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Bioorganic Nutritional Alternatives in Carrots (*Daucus carota var. sativa*), under Intensive Gardening

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Abstract

Context: One oftoday´s challenges is to provide food to all inhabitants, taking into account the growth of global population, especially into the cities. Accordingly, the urban farming systems are important, as they offer a real solution in face of the people's demands.
Objective: To compare different bioorganic nutritional alternatives and their influence on growth and yield indicators in carrots (*Daucus carota var. sativa*).
Methods: This research was done at Ernesto Che Guevara intensive green garden (UEB No. 2), from the Agricultural Company of Esmeralda municipality, between December 2016 and March 2017, on non-gley plastic dark soil with high fertility. A completely randomized experimental design was applied, with five treatments and three replicas, the indicators evaluated were plant height, root length, and yield.
Results: The best agronomic indicators were achieved in the treatments based on fortified liquid humus enriched with boron, calcium, and zinc, which did not differ among them, but were different from the natural liquid humus, and the control. The fortified liquid humus produced the highest yields and the best economic results.
Conclusions: A favorable response was observed to bioorganic alternatives in terms of plant growth and yields. The fortified liquid humus had the best economic effect, with a remarkable increase in revenues, compared to the control.

Key words: intensive green garden, Daucus carota, biostimulants, humus, plant nutrition.

Introduction

The need to produce more food as a result from population growth in approximately 100 million inhabitants, will require more cropland reaching its limits. Then the new systems will demand increases in productivity of agricultural systems, with a view on protecting the environment and health of living beings (García, Pico, Mañalich & Quiñones 1996).

Supplying the world with food is one of the essential challenges of the current century; the number of consumers will grow in the coming decades. In that sense, the fact that demographic growth is mostly occurring in urban areas, which in addition to deteriorating levels of poor urban population, and migration of the rural population seeking better living standards in the cities, urban cropping systems are not just a possible solution, but a future need.

In recent years, agronomic, economic, and social studies have demonstrated the existence of real opportunities for large-scale development of sustainable farming systems that combine technical feasibility, economic viability, and social acceptance (Funes-Monzote, 2009).

Vegetable gardens are currently used intensively, so it is important to ensure proper management of organic fertilization, in order to achieve higher precision and stable yield increases without deteriorating the soil Vento, Caballero, Chaveli, Rodríguez & Casañola, 2012).

It has demanded the creation of activities and structures capable of assuring the stability of this new productive systems (Rodríguez et al., 2007).

In that sense, Barroso, López, Montejo & Mendoza, (2010) demonstrated that one of the alternatives for crop nutrition is the use of biofertilizers such as phosphorine and azotobacter, which combined with liquid humus, have had positive effects on higher crop yields, of up to 30%. Today, they have become feasible agroecological practices that can be applied in the conditions of Cuba.

Within the large variety of garden vegetables subject to these practices are carrots (*Daucus carota var. sativa*), with a relevant place in urban agriculture in Cuba, due to the contributions of vitamin A, potassium, sodium, calcium, phosphorus, iron, etc. It is also very popular among consumers, so it is necessary to conduct further studies of the effects of the said products on the species.

Historically, intensive vegetable garden Ernesto Che Guevara in the municipality of Esmeralda has not been able to produce the expected yields in carrots (*Daucus carota var. sativa*), with only 2,2 kg/m^2, due to inappropriate handling practices. This crop is highly demanded by the population due to all its properties, such as high vitamin A, E, and K contents, and it helps prevent cholesterol and gastrointestinal diseases, which make carrots very popular in the region, regardless of the low yields in the intensive garden. Therefore, the aim of this research was to compare several alternatives of bioorganic fertilization and their influence on growth and yields of carrots (*Daucus carota var. sativa*), at Ernesto Che Guevara intensive vegetable garden.

Materials and Methods

The research was conducted between December 2016 and March 2017, in areas of Ernesto Che Guevara intensive vegetable garden, UEB No.2, from the Agricultural Company in Esmeralda, located on 78^{0}04´46´´ north latitude and 21^{0}50´35´´ west longitude, 27.5 meters above sea level.

The local weather is humid tropical, with mean annual values of precipitation of 1 499.7 mm, evaporation of 2 200 mm, and relative humidity of 82% (National Institute of Hydraulic Resources, 2016).

Planting was made on non-gley plastic dark soil (Soil Institute, 1975), with high fertility, compression, and deficient draining.

A completely randomized experimental design was used, with 5 treatments and 3 replications.

Table 1 shows the treatments and doses used in the study.

Table 1. Treatments and doses

Treatment	Products	Dose
1	Control	-
2	Natural liquid humus	2 L/ha
3	Improved liquid humus	2 L/ha
4	Fortified liquid humus	2 L/ha
5	Liquid humus enriched with boron, calcium, and zinc	2 L/ha

(UCTB Soil Laboratory, Camagüey, 2017)

Certified New Kuroda seeds from the Provincial Seed Company were used.

The liquid humus applied was generated from cattle manure bought from the Agricultural Supplies Company, in Camagüey, and were processed at the Soil Laboratory, in 2017.

The bioorganic nutrients consisted of a dose of 2.0 L/ha, sprayed with a 16 L Matabi backpack, with a frequency of seven (7) days, from germination, totaling six applications during the important phases of the crop.

Soil preparation and other phytotechnical labors, including irrigation, were performed according to the guidelines established in the Manual of Organoponics and Intensive Vegetable Gardens (Rodríguez et al., 2007) and the Technical Instructions for Carrots (Pérez, 2010).

The organic fertilizer contained cattle manure, and was applied before sowing, in 3 kg/m^2 doses.

The indicators evaluated and measured were,

- Plant height: Plant height was measured at 30 and 60 days, from the soil base to the total height of the leaf closest to the middle, using a tape measure.

- Root length: It was measured at 30 and 60 days following sowing, using a tape measure.

- Crop yields: The fresh roots were weighed following harvest, using a commercial balance in an area of 1 m^2.

SPSS, 11.5.1, for Windows was used for statistical analysis. Duncan's multiple range test (0.05 significance) was used in cases of significant differences.

The economic indicators were considered during the productive process; the value of production was established according to the price of the Official Price List by the Ministry of Finances and Prices (2015).

The costs of treatment were calculated considering the prices of the bioproducts applied, labor, energy, seeds, and others.

Results and discussion

Table 2 shows the behavior of plant height. Growth dynamics at 30 and 60 days showed a significant difference in the treatments. Treatments 3, 4, and 5 showed the best results, with no significant differences among them, but with the rest, being the control the lowest value, with no differences from treatment 2. Treatment 4, fortified liquid humus, showed the greatest value (29.4 – 53.1 cm, respectively). This may have occurred because the nutritional composition of these products contain humic acids, auxins, phosphorine, azotobacter, and chemical elements at low concentrations, like zinc, which effects on the elongation of plant cells. Also, the foliar application produces a favorable response in the plant with a direct effect on new adequate metabolic processes in the plant. Additionally, foliar development is linked to a diversion of nutrient into root thickening, and influence on greater crop yields.

Table 2. Plant height

Treatments	Plant height at 30 days (cm)	Plant height at 60 days (cm)
T1	23.2 b	42.0 b
T2	26.1 b	47.3 b
T3	27.2 ab	49.3 ab
T4	29.4 a	53.1 a
T5	28.0 ab	50.2 ab
ESx	0.8839	0.6367

Unequal letters differ for $p \leq 0.05$

Castillo (2014) found the same results, with the positive response of this agronomic indicator in tomato, with values of 69.0--72.4 cm. A similar response was achieved by Hernández (2016) in chard, with the application of those enhancers, and Cisneros (2013), in beans Delicia 364 found a response equivalent to these results, with values of 30.5--45.0 cm in areas of Agroecological farm El Barro, from CCSF Batalla del Uvero.

Table 3 shows root length at 30 and 60 days of sowing. A significant difference can be seen among treatments, especially treatment 4 as the highest value, with no significant differences compared to treatments 3 and 5, but differing from treatment 2 and the control, with the lowest values. Possibly, the establishment of nutritional requirements in adequate proportions generates favorable plant responses, provided that the crop receives the bioorganic and chemical compounds at low concentrations for nutrition while growing. This will be critical for the occurrence of metabolic processes, such as breathing and photosynthesis, leading to proper development; the thicker the roots, the greater the yields.

Table 3. Root length

Treatments	Root length at 30 days (cm)	Root length at 60 days (cm)
T1	4.0 c	15.0 b
T2	6.1 b	17.0 b
T3	7.0 ab	19.3 ab
T4	8.0 a	21.2 a
T5	7.0 ab	19.2 ab
ESx	0.4800	0.9229

Unequal letters differ for $p \leq 0.05$

These results are different than Lozada (2014), at 90 days, the crop was 11.59 and 14.13 cm with the application of improved liquid humus and fortified liquid humus. However, the same results were achieved by López (2010), who reported similar indexes in this cultivar, on suburban farms in Camagüey. Also, Pérez (2012) and Sifontes (2012) found similar results using these bioorganics, applying them on the leaves of beans.

According to Binder (1997), yields begin to form throughout growth and development, since the plant emerges, until the formation of the last organ, under the influence of edaphoclimatic factors (variables). Yields increase or decrease in relation to various morphological and anatomical characteristics (Palacios & Montenegro, 2006).

Table 4 shows the behavior of crop yields, a significant difference was observed in the treatments, being treatments 4 and 5 the best, when the fortified liquid humus and liquid humus enriched with boron, calcium, and zinc are applied. Then the control had the lowest values; hence the plant benefits from the bioorganic alternative with the highest nutritional composition. Perhaps, it is caused by the availability of required nutrients for development of metabolic processes in the plants, which produce greater yielding under these treatments. The lowest index were observed in treatments 2 and 3, (natural liquid humus and improved liquid humus) with no difference between them, but they differed from the others, including the control (lowest value). In that sense, treatments 4 and 5 made a difference, with the best agronomic indicators, which is correlated with the accumulative effect of crop yield response.

Table 4 Crop yields

Treatments	Crop yields (kg/m^2)
T1 Control	7.2 c
T2 Natural liquid humus	8.3 b
T3 Improved liquid humus	8.3 b
T4 Fortified liquid humus	9.2 a
T5 Liquid humus enriched with boron, calcium, and zinc	8.9 ab
ESx	0.4884

Unequal letters differ for $p \leq 0.05$

Similar results were achieved by Hernández (2016), using fortified liquid humus and liquid humus with zinc on the leaves in organoponic chard; it was corroborated in papaya nurseries when the biofertilizers were applied (Portieles, Ruiz, Caballero & García, 2010). The best response was found in the foliar application; also, González (2009), using bioorganic combinations in garden vegetables (crop protection systems), and Montejo (2012), using bioorganic products in different crops of suburban farms in the municipality of Camagüey, increased crop yields between 10 and -15%, which proves the effect of bioorganic enhancers applied on the leaves every 7 days.

Table 5 shows the indicators expenses and economic impact in treatments 4 and 5, with income values of 18.6 $/m^2, and 17.9 $/m^2; the control only showed 13.9 $/m^2. This result shows the benefits of the bioorganic alternatives in local crops (fortified liquid humus and liquid humus enriched with boron, calcium, and zinc).

The cost indicators included the prices of materials and the salaries of the personnel, which remained below the income, producing revenues.

Clearly, the control had the lowest cost values of all the treatments evaluated, since no product was applied for crop nutrition. The rest of the treatments showed a minimum progressive increase, particularly due to bioproduct use. Despite the costs arisen from the use of bioorganic alternatives, in contrast to the control (no application of bioorganics), the economic benefits were higher in terms of crop yields.

Table 5. Economic effect UM: $/m^2

Indicators	T1	T2	T3	T4	T5
Total expenses	3.52	3.57	3.59	3.61	3.57
Total income	17.42	20.09	20.09	22.26	21.54
Revenue	13.9	16.5	16.5	18.6	17.9
Differences from the control		2.6	2.6	4.7	4.0

Similar results were evaluated by González (2009), using bioorganic combinations. This response was corroborated by López & Montejo (2012), using biofertilizers combined with liquid humus on suburban farms in Camagüey.

Conclusions

A favorable response was observed to bioorganic alternatives in terms of plant growth and yields. The fortified liquid humus had the best economic effect, with a remarkable increase in revenues, compared to the control.

Author contribution

Pedro López Labarta: research planning, analysis of results, manuscript redaction, final review.

José Luis Montejo Viamontes: research planning, analysis of results, manuscript redaction, final review.

Yacelis Cárdenas García: literature review, analysis of results, final review.

Dimeri Piñeiro Esquivel: field work, literature review, final review.

Diosmaris de la Caridad Vasallo Cristia: field work, final review.

Amaury Rondón Aquilar: literature review, final review.

Conflicts of interest

The authors declare the existence of no conflicts of interests.

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