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ANSWER OF BEAN (*Vigna unguiculata* L.) VAR. LINA TO DIFFERENT FORMS OF PECTIMORF® APPLICATION

Respuesta del cultivo de habichuela (*Vigna unguiculata* L.) var. Lina a diferentes formas de aplicación del Pectimorf®

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ABSTRACT. The research was carried out in the organoponic The Ketty belonging to the Agricultural enterprise of Santiago de Cuba, in the period between December 2013 - March 2014. The Ketty is a center of national excellence, located in the El Caney town; in this place the productions of bean variety Lina historically have been lower than reported yield of this variety. The Pectimorf® has been proven with success in diverse cultivations to increase the yields that is why the study carried out with this commercial product was with the objective of evaluating the more appropriate form of application of it, in the increment of the yield of the cultivation in study under organoponic conditions. For the assembly of the experiment the product was applied to a concentration of 10 mg L^{-1} in three different forms: imbibition , imbibition + to foliate at the beginning at the flowering and to foliate to the beginning of the flowering they were carried out 4 treatments at random in a block design, with 4 replies. As variable answer they were measured height of the plants, number of leaves, sheaths, longitude and fresh weight of the sheaths as well as agricultural yield. The results showed that the Pectimorf® is an ecological and economically viable alternative to increase the yield of the bean var. Lina in the study area, standing out the form, imbibition + application to foliate to the beginning of the flowering reaching 4,7 kg m^2, a significantly superior increment regarding the control for 95 % of trust.

Key words: bioestimulante, oligogalacturonide, agricultural yield

RESUMEN. La investigación se realizó en el organopónico "La Ketty", perteneciente a la Empresa Agropecuaria Santiago de Cuba, en el período comprendido entre los meses diciembre del 2013-marzo del 2014. "La Ketty" es un centro de excelencia nacional, ubicada en el poblado El Caney, a 5,7 km de la ciudad de Santiago de Cuba, donde las producciones de habichuela variedad Lina históricamente han sido muy por debajo al rendimiento reportado de esta variedad. El Pectimorf® ha sido probado con éxito en diversos cultivos para incrementar los rendimientos, por lo que el estudio realizado con este producto comercial fue con el objetivo de evaluar la forma de aplicación más adecuada del mismo y su efecto sobre el cultivo en estudio, bajo condiciones de organopónico. Para el montaje del experimento el producto se aplicó a una concentración de 10 mg L^{-1} en tres formas diferentes: imbibición de las semillas, aspersión foliar a inicio de la floración y la combinación de ambos. Se realizaron cuatros tratamientos en un diseño de bloques al azar, con cuatro réplicas. Como variable respuesta se midieron la altura de las plantas, el número de hojas, las vainas, la longitud y la masa fresca de las vainas, así como el rendimiento agrícola. Los resultados mostraron que el Pectimorf® constituye una alternativa ecológica y económicamente viable para incrementar el rendimiento de la habichuela var. Lina en la zona de estudio, destacándose la forma combinada, imbibición de semillas+aplicación foliar al inicio de la floración, que permitió alcanzar 4,7 kg m^2.

Palabras clave: bioestimulante, oligogalacturónidos, rendimiento agrícola

INTRODUCTION

Legumes, beans are the most cultivated worldwide. This culture is widely distributed in the tropics, subtropics and temperate regions, with the majority in Latin America and different

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parts of Africa; which is an interesting alternative for farmers in these countries the ability to handle relatively stable prices for its nutritional content and demand from consumers (1).

In our country, beans has a wide demand, especially in vegetables for their participation in daily consumption in many households of the population, proving to be one of the key priorities for urban agriculture; however, the species is consumed in the genus *Vigna sesquipedalis*, which is grown only in the months of Spring-Summer. In Santiago de Cuba province, the cultivation of beans is mainly sown in the spring time, obtaining low yields in production systems, due to drought conditions and high temperatures characteristic of the eastern region (2).

Moreover, to produce vegetables intensively on organic substrates and promote high yields in these crops, it requires proper technological discipline, plus organic fertilization, which must be supplemented with bioactive products (3) which stimulate the growth and development of plants; besides being safe and clean environment. Among these products, Pectimorf® is known for its favorable effect on growth and development, being used successfully to replace traditional growth regulators or in synergy with certain phytohormones (4). It is stimulating rooting, cell growth and differentiation of different species; moreover, it can activate defense mechanisms and decrease or mitigate environmental stress in plants, as described in the patent the product (5).

Based on these considerations, the present study aimed at evaluating the response of bean *(Vigna unguiculata* L.) crop, Lina variety grown in non-optimal time to different forms of application of the commercial product Pectimorf®, under organoponic conditions

MATERIALS AND METHODS

The study was conducted in the period between the months December 2013 to March 2014, in the organoponic "La Ketty", belonging to the Agricultural Company Caney, in Santiago de Cuba province. Seeds of bean crop var. Lina were used from the National Seed Company. Sowing was done directly, double row, at a distance of 0,25 m between plants in traditional beds of 1,20 m wide and 20,0 m long, located at soil level on a substrate consisting of organic cattle manure and soil type brown without typical carbonate according to the latest genetic classification of soils, whose chemical characteristics are shown in Table I. The characterization of the final organic mixture was held at the Provincial Laboratory of soil delegation of Agriculture in Santiago de Cuba. Cultural attentions were performed according to the recommendations of the technical manual for urban agriculture (6).

Table I. Chemical characteristics of substrate used to sow beans

pH (H_2O)	P_2O_5 (mg 100 g)	K_2O (mg 100 g)	Organic carbon (mg L^{-1})
7,1	22,29	161,6	1,33

pH H_2O: potentiometric method, P2O5 and K2O: Machiguin method, organic carbon: Walkley-Black method (6).

Meteorological data for the period of the experiment development were taken from the Meteorological Station of Santiago de Cuba province.

In Table II monthly averages of temperature, relative humidity and rainfall are shown.

Table II. Climatic variables of the experiment development period

	Temperature (^{0}C)	Relative humidity (%)	Precipitations (mm)
December	26,3	68	23,8
January	25,8	69	77,2
February	26,1	70	78
March	26,3	67	64,3

For this crop can be considered a favorable amount of rain, they fall between 80 and 96 mm monthly. The average temperature ranged between 25,8 and 26,3 °C, permissible for the growth of this variety (7), which develops in precisely ranges from 25 to 27 °C, the same happened with the relative humidity, their values ranged from 68 and 70 % in the first value below the range that allows the crop.

The bioactive product produced by research conducted at the Department of Physiology and Biochemistry of the National Institute of Agricultural Sciences (INCA), in Cuba, was applied in a solution of 10 mg L^{-1} in response to results obtained previously (8). It was applied in three different ways: imbibed the seeds for four hours before planting (I), foliar sprinkle at the beginning of flowering (F) and the combination of both forms: imbibition + foliar (I + F). These treatments were compared with seeds imbibed in distilled water

for the same period of time, then air dried on filter paper. Foliar spraying was carried out with a backpack Matabi 16 L capacity, wetting the plants well in the early hours after the dew disappear.

Treatments studied

1 Treatment control without application of Pectimorf

2 imbibition of seeds

3 imbibition and foliar application at the beginning of flowering

4 Foliar application at the beginning of flowering

A design randomized block with four replicates per treatment was used. To estimate the variables of plant growth stimulators, they were randomly selected five plants per replica. Each of the sampled plants was determined at 40 and 50 days after sowing (DAS): plant height [PH, (cm)] and the number of leaves per plant [NL (u)]. The number of pods per plant [NPP, (u)] was evaluated in the state of green pods, filled with grain, making the count directly on selected plants. At the time of harvest was determined: number of pods to harvest per plant [NPH, (U)], pod length [PL (cm)], fresh weight of pods (g) and crop yield (kg m^2).

The data were statistically processed by analysis of variance dual classification, comparing the means, according to the multiple range test of Duncan. For the analysis it was used the statistical package Statgraphics Plus 5.1 for Windows.

RESULTS AND DISCUSSION

It was found that those seeds treated with the bioactive product Pectimorf® showed better performance in relation to plant height and smaller correspond to the control treatment. Through Table III, the effectiveness of this compound as stimulator of evaluated indicators is shown. This proves the point made by several authors on the oligogalacturonide (Pectimorf®) (9), which can be used for physiological effects of changes in plants, such as size (height).

The effect of this biostimulator product on the variable height of the plant has been reported in Anthurium, soybeans and sorghum crops. In this respect, work performed with oligogalacturonide (10, 4) concerned that significant growth of cultures treated with Pectimorf® responds to, on the one hand influences the activation of cell division and elongation of cell walls (3, 9) and on the other, are soluble oligosaccharides produced by partial degradation of the constituent polymers of the cell wall, biologically active at very low concentrations, which characterizes this group of biomolecules as a new hormone hierarchy in the context of communication between plants and the environment.

Table III. Influence of the Pectimorf® application form at the height of the bean crop plants evaluated at 40 and 50 days after sowing (DAS)

Treatments	Height (cm)	
	40 DAS	50 DAS
T1	21,77 d	29,35 d
T2	33,54 b	41,11 b
T3	36,61 a	65,65 a
T4	30,03 c	39,10 c
ES	0,7997	0,8835

Mean values with no common superscripts differ at p<0,05

T1- control, untreated seeds with Pectimorf®

T2- seeds imbibed with Pectimorf® 10 mg L-1

T3- imbibed seeds with Pectimorf® 10 mg L-1 and foliar application before flowering with Pectimorf® to 10mg L-1

T4- untreated seeds and foliar application Pectimorf® 10 mg L-1 before flowering

As for the number of leaves, an increase of this variable was observed in treatments with Pectimorf®. This increase in the number of leaves was apparent in both sampling times, showing superior to untreated being able to appreciate figures in Table IV. This result was significant when a concentration of 10 mg L^{-1} of product was applied and, in the cultivation Anthurium where emission of leaves is favored (4).

Table IV. Number of bean crop leaves assessed at 40 and 50 DAS and treated or not with Pectimorf®

Treatments	Number od leaves (u)	
	40 DAS	50 DAS
T1	12,85 d	15,15 d
T2	15,85 c	18,75 c
T3	24,2 a	25,35 a
T4	18,90 b	22,50 b
ES	0,4948	0,6376

Mean values with different letters uncommon each other at p<0,05

T1 – control, untreated seeds with Pectimorf®

T2- imbibed seeds with Pectimorf® 10 mg L-1

T3- imbibed seeds with Pectimorf® 10 mg L-1 and foliar application before flowering with Pectimorf® to 10 mg L-1

T4- untreated seeds and foliar application with Pectimorf® 10 mg L-1 before flowering

This result in leaf development could be seen with the application of bioactive product, it could be given because the used dose of Pectimorf® was able to induce adequate endogenous hormonal balance to induce increased cell division process of the buds originate leaves. It is considered that these substances could carry information and be carriers of chemical messages that trigger physiological processes of cell division, because they promote plant cells the synthesis of important substances that act in these processes, as oligogalacturonides are involved in numerous responses cell growth and development, among which are induced cell elongation auxin and cell differentiation among others (11). These bioregulators are effective in morphogenetic processes as substitutes or supplement auxin and cytokinin.

It is known, the potential of Pectimorf® as rooting (5), may also contribute to the further leaf development, if one takes into account that the mixture stimulates the formation of roots from the crop early stages with the possibility to ensure efficient delivery of water and mineral salts and, therefore, greater success in the development of the plant (6).

shown in Table V that treatments which have involved the bioactive natural product under study, significantly increased this indicator, showing a stimulus at both time points on the number of pods, coinciding these results with those reported on the response cultivation of beans to the application of different bioproducts, which stimulate the formation of the organs of the plant (12).

Table V. Behavior of pod number by plants application or not of Pectimorf®

Tratamientos	Número de vainas (u)	
	NVP	NVC
T1	2,75 d	9,65 d
T2	3,60 c	12,45 c
T3	5,35 a	15,60 a
T4	4,65 b	14,5 b
ES	0,2014	0,3884

Mean values with different letters uncommon each other p≤0,05

T1 – control, untreated seeds with Pectimorf®

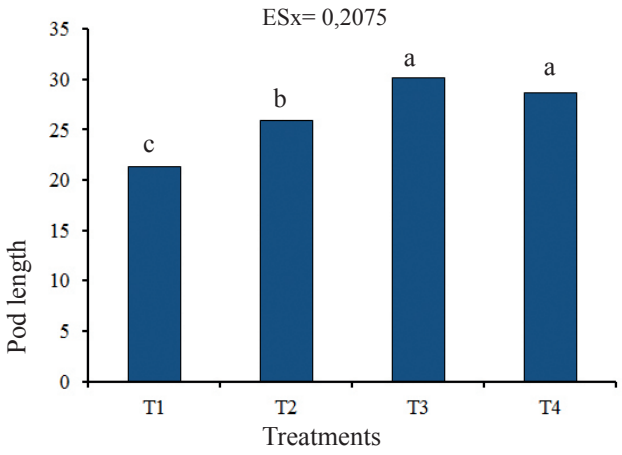
T2- seeds embedded with Pectimorf® 10 mg L-1

T3- imbibed seeds with Pectimorf® 10 mg L-1 and foliar application before flowering with 10 mg L-1 of Pectimorf®

T4- untreated seeds and foliar application with Pectimorf® 10 mg L-1 before flowering

NPP-Number of pods per plant (u) NPH- harvesting pods Number (u)

Regarding the variable number of pods, are those related to the length of the pods at the time of harvest results confirm the effectiveness of Pectimorf®, reaching the highest values in the treatments treated with this product, among which showed no significant differences. However Pectimorf® treated with both treatments showed significant differences regarding the treatment of the imbibed control and where smaller pods (Figure 1) seeds were observed.



The bars on the columns represent standard deviation (σ) to 5 % error. Different letters indicate differences statistically significant

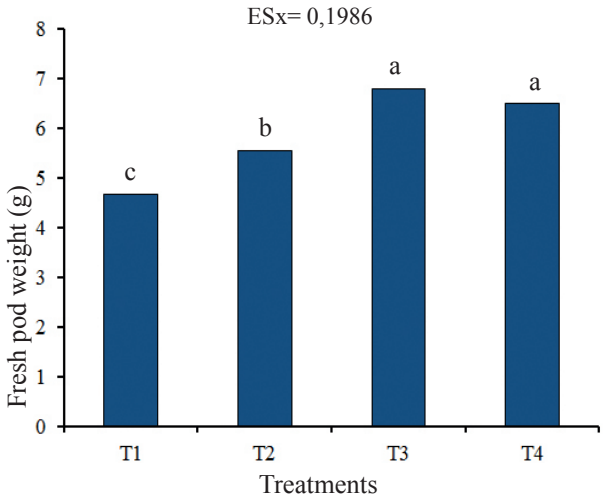
Figure 1. Influence of the Pectimorf® application forms on the length of the pods in the cultivation of beans var. Lina

With the results shown in Figure 1, it can be inferred that the fact actuate the Pectimorf® as growth regulator when applied exogenously, could regulate positively some of the physiological processes in the plant, leading to a stimulus in the dormancy of buds, leaf primordia and further development of these (13).

Despite having found a greater effect of treatment 3 over 4 in the number of pods (Table V), when analyzing the length of pods (Figure 1), no difference between the two treatments are shown, so these results could be related to the number of grains per pod, yield component makes this have different behaviors, which reiterates how useful are other components to evaluate the response of crops.

Interestingly the results shown in Figure 2, because of in the variants where the bioactive product Pectimorf® is used, the variables: fresh mass of bean pods was favored. This indicates a positive effect of alternative solutions, noting that between treatments foliar application and combination: imbibition of seeds and foliar sprinkling,

there was no significant difference. In the literature reviewed it has been found that the foliar sprinkling of an oligogalacturonide mixture favors variables as growth and development plants (14). Apparently, an increase in the endogenous levels in the plant with the exogenous application of the oligogalacturonide mixture is an alternative to consider for the production of beans, as it facilitated the growth and development of pods formed in the sprayed plants respect the control treatment.

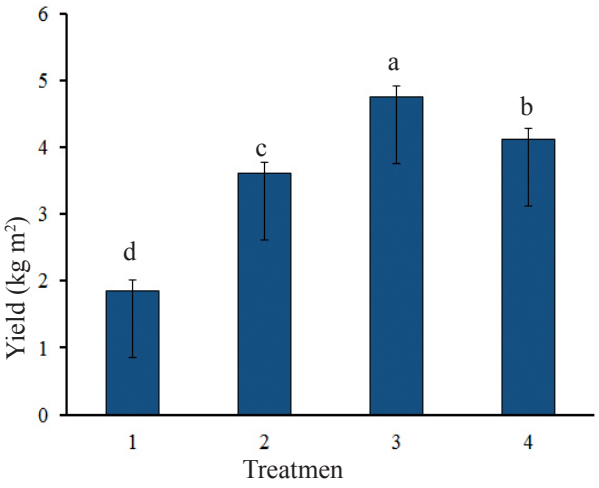


The bars on the columns represent standard deviation (σ) to 5 % error. Different letters indicate differences statistically significant

Figure 2. Influence of Pectimorf® application forms on fresh mass of pods in the cultivation of beans var. Lina

However, for the performance variable, reflected in Figure 3, the stimulatory effect of Pectimorf® shown in the increase in this indicator for the different variants of application thereof, proving to be treatment 3, corresponding to the shape of combined application (imbibition of seeds and foliar application), higher than the rest of the treatments under study. Given that this way of application turned out to be the best performers in the variables plant height, number of leaves, pods and performance, it could then be considered as an alternative to increase performance Lina crop variety bean.

One of the fundamental objectives of the application of plant growth bioestimulants is to determine how far it is possible to increase yields, in this case already successful (15).



The bars on the columns represent standard deviation (σ) to 5 % error. Different letters indicate differences statistically significant

Figure 3. Effect of bioactive product Pectimorf® on crop yield of bean var. Lina

The oligogalacturonide have high biological activity, which is determined by their degree of polymerization, so they can be used for agricultural purposes, with the aim of increasing yields.

Moreover, the value in the variable performance achieved by applying the product in combination

Bioactive study (imbibition and foliar), matches with reported by several researchers regarding applications vegetables purines and biostimulants to green beans variety Canton-1 (16). In addition corroborate the results reported to evaluate three bioproducts (Biobras 16, Liplant and oligogalacturonides) in the cultivation of tomato (variety Amalia) (17).

CONCLUSIONS

♦ From the above results it can be concluded that the different forms of Pectimorf® application used in the soil and climatic conditions of the study area, stimulated the growth and development of the cultivation of bean var. Lina and agricultural performance, proving to be the most effective form of application, corresponding to the application of the bioactive product to seeds by imbibition and foliar sprinkling at the beginning of flowering.

♦ the effect of the product on the formation and growth of bean pods, as the most important organs for consumption was evident. Although the study about the potential of this oligogalacturonide mixture in vegetables needs to be addressed in greater depth, this indicates the possibility of using it as a growth promoter in this type of crop.

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