Effect of Bioorganic Enhancers on Bean (*Phaseolus vulgaris* L.) Yields

Ignacio Corrales Garriga[1], Pedro Jesús López Labarta [2]. & Eduard Chapman Nicot [3].

Received: September 13, 2016
Accepted: March 3, 2017

ABSTRACT

This research took place on El Huerto Farm, Cándido González Cooperative of Credit and Services, in the province of Camaguey, Cuba, on low-natural-fertility, red-brown, mulled magnesian ferrallitic soil. The goal of the study was to increase yields of bean variety "Rosa", using bio-organic enhancers applied every seven days after seed germination. A randomized block design was made, with six treatments and four replicas. The indicators evaluated were, number of pod per plants, number of beans per pod, volume of 100 beans, and crop yields. A computerized two-way analysis of variance was used for evaluation of the experimental data; the Duncan´s test was applied to significant values (5%). The treatment with natural liquid humus + potassium nitrate + potassium sulfate produced the highest rise in yields and related components.

KEY WORDS/: bio-organic enhancers, liquid humus, beans, Phaseolus vulgaris

INTRODUCTION

Beans (Phaseolus vulgaris L) is originally from the Americas. Globally, it is one of the most important edible legumes thanks to widespread distribution, and because of its importance in human nutrition, with high protein contents. In Latin America and other third world countries, beans are the "*meat of the poor*" (Benítez, 2011).

Beans are highly demanded worldwide. Brazil, India, and the US are the largest world producers. In the 2000-2008 period, the world´s production of beans accounted for 17 450 803-20 991 898 t, harvested in 23 667 767-28 189 680 ha (0.68-0.76 t.ha, according to FAOSTAT, 2010).

In Cuba, beans are highly demanded. Though its production was mostly in charge of non-agricultural companies and imports increased, these actions did not suffice the shortages of animal protein that the circumstances demanded at the time. It also led to a significant rise in prices in the informal market, after 1994. Accordingly, the national supply responded to such incentives, now made legal through the farmer´s market. Approximately, beans are cultivated in 52 000 ha, with the addition of the lands used for self consumption. The government-owned companies can only meet 5% of the current demand, the rest is covered by imports of 120 000t annually, at 40 million dollars (MINAG, 2009).

[1] Eng. Agronomist, M. Sc. Soil Fertility, Assistant Researcher, UCTB Camagüey: icorrales@suelos.cmg.minag.cu
[2] Eng. Agronomist Especialist, Development-Research Dpt. - UCTB Camagüey: plopez@suelos.cmg.minag.cu
[3] Agricultural Enterprise Camagüey.

Agrisost |2017, Vol.23, No.2: pages: 57-65 **ISSN 1025-0247**
Available in: http://revistas.reduc.edu.cu/index.php/agrisost/index

The common bean (Phaseolus vulgaris L) is an important part of the Cuban diet, the national production is in charge of the Ministry of Agriculture, with 135 964 ha in 2015, and an output of 190 350 t (1.4 t/ha), including seed production, posing an enormous challenge to the Cuban economy (Benítez *et al*., 2011).

Production, distribution and management of beans in the province of Camaguey demands agrotechnical, phytosanitary, and edaphoclimatic requirements that can be adapted to the new economic and environmental scenarios. The active participation of all actors is important. One critical factor, however, is viral diseases transmitted by the white fly (Martínez et al., 2007).

The growing food demands created by an ever-increasing world population have compelled farmers to use mineral fertilizers to raise yields (Soil Institute, 2010), which causes serious environmental pollution derived from the reckless use of these fertilizers. As a result, new alternative types of fertilizers have been developed.

In tropical and subtropical countries, different bio-organic alternatives are being used today, depending on the progress made by agroecological trends (Barroso, 2015). In Cuba, there has been an increase of this movement in recent years, by means of urban and suburban agriculture, through programs that encourage the application of these products. The aim of this paper was to present some of the alternatives used, like natural liquid humus, improved liquid humus, and natural liquid humus plus other nutritional components, with an effect on crop growth and development.

MATERIALS AND METHODS

This study took place in the period January-April, 2015, on El Huerto Farm (20.13 ha) at Cándido González Strengthened Cooperative of Credits and Services (CCSF), located 5 km northeast of the city of Camaguey, 21º21´40” north latitude and 77º51´30” west longitude, 120 meters above sea level. The Rosa variety was planted on the farm studied, on a mulled brown red magnesian ferrallitic soil (Hernández *et al*., 1999). The water used for irrigation was supplied from a dam.

The seeds were inoculated with Rhizobium before sowing. Four foliar applications were made early in the mornings, every seven days, seven days after germination, following the set dose (Table 1), using a 16 l backpack sprayer; dosage was adjusted in each treatment. A randomized block design was made, with six treatments and four replicas.

Table 1. Treatment type

Treatments	Description	Dose (L.ha-1)
1	Control	-
2	Natural liquid humus	2.0
3	Improved liquid humus	2.0
4	Fortified liquid humus	2.0
5	Natural liquid humus + Rhizobium	2.0
6	Natural liquid humus + Potassium nitrate + Potassium sulfate	2.0

Soil preparation and other phytocare works were made according to the Technical Instructions Manual for beans (MINAG, 2009).

Table 2. Lot characteristics

Length (m)	**10**
Width (m)	2.8
Lot area (m2)	28
Distance between lots (m)	1
Number of furrows	4
Furrows for evaluation	2
Calculation area (m2)	11.2
Plantation distance (m)	0.70 x 0.20
Total experimental area (m^2)	728

Experimental variables

- The height of 10 plants per lot was measured from the soil to the primary meristem, on days 30 and 60 (using a measure tape).
- Pods per plant (10 plants chosen at random) was evaluated in the lot area calculated.
- The number of beans per pod was counted in all the plants (10 plants per lot).
- Volume containing 100 beans (100 beans were chosen at random and their mass was calculated).
- Yields (all the plants within the area studied in the lots were harvested, and the yields were expressed in t/ha.

Harvest was made in the two central furrows of each lot, in the area studied, and yields were calculated in $t.ha^{-1}$.

Two-way variance analysis was used for data processing, through SSPS 11.5.1 (1999), for Windows. Instances of significant differences (5%) were estimated by Duncan´s multiple range test. The financial analysis included the costs of the experiment, such as water expenses in all the treatments, and income and profits.

RESULTS AND DISCUSSION

Plant height was stimulated with the application of bio-organic enhancers

Table 3. Plant height (cm)

Treatment	30 days	60 days
Control	18.2b	23.9c
Natural liquid humus	20.9a	25.8bc
Improved liquid humus	20.9a	26.4b
Fortified liquid humus	22.1a	29.1a

Agrisost | 2017, Vol.23, No.2: pages: 57-65 ISSN 1025-0247
Available in: http://revistas.reduc.edu.cu/index.php/agrisost/index

Natural liquid humus + Rhizobium	20.9a	28.4a
Natural liquid humus + Potassium nitrate + Potassium sulfate	22.1a	28.7a
Mean SE	0.39 *	0.59

Note: a,…b,…c,.. Unequal letters are significantly different for p≤0.05%

Thirty days after germination, all the treatments that used bio-organic enhancers had significantly different values in relation to the control, though no significant differences were observed among their means. It may have been caused by the assimilation of the products by the plants during the growth stage that led to homogeneous size increase. Accordingly, the nutritional conditions had been configured for assimilation, proving the convenience of such alternatives for bean nutrition, according to Bonner and Galston (1972), Reyes (1992), cited by Socorro *et al.* (2006), on reference to plant height as a particular genetic feature of the plant in interaction with the environment, and it is the result of the number of nodes and the distance between nodes on the stem.

However, after 60 days of planted, the application of bio-organic enhancers caused a different effect, when the natural liquid humus was applied (treatment 2); no significant differences were observed compared to the control, but when other components were added, significantly higher values were observed in relation to the control. It demonstrated that the plant´s nutritional requirements were met in the same proportion as the enhancers were improved. Height was greater, though no significant differences were observed between them, which might have been caused by the favorable assimilation of the new component by the plant.

Similar results were achieved by Socorro and Martin (1998), with 19.16 cm for the growth stage; however, García *et al.* (2011), had different results. They made comparative studies of two common black bean varieties in the Pinar del Rio province, and reported heights of 37 and 43 cm. They claimed that the behavior of the crop was associated with the response of biotypes, and the expression of individual features, depending on the environmental conditions.

Table 4 Number of pods per plant

Treatments	Pods per plant	Beans per pod
Control	9.1f	5.3 c
Natural liquid humus	11.0 e	5.3 c
Improved liquid humus	12.2 d	5.6 b
Fortified liquid humus	13.2 c	5.9 a
Natural liquid humus + Rhizobium	14.0 b	5.8 a
Natural liquid humus + Potassium nitrate + Potassium sulfate	15.3 a	5.9 a
Mean SE	0.24*	0.49*

Note: a,…b,…c,.. Unequal letters are significantly different for p≤0.05%

Number of pods per plant (Table 4), in treatment 6 the plants had the best response (15.3 pods on average), with significant differences from the other treatments, possibly due to the composition of the enhancer. In addition to the natural liquid humus, it contained potassium nitrate and potassium sulfate, and were applied at the right time, improving the conditions for assimilation. It produced an increase in the number of pods per plants, and it coincided Rosario (2006), who pointed that the number of pods may be affected by the nutritional status of the plant during formation. Besides, the more the treatments were improved, the more favorable effects they produced on the number of pods. Number of beans per pod; the largest numbers were observed in the treatments containing fortified liquid humus, natural liquid humus + Rhizobium, and natural liquid humus + potassium nitrate + potassium sulfate. Their values were significantly higher than the rest of the treatments, though no statistically significant differences were observed among them. The application of natural liquid humus did not stimulate the number of beans per pod in comparison to the control, since their values had no statistical differences. These results were similar to other results achieved by Torres (2006), who studied black bean varieties in the municipality of Majibacoa, and obtained an average top of 5.8 beans per pod. He also noted that the behavior of beans per pod was linked to the amount of nutrients in the plant, that stimulate the formation of the seed.

Table 5. Effect of enhancers on a 100 bean volume (g)

Treatments	Volume of 100 beans (g)
Control	17.68 c
Natural liquid humus	19.42 b
Improved liquid humus	19.73 ab
Fortified liquid humus	20.32 ab
Natural liquid humus + Rhizobium	20.32 ab
Natural liquid humus + Potassium nitrate + Potassium sulfate	21.12 a
Mean SE	0.31*

Note: a,…b,…c,.. Unequal letters are significantly different for $p \leq 0.05$

The 100 bean volume (Table 5) had significantly higher values than the control, as a response to the application of bio-organic enhancers with Rhizobium in all the treatments. The natural, improved, and fortified liquid humus were applied, and their values were not significantly different from the treatments where Rhizobium was added in the applications, though the treatments with added potassium nitrate and potassium sulfate had significantly different values from the control, which only received the natural liquid humus. These results differed from the Technical Instructions for beans (2011), reaching the 20 g, but they were similar to results by Cisneros (2013) on a study of variety Delicia 364, using bio-organic products in different conditions.

Table 6. Effects of enhancer application on yields

Treatments	Yields (t/ha)
Control	0.98 e
Natural liquid humus	1.07 d
Improved liquid humus	1.09 d
Fortified liquid humus	1.14 c
Natural liquid humus + Rhizobium	1.33 b
Natural liquid humus + Potassium nitrate + Potassium sulfate	1.40 a
Mean SE	0.054*

Note: a,…b,…c,.. Unequal letters are significantly different for $p \leq 0.05$

The effect of bio-organic enhancers on yields is shown in Table 6; the application of these products increased yields, with a significant difference in relation to the control. The table also shows that the enhanced natural liquid humus increased yields, with significant higher values between the means. When the natural liquid humus was applied with the addition of potassium nitrate and potassium sulfate, the yields showed significant differences from the other treatments, which might have been produced by the composition of the enhancer, and the effects of nitrate, sulfur, and potassium on plant growth and development, since proper nutritional conditions for higher yields were created. This response corroborated the results achieved by Montejo *et al*. (2012) on suburban farms engaged in garden vegetables and fruits (2012), in the municipality of Camaguey; and by López *et al* (2012), using organic enhancers to increase crop yields in beans, vegetables, and pastures. The results of this study were similar to López and Montejo (2012) on suburban farm trials, with 1.97 t/ha^{-1}; however, the yields were inferior to Socorro and Martín (1998), who achieved 2.5 and 2.7 $t.ha^{-1}$, respectively. Nevertheless, the results of this study were superior to Rodríguez (2006), who studied 15 bean varieties in the municipality of Majibacoa, with yields of 0.33 and 0.48 $t.ha^{-1}$, and reports made by Pupo (2007), who evaluated 9 varieties of black beans in the same municipality, with yields of 0.59 and 1.19 $t.ha^{-1}$.

CONCLUSIONS

The application of bio-organic products to beans (variety Rosa) had a positive impact on plant growth and development; the most effective treatment was the natural liquid humus, potassium nitrate and potassium sulfate.

The most economically efficient bio-organic enhancer coincided with the one that produced the highest yield increases.

RECOMMENDATIONS

Further studies of possible alternatives should be made for other crops in similar edaphoclimatic conditions.

Agrisost | 2017, Vol.23, No.2: pages: 58-65 ISSN 1025-0247
Available in: http://revistas.reduc.edu.cu/index.php/agrisost/index

REFERENCES

Benitez. R.,Faure, B., León, Y.,Chaveco, O. & García, E. (2011). Nueva variedad de frijol común para la producción comercial en Cuba. [Resúmenes]*Encuentro Internacional de Arroz.* La Habana, Cuba: [s.n.].

Bonner, J. & Galston, W. A. (1972). *Principios de Fisiología Vegetal.* La Habana, Cuba: Pueblo y Educación.

Cisneros, B (2013). Evaluación agroproductiva del cultivo del frijol *Phaseolus vulgaris L*, variedad Delicias 364 mediante la utilización de productos bioorgánicos en una finca agroecológica

FAOSTAT (2010). *Tipos de importaciones de Frijoles Secos .Dirección de Estadística*. La Habana, Cuba.

García, J.C., Quintero, E. Gil, V. D.,Chaveco, O. & Rodríguez, G. (2011). Colección germoplasma de frijol fortificado en hierro y zinc comportamiento agronómico y preferencia por los productores. Summaries. IV Encuentro Internacional de Arroz. La Habana, Cuba: [s.n.].

Hernández, A. (1999). *Nueva versión de la Clasificación genética de los Suelos de Cuba.* Ciudad de La Habana, Cuba: Instituto de Suelos; Ministerio de la Agricultura.

Instituto de Suelos (2010). *Los biofertilizantes y estimuladores, una alternativa para lograr la agricultura sostenible.* Camagüey, Cuba.

Instructivo técnico para el cultivo del frijol. (2011) La Habana, Cuba: Ministerio de la Agricultura.

López, P; J. Montejo; I. Corrales; P. Chavelis y E. Pérez (2012). Empleo de potenciadores bioorganicos para incrementar rendimientos en sistemas productivo. Informe final de proyecto. UCTB de Suelos Camaguey, p 37.

Martínez, E., Barrios, G., Rovesti, L. &Santos, R. (2007). Manejo Integral de Plagas. Manual Práctico. En *La protección de cultivos.*(p. 19). [s.l.]: [s.n.].

Ministerio de la Agricultura (2009). *Instructivo técnico del cultivo del frijol*. La Habana, Cuba: Autor.

Montejo, J; P. López; I. Corrales; R. Barroso y A.C. Rosabal (2012). Manejo de la nutrición integrada en casas de cultivo de la granja urbana, p 28. Informe final UCTB de suelos de Camagüey.

Pupo, L (2007). Evaluación de 9 variedades de frijol negro (Phaseolus vulgaris L) en las condiciones edafoclimáticas del municipio Majibacoa. Trabajo de Diploma.

Reyes, J. (1992). Historia de la producción del maíz. En *memoria del Simposio Internacional de Sanidad Vegetal.* (p. 47).Managua, Nicaragua: ESAVE-UNA.

Rosario, E., Socorro, Z. Joya, J. Zoraida del Socorro L, (2006). Evaluación Preliminar de 36 genotipos de frijol común (Phaseolus vulgaris L.) en la época postrera en Macico, Somoto.Trabajo de Diploma. Managua. Nicaragua.

Rodríguez, Y. (2006) Evaluación de quince cultivares de frijol rojo (Phaseolus vulgaris, L) en las condiciones edafoclimáticas del Municipio Majibacoa (en opción al título de ingeniero agrónomo).Centro Universitario de Las Tunas

Socorro, E.O. & Arelis Maria, R. (2006). *Efecto de la Densidad Poblacional y la época de siembra en el rendimiento y la calidad de la semilla de una población de Caupí Rojo (Vigna unguiculada L.) en la finca El Plantel.* Trabajo de grado, Ingeniero Agrónomo, Managua, Nicaragua.

Socorro, Q.M., Martín, F.&David. (1998).*Granos.* México, DF: Instituto Politécnico Nacional.