAG (2018)).
2. Integrated management program (which included the reduction of the number of applications, when making applications of the antagonist *Trichoderma harzianum* Rifai, as a foliar treatment for the control of diseases of the aerial part of the plant) (**IPM Program,** Folgueras *et al.* (2020a)).

The study was conducted on a calcic haplic phaeozems soil, according to the Cuban Soil Classification (Hernández *et al.,* 2015). The agrotechnical work was carried out according to the Technical Instruction for Potato Production in Cuba (MINAG, 2018). The plots were made up of six rows 8.00 m long, separated by 0.90 m, with a total of 180 plants in 36 m^2.

The methodology used to calculate the environmental impact indicator was developed by Cornell University (Kovach *et al.,* 2004; Maza, 2018).

RESULTS AND DISCUSSION

The results show that with 15 applications planned in the traditional program, an environmental impact per hectare was achieved, equivalent to 432.68 units (Table 1). However, when applying the IPM Program, this value was 332.74, which allowed a reduction of 99.94 units of the EI/ha.

Table 1. Calculation of the Environmental Impact Value (EI) in treatments for the control of foliar diseases in potato (Traditional Program)

Fungicides	Active ingredient	Concentration	Amount per ha	No. of applications	EIQ	EI/ha
Cuproflow 38 SC	Copper oxychloride	38 %	2	4	67,67	205,71
Sphere Max 535 SC	Trifloxystrobin + cyproconazole	53,5 %	0,3	1	30,90	4,95
Fantic Star FMC	Benalaxyl + chlorothalonil	55 %	2	3	40,40	133,32
Silvacur® Combi 30 EC	Tebuconazole + triadimenol	30 %	0,5	1	40,30	6,04
Verita® 71,1 WG	Fosetyl Al + Fenamidone	71,1 %	2	2	11,30	32,13
Orius 25 CE	Tebuconazole	25 %	0,5	1	40,33	5,04
Positron Duo PH 69	Iprovalicarb + propineb	69 %	2,5	1	16,90	29,11
Amistar® 50 WG	Azoxystrobin	50 %	1	1	15,20	7,60
Domark® 40 EW	Tetraconazole	40 %	0,5	1	43,90	8,78
EI/ha Final						**432,68**

* EIQ, Environmental Impact Coefficient. ** EI, Environmental Impact Value

These results corroborate those ones obtained by other authors, such as Gianelli (2017) who assured the importance of calculating the environmental impact coefficient, as an incomparable aid for farmers who use integrated pest and disease management programs, without excluding the use of chemical pesticides because their intervention is necessary.
Argentinean researchers (Perotti *et al.,* 2016*)* evaluated three management strategies for the soybean pest complex and as a result they obtained a very lower environmental impact, when applying integrated management strategies. The interaction among natural enemies, biological controls and harmful insects, associated with IPM programs, showed a paradigm of integration in this type of management strategies, which do not exclude the use of pesticides.

The following applications were made with the proposed new technology (Table 2):

Table 2. Applications made with the new management proposal (IPM Program).

Fungicides	Active ingredient	Concentration	Amount per ha	No. of applications	EIQ	EI/ha
Cuproflow 38 SC	Copper oxychloride	38 %	2	3	67,67	154,28
Fantic Star FMC	Benalaxyl + chlorothalonil	55 %	2	3	40,40	133,32
Silvacur® Combi 30 EC	Tebuconazole + triadimenol	30 %	0,5	1	40,30	6,04
Orius 25 CE	Tebuconazole	25 %	0,5	1	40,33	5,04
Sphere Max 535 SC	Trifloxystrobin + ciproconazole	53,5 %	0,3	1	30,90	4,95
Positron Duo PH 69	Iprovalicarb + propineb	69 %	2,5	1	16,90	29,11
					EI/ha Final	**332,74**

During the first 48 days of planting the crop, only the antagonist *Trichoderma harzianum* Rifai was applied. This is a natural, biocompatible bioproduct and harmless to the environment, so with these first applications, the crop was protected from foliar diseases until 48 days. This became it an ideal substitute for today's plant protection products which are highly harmful to the environment.
The harvest was carried out after 90 days. This result reaffirms that knowledge, science, technology and innovation are undoubtedly key elements for advancing development (Díaz-Canel and Núñez, 2020).

CONCLUSIONS

1. From 15 applications of fungicides planned in the phytosanitary program only 10 were made, which reduced the environmental impact per hectare by 99.94 units.
2. The result showed the urgency of using the phytosanitary control and accurate diagnosis as effective means to prevent the environmental impact caused by

pesticides, aspects that will help assume successful provisions on the protection of plants.

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