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ANSWER OF TWO COMMON BEANS CULTIVARS TO FOLIAR APPLICATION OF EFFICIENT MICROORGANISMS

Respuesta de dos cultivares de frijol común a la aplicación foliar de microorganismos eficientes

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ABSTRACT. In order to evaluate the effect of foliar application of efficient microorganisms (EM) in the morphological and productive behavior of two cultivars of common bean. The experiment was carried out in the Cooperative of Credit and Service "Martires de Taguasco," Sancti Spíritus, Cuba, between the months of November, 2012 to March, 2013. Sowing was carried out on Brown Sialitic Carbonated soil. Four concentrations were studied: 0, 50, 100 and 200 mg L^{-1} of EM per liter of water, on the cultivar Velazco largo (VLR) and Cuba cueto (CC-25-9-N), applied of foliar form, every seven days from 10 days after germination until flowering (R6). During the development of the crop, the average of leaves per plant were determined and the dry matter g $plants^{-1}$ and at harvest time the number of pods, grains per pods, 100 grains mass and yield (t ha^{-1}). The foliar application of efficient microorganisms stimulated the morphological and productive parameters evaluated and the cultivar CC-25-9-N presented more responses to foliar application that to VLR cultivar and the both cultivars, the best results were attained, to the concentration of 100 mg L^{-1}, because increase the productivity in 1.13 t ha^{-1} in the cultivar VLR and 1.15 t ha^{-1} in CC-25-9-N with respect to control without application.

Key words: spraying application, biofertilizer, grains, varieties, sustainable agricultural

RESUMEN. Con el objetivo de evaluar el efecto de la aplicación foliar de diferentes concentraciones de microorganismos eficientes en el comportamiento morfológico y productivo de dos cultivares de frijol común, se desarrolló un experimento en la Cooperativa de Créditos y Servicios "Mártires de Taguasco", Sancti Spíritus, Cuba, entre los meses de noviembre de 2012 a febrero de 2013. La siembra se realizó sobre un suelo Pardo Sialítico Carbonatado. Fueron estudiadas cuatros concentraciones de microorganismos eficientes: 0, 50, 100 y 200 mg L^{-1}, aplicadas de forma foliar, cada siete días a partir de los 10 días después de la germinación hasta la floración (R6), sobre los cultivares Velazco largo (VLR) y Cuba cueto (CC-25-9-N). Durante el desarrollo del cultivo se determinó el promedio de hojas por plantas y la materia seca g $plantas^{-1}$) y al momento de la cosecha el número de vainas, granos por vainas, masa de 100 granos y el rendimiento (t ha^{-1}). La aplicación foliar de microorganismos eficientes estimuló los parámetros morfológicos y productivos evaluados, el cultivar CC-25-9-N presentó mayores respuestas a la aplicación foliar que el VLR y en ambos cultivares, los mejores resultados fueron logrados con la concentración de 100 mg L^{-1}, porque incrementó la productividad en 1,13 t ha^{-1} en el cultivar VLR y 1,15 t ha^{-1} en el CC-25-9-N con respecto al control sin aplicación.

Palabras clave: aspersión foliar, biofertilizante, granos, variedades, agricultura sostenible

INTRODUCTION

The bean is one of the legume species that has a preferential place, due to its nutritional composition, as it is a source rich in proteins, minerals such as calcium, iron, phosphorus, magnesium and zinc and the vitamins thiamine, niacin and folic acid (1).

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The production of this legume is important, because it is a source of alternative protein and minerals incorporated into the daily diet of Cuban citizens; however, production in Cuba satisfies only 3 % of consumer demand, so it is necessary to import around 110,000 tons of grain each year. For this reason, one of the priorities of Cuban agriculture, at present, is to increase the production of this crop, using technologies that are friendly to the environment (2).

Many organic products have been used to enhance the ecological management and productivity of this crop, including biofertilizers and biostimulants. In recent years, many bio-stimulants and organic biofertilizers have allowed plants to overcome stress situations in adverse environmental conditions, favoring growth, development and yield, with a decrease in the use of chemical substances (3).

One of the alternatives that is currently presented in the world is the application of efficient microorganisms (ME), which well used, reduce not only the contamination of the microenvironment (control of unpleasant odors, flies), but also improve the quality of the chicken manure, accelerate the stabilization of the composting process and reduce the environmental impact caused by this type of exploitation (4).

This production technology was developed by Dr. Teuro Higa, Japan, who tested a group of microorganisms, which perform many functions in the soil, such as maintaining order and the normal cycles of multiple substances. This work is permanent and thanks to it, life on the ground is maintained. These organisms live naturally in the soil (bacteria, fungi, actinomycetes) and fulfill various functions, especially the degradation and transformation of various materials to be used in the nutrition of plants (5,6).

Efficient microorganisms are a microbial consortium of different species of beneficial aerobic and anaerobic microorganisms. Cultivated in a liquid medium, this intelligent combination contains around eighty types of microorganisms, being mostly composed of phototropic or photosynthetic bacteria, lactic acid bacteria, fungi, yeasts and actinomycetes; which are applied as an inoculant to increase the microbial diversity of soils (7). This in turn increases the quality and health of the soils, which increases the growth, quality and yield of the crops (8).

Currently, the main bean producing regions in Cuba are affected by several agronomic factors, among which is the inadequate management in the application of chemical and organic fertilizers, especially the latter that constitute an alternative to the substitution of imports and significant in the sustainable production of food. Based on these considerations, the present work was proposed with the general objective of evaluating the effect of foliar application of different concentrations of efficient microorganisms on the morphological and productive behavior of two common bean cultivars.

MATERIALS AND METHODS

Experiment Location

The research was carried out in the areas of the Strengthened Cooperative of Credits and Services “Mártires de Taguasco” (22° 6’17.588’’N; 79° 22’33.544’’W), located in the municipality of Cabaiguán, Sancti Spíritus province, Cuba, during the months from November to February, corresponding to the period 2012-2013 of optimum sowing of the bean crop The distance of sowing used was 0.70 m between rows and 0.07 m between plants.

Characteristics of cultivars

The cultivars used were Velazco largo (VLR) and Cuba cueto (CC-25-9-N); in the first the grains are red, with a yield potential of 2.3 t ha^{-1}, growth habit type I and a cycle of 72 to 77 days and the second presents black grains, with a potential of yield of 2.7 t ha^{-1}, growth habit type III and a cycle between 75-80 days. The management of sowing, fertilization and phytosanitary control was carried out according to the Technological Guide for cultivation (9).

Type of soil and main characteristics

The soil type was Brown sialitic carbonated (10), Cambisol (11). This is a soil of ABC profile, from medium to shallow, from brown to dark brown and sometimes blue green colors when there are oxidation conditions in the medium, due to poor drainage or compaction. They are clay soils with a predominance of type 2: 1 Montmorillonite clays. It represents young stages of soil formation and among its major agro-productive constraints are the low effective depth and the susceptibility to compaction, when they are not managed properly. The average slope, of all the evaluated plots, did not exceed 3 %, considered as little undulating. This is an important feature that was taken into account in the design, given that depending on the slope, the degree of water absorption where the cover is used may be greater or less, as well as the erosion in the control plots

Experimental design and treatments

A randomized block design was used, in a 2x4 factorial scheme, two factors were studied, the first consisting of two cultivars of common bean, Velazco largo and Cuba cueto and the second composed of four treatments with efficient microorganisms (ME) (control without application of ME, only water), 50, 100 and 200 mL of ME per liter of water), with three blocks to form 24 plots. The treatments were foliar after 10 days after germination (stage V2) until the beginning of flowering (R6).

Características del producto utilizado

The inoculum composed of *Bacillus subtilis* B/23-45-10 Nato (5.4 10^4 ucf mL^{-1}), *Lactobacillus bulgaricum* B/103-4-1 (3.6 10^4 ucf mL^{-1}), and *Saccharomyces cereviciae* L-25-7-12 (22.3 10^5 ucf mL^{-1}), with a quality certificate issued by ICIDCA, code R-ID-B-Prot-01-01, was acquired in the Labiofam branch of Sancti Spiritus, carried out according to the methodology proposed by Olivera (12) and characterized by other authors (13), with the following characteristics: dry matter 17.0 g L^{-1}, organic matter 11.0 g L^{-1}; pH 3.16; ammoniacal nitrogen ($N\text{-}NH^{4+}$) 0.03 mg L^{-1}; potassium (K^+) 0.80 mg L^{-1}; phosphorus ($H_2PO_4^-$) 0.83 mg L^{-1}; calcium (Ca^{2+}) 24, 05 mg L^{-1} and magnesium (Mg^{2+}) 4,86 mg L^{-1}.

Evaluated variables

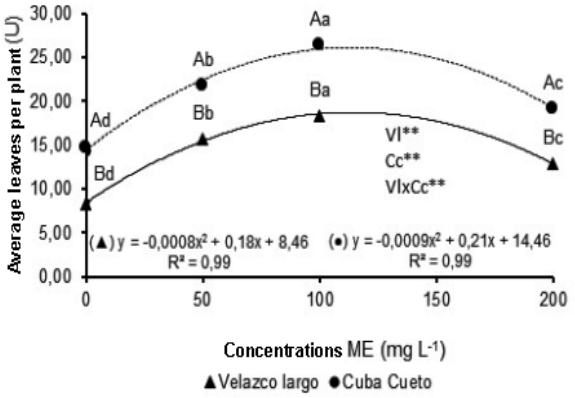
The observations of the evaluated variables corresponded to the criteria exposed by descriptors recommended in the stages of growth and development of the crop (14), the samplings were made in the plants corresponding to one square meter and the morpho-physiological indicators determined were: the average of leaves per plant; dry matter (g $plants^{-1}$); average pods per plants; average grains per pods; mass of 100 grains (g 100 $seeds^{-1}$) and yield (t ha^{-1}).

Analysis and statistical processing

The data obtained were subjected to a regression analysis by polynomials, the significance of the variance by the F test and the means were compared through the Tukey Multiple Range test with a 5 % probability, the data were processed in the AgroEstat® statistical package (15) for Microsoft Windows.

RESULTS AND DISCUSSION

Figure 1 shows how the foliar applications of efficient microorganisms in both cultivars were adjusted to a model by quadratic polynomials. These treatments showed statistical differences between them and with respect to the control and the concentration that highest average value of leaves per plant reached was 100 mg L^{-1}, achieving increases of 10.03 leaves per plant in the Velazco largo cultivar and 11.76 in Cuba cueto, with respect to control without application, which meant an increase of this indicator of 45.46 and 79.95 % respectively. It also exceeded the concentrations of 50 and 200 mg L^{-1} ME with increases of 16.76 and 42.12 % in the red and black cultivars of 38.15 and 64.27%, respectively.



Capital letters differ between cultivars and lowercase between ME concentrations, according to Tukey ($p \leq 0.05$)

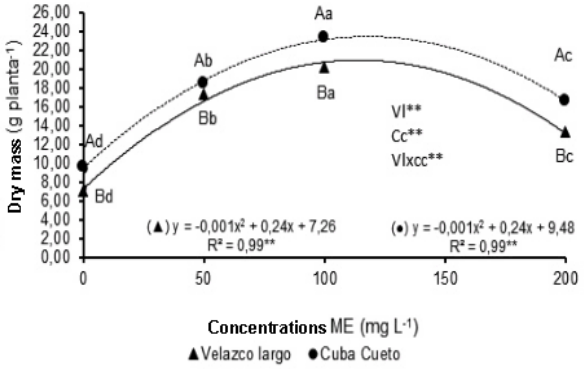
CV = 6.10 %; ES (±) = 0.53. ** Significant at 99 % confidence

Figure 1. Behavior of the average number of leaves per plant in common bean cultivars according to the concentrations of efficient microorganisms

The results in this indicator of the evaluated growth, allowed corroborating the results of other authors (16). Positive effects were achieved in vegetables, where the best results were achieved with foliar application of doses of multipurpose native microorganisms at the concentration of 50 mg dm^{-1}, surpassing the control if application (17).

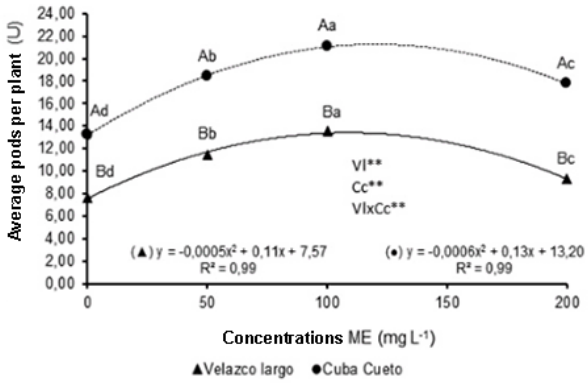
Similar results were obtained for this crop with the use of a concentration of 50 mg dm^{-1} of ME-50 combined with FitoMas-E in the cv. Bat-304, achieved an increase of the average of leaves per plant, with respect to the control (18).

In Figure 2, it is observed that the concentrations of efficient leaf-applied microorganisms exerted a positive effect on the production of dry matter, there being significant differences between the treatments with the control in both cultivars, where the cultivar Cuba Cueto increased the production of this indicator with respect to Velazco largo one. The highest production averages were achieved when the concentration of 100 mg L^{-1} ME was applied per liter of water for the cultivars, the increases compared to the control were 13.2 in the cultivar VL and 13.7 g $plant^{-1}$ in the CC-25-9-N, which meant increases of 34.7 and 41.1 %, respectively.



Capital letters differ between cultivars and lowercase between ME concentrations, according to Tukey (p≤0.05). CV = 6.10 %; ES (±) = 0.56. ** Significant at 99 % confidence

Figure 2. Behavior of the production of dry matter in common bean cultivars according to the concentrations of efficient microorganisms



Uppercase letters differ between cultivars and lowercase between ME concentrations, according to Tukey (p≤0.05). CV = 5.35 %; ES (±) = 0.47. ** Significant at 99 % confidence

Figure 3. Behavior of pod average per plant in common bean cultivars according to the concentrations of efficient microorganisms

In a research carried out on the onion crop, statistical differences were obtained (p≤0,05) and the masses of the aerial part of the plants were increased, with the application of efficient microorganisms, when these were applied at 15 mL m^2 (19).

In this sense the production of total dry mass is the result of the efficiency of the foliage in the interception and use of solar radiation available during the growth cycle, a process governed by internal factors of the plant, such as the behavior of photosynthesis and breathing (20).

The average pod production per plant (Figure 3) in the two varieties studied, the foliar applications of efficient microorganisms differed significantly between them and with control treatment. The two cultivars were adjusted to a quadratic model and to a strong and positive response, where the cultivar Cuba cueto reached greater responses to the foliar application of ME with respect to Velazco largo one and in both the best results were achieved with the concentration of 100 mg L^{-1}, with increases higher than the concentrations of 50 and 200 mg L^{-1} and the control without application in 5,90 in the cultivar VLR and 7,87 pods per plant in the CC-25-9-N, which it meant an increase of this indicator by 57.0 and 63.0 %, respectively.

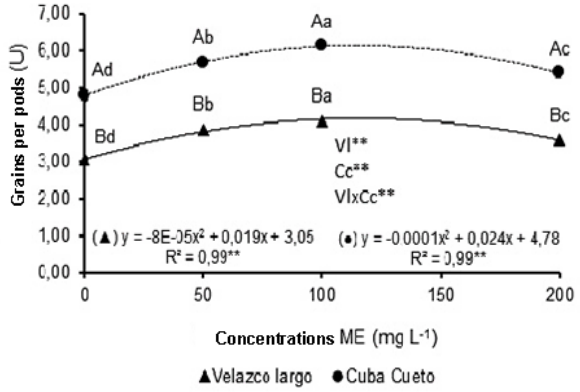
In a trial where a concentration of 100 mg L^{-1} of efficient microorganisms was used, in the cultivation of maize, significant differences were obtained and an increase of 15.9 % in the production of ears per plant, in relation to the control (twenty-one).

Similar effects for this indicator were achieved with the combined application of ME-50 and FitoMas-E because the average pods per plant increased by 40 % in relation to the control (18).

In a work where several stimulants were evaluated in two common bean cultivars, the authors obtained that, the biostimulant effect observed by the Biobras-16 increased the number of pods per plant only in the cv. CUL 156 (22); However, in the results obtained in this research, the biostimulant effect of the application of ME was demonstrated in the two cultivars (VLR and CC-25-9-N).

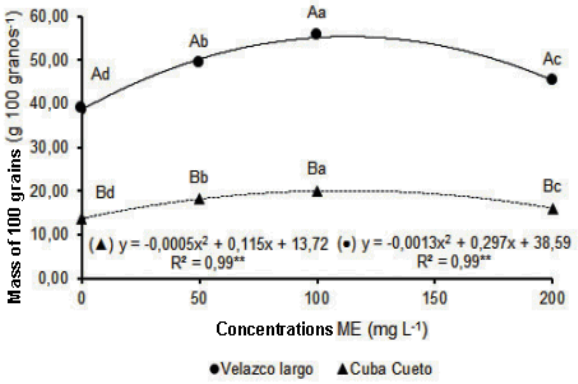
Regarding the average of grains per pod, in Figure 4 it is observed that the foliar applications of ME showed significant differences among them and significantly exceeded the control. The effect achieved in both cultivars was adjusted to a quadratic model, observing a strong and positive response. The cultivar Cuba Cueto surpassed the cv. Velazco largo in the production of grains per pod and the highest responses were reached for the two cultivars with the concentration of 100 mg L^{-1}, because it exceeded the production achieved by the concentrations of 50 and 200 mg L^{-1}. The increases, compared to the untreated, were 1.07 in the VLR and 1.33 grains per pod in the CC-25-9-N, for an average increase of this indicator of 28.0 and 35.0 %, respectively.

Similar effects were achieved when evaluating the results of several stimulants in two cultivars of common bean (CC-25-9-N and CUL 156), where the cultivar Cuba cueto CC-25-9-N, in the treatment with Biobras-16 only significantly increased the number of grains per plant (22).



Uppercase letters differ between cultivars and lowercase between ME concentrations, according to Tukey (p≤0.05). CV = 9.28 %; ES (±) = 0.24. ** Significant at 99 % confidence

Figure 4. Behavior of average grains per pod in common bean cultivars according to the concentrations of efficient microorganisms



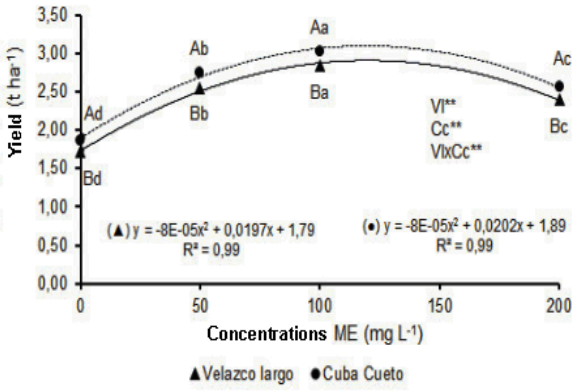
Uppercase letters differ between cultivars and lowercase between ME concentrations, according to Tukey (p≤0.05). CV = 5.75 %; ES (±) = 0.91. ** Significant at 99% confidence

Figure 5. Behavior of the mass of 100 grains according to the concentrations of efficient microorganisms

In this study the 100 mg L^{-1} treatment showed the highest mass production of 100 grains for the two cultivars evaluated (Figure 5), with significant differences between the concentrations of 50 and 200 mg L^{-1} and the control without application. The studied variants were adjusted to a quadratic regression model, with strong and positive responses. In this indicator the cv. Velazco largo reached higher average values than Cuba counted. The increases with respect to the control were 43.0 % in the cultivar of red beans and 46.0 % in the black ones.

Similar effects were achieved in a study where a 100 mg L^{-1} concentration of efficient microorganisms was applied in the maize crop, where they managed to obtain significant differences in the mass of the corn without straw, with an increase of 29.8 % of the treated with respect to control (21).

Figure 6 shows the effect of the treatments on the yield of both cultivars studied. It is observed that the best performance was achieved by the variant where 100 mg L^{-1} was applied, with significant differences in relation to the other concentrations and control without application. The models were adjusted to quadratic equations, with strong and positive responses. Increases in the concentration of 100 mg L^{-1} with respect to the concentrations of 50 and 200 mg L^{-1} ME and the control in the VLR cultivar were 10.0, 16.0 and 40 %, respectively and in CC-25-9-N of 9.0, 15 and 38.0 %, respectively. The increase in the yield of this concentration is justified because it exceeded the other parameters evaluated in relation to the other concentrations used.



Uppercase letters differ between cultivars and lowercase between ME concentrations, according to Tukey (p≤0.05). CV = 9.59 %; ES (±) = 0.04. ** significant at 99 % confidence, according to the proposed regression model

Figure 6. Behavior of the productivity of common bean cultivars according to the concentrations of efficient microorganisms

The sprinkling of the seeds with Biobras-16®, prior to the inoculation with Azofert®, stimulated the yield of the plants of both bean cultivars (CC-25-9-N and CUL 156), in such a way that it significantly exceeded (29-30 %) to that obtained in the plants of the control treatment (100 % N) (22).

With the foliar application of efficient microorganisms (ME-50) at the dose of 7 L ha^{-1} in the rice culture, the yield was increased by 0.80 t ha^{-1} in relation to the control treatment (23).

CONCLUSIONS

- Foliar application of effective microorganisms and production stimulated morphological parameters evaluated, as the number of leaves, the dry mass, average pods, beans by pods, the mass of 100 grains and the yield of the cultivars evaluated against with control without application.
- The cultivar Cuba cueto presented greater responses to the foliar application of ME, compared to Velazco largo one and in both cultivars, the best results were achieved at the concentration of 100 mg L^{-1}, because it increased productivity by 1.13 t^{-1} in the cultivar Velazco largo and 1.15 t ha^{-1} in the variety Cuba cueto, in relation to the control without application.

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