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Original article

EcoMic® biofertilizer application in the cultivation of bean in two production systems

Aplicación del biofertilizante EcoMic® en el cultivo de la habichuela en dos sistemas de producción

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ABSTRACT: The research was carried out at the "Los Palacios" Urban Farm, belonging to the Cubaquivir Agroindustrial Company where a Ferrallitic Yellowish Leach Petroferric soil predominates with the aim of evaluating the effect of the biofertilizer EcoMic® application in the cultivation of the bean *cv*. Canton in two different production systems. Biofertilizers was applied at a dose of 10 % based on the seed mass before sowing by the coating method. In the intensive production area two plots of 0.25 ha were planted. One with seed treated with the biofertilizer (MA) and the other untreated (noMA) and in the organoponic two beds of 10 m long x 1.20 m Wide. The percentage of mycorrhizal colonization, plant height, number of pods per plant, pod length, number of seeds per pod and agricultural yield were evaluated in both treatments and production systems. It was obtained as a result that in the treatments with EcoMic®, the plant height increased, the number of pods per plant, the length of the pods, the number of seeds per pod and the agricultural seed yield between 15 and 23 %. The greatest increases in the growth and development of bean plants were obtained under organoponic conditions.

Keywords: arbuscular mycorrhizae, yield, legume, seed, *Vigna unguiculata*.

RESUMEN: La investigación se realizó en la Granja Urbana "Los Palacios", perteneciente a la Empresa Agroindustrial Cubaquivir, donde predomina el suelo Ferralítico Amarillento Lixiviado Petroférrico, con el objetivo de evaluar el efecto de la aplicación del biofertilizante EcoMic® en el cultivo de la habichuela, cv. Cantón, en dos sistemas de producción diferente. El biofertilizante se aplicó a la dosis de 10 % en base a la masa de la semilla antes de la siembra, por el método de recubrimiento. En el área de producción intensiva se sembraron dos parcelas de 0,25 ha, una con semilla tratada con el biofertilizante (MA) y la otra sin tratar (no MA), y en el organopónico dos canteros de 10 m de largo y 1,20 m de ancho. Se evaluó, en ambos tratamientos y sistemas de producción, el porcentaje de colonización micorrízica, la altura de las plantas, el número de vainas por planta, la longitud de las vainas, el número de semillas por vaina y el rendimiento agrícola. Se obtuvo como resultado que, en los tratamientos con EcoMic®, se incrementó la altura de la planta, el número de vainas por planta, la longitud de las vainas, el número de semillas por vaina y el rendimiento agrícola de semilla, entre 15 y 23 %. Los mayores incrementos en el crecimiento y desarrollo de las plantas de habichuelas se obtuvieron en condiciones de organopónico.

Palabras clave: micorrizas arbusculares, rendimiento, leguminosa, semilla, *Vigna unguiculata*.

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INTRODUCTION

Beans (*Vigna unguiculata* L. Walp) stand out for their nutritional value in proteins, calories, vitamins and minerals which are lacking in many other basic foods (1). It is a vegetable that is consumed in various parts of the world, mainly in Asia. Africa and Latin America, so it represents a high percentage for the nutrition of millions of people (2) and in addition, it is a source of Fe and Zn (1).

Cuban agricultural ecosystems and among these, those belonging to the system of urban and peri-urban agriculture, have a high biodiversity with healthy productions and present problems with the supply of seeds of the most consumed spices; as well as with the source of improvement of the fertility of soils and substrates. For this reason, the use of biofertilizers is recommended as an alternative to improve the efficiency of the production system and maintain yields.

The use of edaphic microorganisms in agriculture constitutes a promising alternative to satisfy the nutritional needs of crops and to obtain adequate levels of yield and quality of products, making possible the partial or total saving of mineral fertilizers, as well as increasing the biological processes in the soil. Many of the problems that exist in plant nutrition can be solved through biotechnology, taking into account the capabilities of microorganisms and their importance, which is why the use of these microorganisms, whether they come from fungi or bacteria, should be promoted and favored (3). These microorganisms can be crucial for sustainable productions in low-input systems and likewise, stimulate plant growth by increasing the availability of nutrients for plants, producing phytohormones and promoting the biological control of pathogens in the soil (4).

The fungi that form arbuscular mycorrhizae originate a series of benefits for plants, among which the following can be mentioned: increases in growth and agricultural yields; increase the use of fertilizers and soil nutrients and therefore, decrease the application costs of these inputs; protect the root system of plants against certain fungal diseases and contribute to the biological activity of the soil (5). It was reported by several authors that beans respond positively to arbuscular mycorrhizal symbiosis (AMS) (6,7).

The present work had the objective of evaluating the effect of EcoMic® biofertilizer application on the cultivation of the string bean cv. Canton in two production systems.

MATERIALS AND METHODS

The work was carried out in two seed production areas of the Urban Farm "Los Palacios", belonging to the Agroindustrial Company Cubaquivir. One area of 0.5 ha in the Seed Farm, where a Yellowish Ferrallitic Leached Petroferric soil predominates (8), of low fertility (Table 1) according to the results of the soil analysis carried out by the Provincial Laboratory of Pinar del Rio. The other production system was in the company's organoponic system, where the beds had been activated with fresh organic matter.

The area of the seed farm was divided in two plots at 50 %; in one of them the bean seeds were sown coated (pelletized) with EcoMic® biofertilizer, which was applied at a dose equivalent to 10 % based on the mass of the seed (7) and the other was taken as a control. Sowing was carried out in the first fortnight of June 2018, using as planting frame 0.70 m of row by 0.10 m of root ball, the agro-technical work was carried out according to the technical instructions of the crop (9). In the case of organoponics, two furrows were established in each bed at a distance of 0.70 m and 0.10 m between plants.

Evaluations

At 60 days after emergence (DAE) in each bean seed production system, 40 plants were randomly marked per treatment and the evaluation of plant height (cm) was carried out. As the crop provided mature pods, they were harvested and at 85 DDE the total harvest of the crop area was carried out, but first the percentage of mycorrhizal colonization (%) was evaluated by the intercept method (10), pod number per plant, pod length (cm) and the average number of seeds per pod in the production systems. In the case of mycorrhizal colonization, roots of bean plants were washed with abundant water and finest roots were extracted to form a root pull of ten plants, equivalent to four samples per treatment, and they were stained according to the proposed protocol (5).

In the intensive production area, five sampling points were established on the diagonal to determine the agricultural yield of bean seeds (1 m^2). In the case of the organoponics, five points of 1 m^2 were sampled in each bed.

The mean values of the evaluations and samplings were compared based on confidence intervals for α=0.05.

Table 1. Soil fertility characteristics of the soil used in the study

Depth (cm)	pH	OM (%)	P_2O_5	Ca	Mg	K	Na	CIC
			(mg 100 g soil^{-1})					
0-20	5.6	1.41	0.9	2.49	2.31	0.25	0.20	9.39
depth (cm)				(%)				
		Sand		Loam			Clay	
0-20		65.66		13.08			21.26	

RESULTS AND DISCUSSION

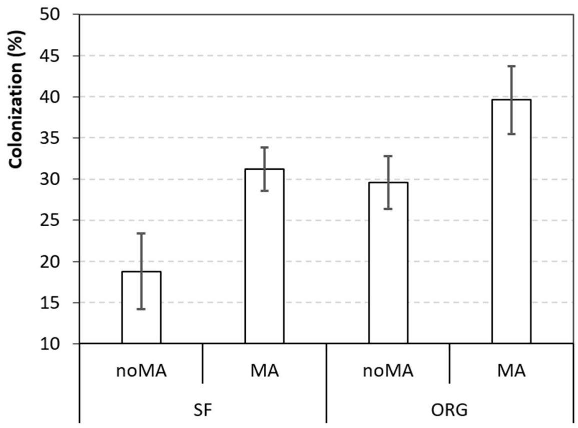
The application of EcoMic® biofertilizer in the bean crop conditioned increases in fungal (mycorrhizal colonization) and agronomic variables (pod length; number of seeds per pod and number of pods per plant) evaluated in two seed production systems. An increase in the percentage of mycorrhizal colonization was found in the inoculated treatments in both production systems by 66 and 34 %, respectively (Figure 1).

It is important to point out that a higher percentage of increase was evidenced in the intensive production system, that is, in the Seed Farm, because this area, according to the soil analysis, presented low fertility and, therefore, the plant may be showing a greater mycorrhizal dependence. In this regard, it was reported that mycorrhizal symbiosis shows greater effectiveness when agricultural crops are treated with EcoMic® biofertilizer and grown in soils with low fertility (5). The colonization percentage found in the non-inoculated treatments (no AMF) corresponds to the natural symbiosis that plants establish with soil-dwelling Arbuscular Mycorrhizal Fungi (AMF).

Several authors have reported similar behavior for the bean crop, with colonization values fluctuating between 15 and 30 % (6). However, there is no colonization threshold according to the type of soil and much less according to the crop, so the percentage of colonization in the roots of the plants are subject to edaphic factors, species and prevailing environmental conditions (5,11). In this regard, it was reported that it is difficult to relate yield effects to the abundance of any AMF strain in roots due to the lack of an adequate methodology to trace this taxon in the field (12). However there are criteria that assured that native AMF from soils show low potential to develop mycorrhizal symbiotic, which limits growth and foliar P concentration in the host plant (13).

Plant height was higher in mycorrhizal treatments (Table 2), as well as the number of pods, pod length and the number of seeds per pod, compared to untreated plants in both production systems.

Similar results to those reported in this research are reported in the scientific literature for this crop, but in combination with other byproducts or biostimulants, such is the case of the combination in EcoMic® with Spirulina application (7); application of EcoMic® with earthworm humus (14) and the combination of EcoMic® with efficient microorganisms (15). In general, both in this research and in those mentioned above, EcoMic® treatments are always favored by its application, due to its effect on water and nutrient absorption (5,16).



Seed farm (SF); Organoponics (ORG)Marks above columns mean ± confidence interval. n = 40

Figure 1. Mycorrhizal colonization in bean plants cv. Canton with and without EcoMic® biofertilizer application in two production systems

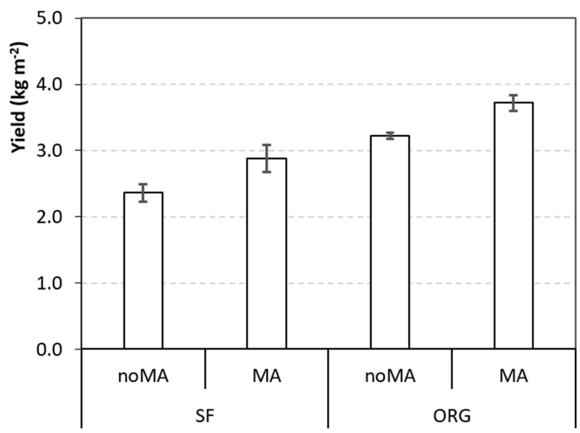
Regarding the agricultural yield of the seed in the two production systems. it was found that always the treatments with the biofertilizer EcoMic® showed the highest values (Figure 2) which correspond to an increase between 15 and 23 %, respectively. It should be noted that the production values in the seed farm were below those found in organoponic conditions, a behavior that corresponds to low soil fertility and agronomic management appropriate to the form of production.

In this specific case, the increase in yields was strongly related to increases in mycorrhizal treatments in the number of pods per plant, the length of pods and the number of seeds per pod. Several investigations have demonstrated the increase in agricultural yields due to the effect of biofertilizer application (5,17). Similar responses to those found in this study were reported in the cultivation of beans (7,14,15) with the EcoMic® application and other biofertilizers and byproducts. In a general sense, these authors found an increase in atmospheric nitrogen fixation, greater root exploration area and, consequently, increased water and nutrient absorption from the soil, which contributed to the improvement of growth and development of the bean crop.

Table 2. Agronomic variables in bean plants cv. Canton with and without EcoMic® biofertilizer application in two production systems

Treatments		PH	N_P	P_L	N_S
SF	Without EcoMic®	36.98 ± 0.45	24.06 ± 0.44	30.91 ± 0.36	14.05 ± 0.29
	With EcoMic®	44.94 ± 0.38	27.74 ± 0.51	34.96 ± 0.37	17.02 ± 0.33
ORG	Without EcoMic®	39.75 ± 0.50	26.87 ± 0.75	32.8 ± 0.43	15.15 ± 0.31
	With EcoMic®	48.8 ± 0.54	30.27 ± 0.59	36.645 ± 0.62	20.37 ± 0.39

Seed farm (SF); Organoponics (ORG); Plant height (PH); Pod length (P_L);
Number of seeds per pod (N_S); Number of pods per plant (N_P). ± Confidence interval. n = 40.



Seed farm (FS); Organoponics (ORG)

Marks above columns mean ± confidence interval. n = 40

Figure 2. Agricultural yield of bean plants cv. Canton with and without EcoMic® biofertilizer application in two production systems

CONCLUSIONS

- EcoMic® biofertilizer application increases plant height, number of pods per plant, pod length, number of seeds per pod and agricultural seed yield by 15 to 23 %.
- The greatest increases in growth and development of bean plants are obtained under organoponic conditions.

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