

**EFFICIENT MICROORGANISMS APPLIED TO  
THE SOIL AND IN COVER ON THE QUINOA  
CROP (*Chenopodium quinoa*)**

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**ABSTRACT**

The present study had as objective to know the effects of the natural fertilizer, from a biological compound of Efficient Microorganisms (EM-4), applied on the soil and in cover of quinoa, over its phytotechnics properties and its production. The experiment was conducted in a greenhouse, in a totally randomized blocks design, in a factorial scheme 4x2+1 with three replicates. The first factor constituted of four doses of EM (3, 6, 9 and 12%) applied on the soil before sowing, the second factor was the application or not of the compound via foliar. The additional treatment was considered a control treatment without any application of EM. It was evaluated plant height, inflorescence height, stem diameter, inflorescence diameter, root length, root volume, root dry mass and production. The results indicate that the use of Efficient Microorganisms (EMs) increase the production in 40% independent of the dose applied, when compared to the control. The foliar or soil application of EM-4 did not influence in the production components and in the production of quinoa.

*Keywords: Agroecological management, biofertilizer, organic agriculture.*

**1. INTRODUCTION**

Quinoa (*Chenopodium quinoa* Willd.) is an annual grain specie from the south America which has been cultivated in various different regions, contributing to its adaptation and to the diversification of the agriculture [1].

In Brazil the quinoa crop was introduced in the decade of 90, as part of a tentative to diversify the production system in the Brazilian 'Cerrado'. The crop is well known by its nutritional properties, especially in its protein quality and in the absence of gluten. Its world consumption is growing because it is an equilibrated food, allowing the replacement of corn and soybean in its capacity to complement the human and animal nutrition. Thus, becoming a good alternative for the diversification of the production, since it is an economically viable crop, with great potential to be used in the organic cropping system [1]. However, its cultivation in Brazil is still recent, that is, it demands more studies about its nutritional needs and management.

The organic cropping system aims to replace the agriculture with many chemicals for one were only natural inputs are used, as the stone dust, and the organic matter that are added to the soil, and the control of pests and disease by means of different measures similar to the environment's natural conditions. In this system, the soil organic matter stands out due to the management of its physic-chemical properties [2].

In the organic production system, many fertilization alternatives are used, such as the fertilization with cover crops, organic fertilizers made by animal wastes, worm compounds, composts, stone powder, bokashi and the use of efficient microorganisms. The choice of which should be used is often made based on what the producer has, thus, there is not a rule [3,4].

The cocktail of efficient microorganisms (EM) is a bio-organic formula composed of a combination of microbial inoculants, capable of stimulating the plant development and the soil fertility [5]. This biofertilizer has a biological composition that is still commercially unknown, but studies have shown that it has more than 10 genera and 80 species of microorganisms, from which can be mentioned bacteria that produce lactic acid, yeast, actinomycetes, filamentous fungus and photosynthetic bacteria [6].

Microorganisms are responsible for various biochemical reactions related not only with the organic matter transformation, but also with the weathering of stones, by the remineralization process, acting as regulators of nutrients by means of the organic matter decomposition and elements cycling, being, thus, source and drain of nutrients for the plants development [7]. The use of the EM compound does not only help in the supply of nutrients, but also reduces the production costs.

The microorganisms from the EM are capable of producing organic substances that are useful to plants, as well as to the soil microbiota. It is suggested that the EM produces bioactive compounds that act in the plant energetic balance which is favored by the reduction in what is spent in the biosynthesis of proteins during the photosynthesis, which is increased, enhancing the production [6].

Thus, the present study had as objective to know the effects of the natural fertilizer, from a biological compound EM-4, applied on the soil and in cover of quinoa, over its phytotechnics properties and its production.

## **2. MATERIAL AND METHODS**

### **2.1 Place of experiment**

The experiment was conducted in a greenhouse, belonging to the Western University of Parana. The region weather is classified, according to Köppen, as Cfa with hot summers and infrequent frosts. The annual average temperature is of 21 °C, being the minimum of 15 °C and the maximum of 28 °C.

The experimental design used was of randomized blocks, in a factorial scheme (4x2) +1 additional treatment, with three replicates. The first factor constituted on the application of four different doses of EM-4 in the soil, in the dilutions of 3, 6, 9 and 12%. The second factor constituted on the application, or not, of the efficient microorganisms via leaves, using the same dilutions that were applied to the soil (3, 6, 9, and 12%). The additional treatment constituted in the cultivation of quinoa without the application of EM-4.

The soil was sieved prior to the experiment to remove very big aggregates. The soil had a clayey texture, being posteriorly classified as Oxisil. After sieved, it was put into a concrete mixer to mix it with the base fertilizer. For all treatments, including the control, it was added the equivalent to 2 t ha<sup>-1</sup> of a bokashi compound, and 6 t ha<sup>-1</sup> of chicken bed. After homogenized, 8 kg of soil was weight and put into each pot. Before sowing, in each pot, it was added the biofertilizer EM-4, into the soil, to their respective doses studied.

The foliar application with the EM-4 was made 25 days after sowing, this application was repeated every two weeks until the physiologic maturation stage, totaling seven foliar applications.

The EM-4 cocktail of microorganisms was made by collecting microorganisms from a forest, using as substrate cooked rice which was added to bamboos, being these left in the woods for three days. Next, the bamboos were collected and then discarded the colonies with a dark color, using only the material with a pink, blue or yellow color. After separated, the rice was mixed in water with a sugarcane molasses, being it constantly shaken for three days in an agitator. Next the mixture was filtered and stored into pet bottles, being daily opened to release the gases. From this point the compound was multiplied [6].

Quinoa was sowed during the fall-winter period, using seeds from a strain that is under development and evaluation by the breeding program of the State University of Western Paraná – “Unioeste”. Seeds were manually sowed, adding 12 seed per pot at a 5 cm depth and, seven days after germination, plants were thinned, leaving only three plants per pot. Irrigation was daily made to keep the soil as near to the field capacity as possible. Weeds were manually controlled, being registered no occurrence of insects and diseases.

One hundred days after sowing were evaluated the following parameters: plant height with a measuring tape graduated in meters, stem diameter with a digital caliper, inflorescence height and diameter with a tape; and at 107 days after sowing, when plants presented 90% off their inflorescences with a light brown color, the inflorescence was harvested.

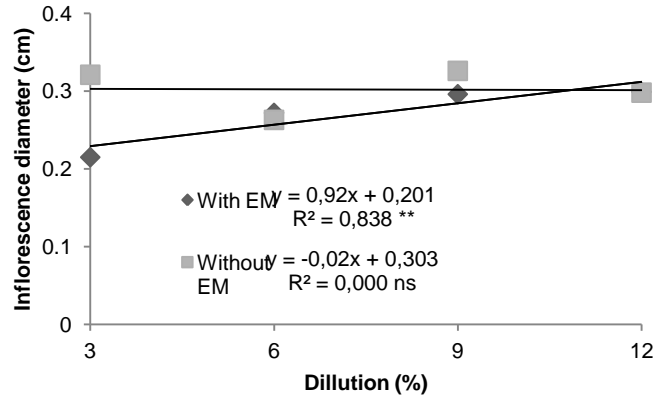
The inflorescences were put into paper bags and taken to an air forced circulation oven at 65 °C until they reached a constant mass. After dry, they were weight to obtain the production per pot. After the inflorescence was harvested, all aerial part was removed by cutting the plants close to the ground.

For the removal of the root system the pots were submerged in water to humidify the soil, and next, with a hose, the roots were washed to remove all the soil, allowing the roots to remain undamaged. In the sequence, roots were taken to a laboratory for the obtention of the following parameters: root length with a tape graduated in meters, and root volume. For the evaluation of the root volume, they were submerged into a graduated cylinder with a known water volume and then checked the amount of water that dislocated. Then, roots were taken to an air forced circulation oven at 65 °C until they reached a constant mass.

The results were tabulated and submitted to a variance analysis. For the quantitative data, when significant they were submitted to a regression analysis and for the qualitative data, when significant, they were compared by the Tukey test at 5% of probability with the statistical software SISVAR [8].

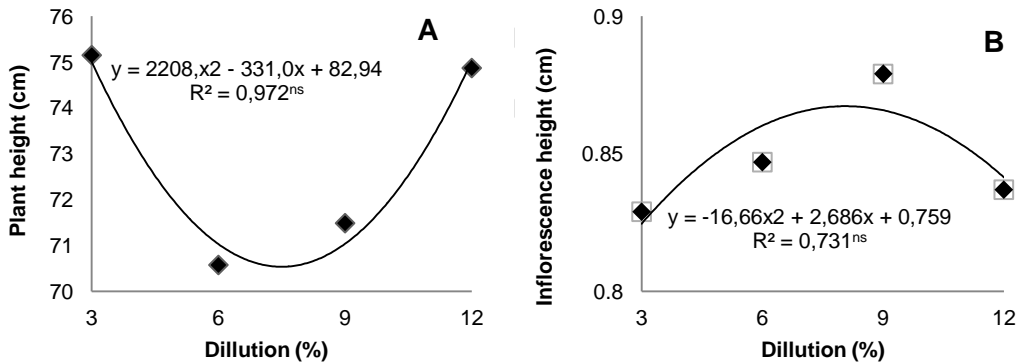
### **3. RESULTS AND DISCUSSION**

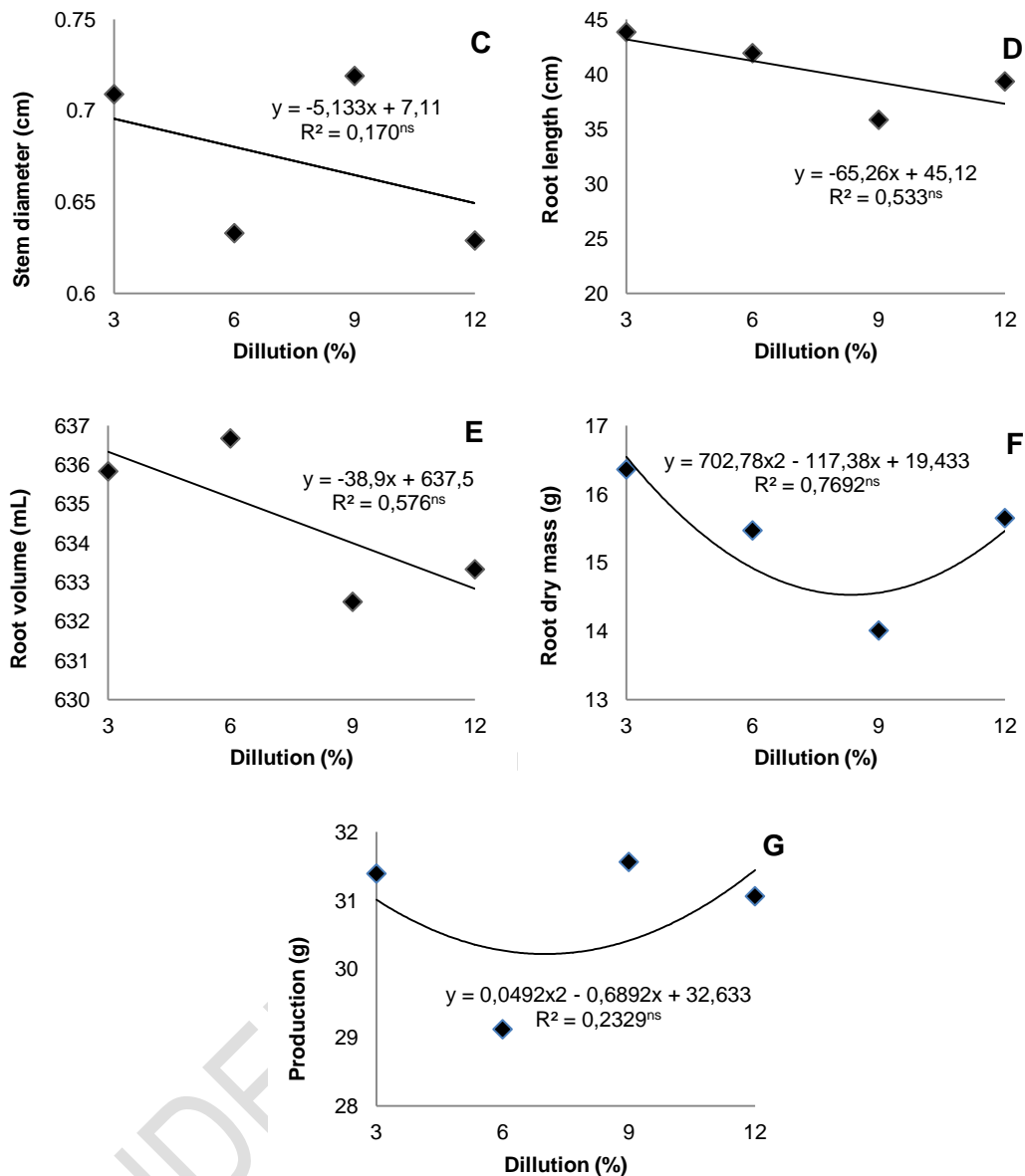
The results show an effect for the interaction between the doses of EM applied to the soil and in cover for the inflorescence diameter of quinoa; being this a crescent linear response for the treatments that received the EM-4 via foliar, and decrescent without application (Figure 1).



**Figure 1.** Inflorescence diameter of quinoa plants submitted to doses of EM-4 applied on the soil, and with or without application of EM-4 in cover.

For the parameters, plant height, stem diameter, height and diameter of the inflorescence, volume and weight of roots, and quinoa production, no effects from the application of EM-4 applied on the soil or via foliar were observed (Figure 2). Observing the figures, there is an indicative that for these parameters, the increase in the doses of EM-4 had a negative effect over them. It is worth mentioning that there was fertilization with bokashi and chicken bed, in all treatments and, as these fertilizers are rich in humic substances, there might have occurred an excess of phytohormones that caused phytotoxicity on the plants.





**Figure 2.** Average results for plant height (A), inflorescence height (B), stem diameter (C), root length (D), root volume (E), root dry mass (F), production (G) of quinoa under application of different doses of EM.

Corroborating with these results, Muller and Meinerz [9], did not find meaningful effects in the maize production after its seeds were inoculated with EM-4. Ronzelli Junior et al [10] also have not found effect from the use of efficient microorganisms in beans, except for the number of green beans per plant and for the productivity. However, in the present study the productivity did not increase with the increase in the doses of EM.

Conceição et al. [11], even without working with quinoa, observed satisfactory results for the application of EM at the dose of 0,3% in the height of basil plants.

When the control without any application of EM-4 was evaluated comparing the use of EM, meaningful differences were observed for the production, without any effect being observed for plant height, stem diameter, inflorescence height and diameter, root length, volume and dry mass (Table 1).

**Table 1.** Plant height (PH), stem diameter (SD), inflorescence height (IH), inflorescence diameter (ID), root length (RL), root volume (RV), root dry mass (RDM) and production (Prod) of quinoa plants submitted or not to the application of EM.

	PH	SD	IH	ID	RL	RV	RDM	Prod.
	-----cm-----					mL	-----g-----	
<b>Factorial</b>	73,02 <sup>ns</sup>	0,67 <sup>ns</sup>	8,84 <sup>ns</sup>	2,88 <sup>ns</sup>	40,22 <sup>ns</sup>	634,58 <sup>ns</sup>	15,38 <sup>ns</sup>	30,78a
<b>Control</b>	69,92	0,66	9,31	3,11	34,93	630,00	16,41	21,92b
<b>Lsd</b>	10,48	0,11	1,98	0,43	10,18	17,07	5,26	5,28

\*Means followed by different letters, lowercase in the column, differ from each other by the Tukey test ( $P \leq 0.05$ ).

The application of EM promoted a 40% increase in the production of quinoa when compared to the treatment without EM, showing that the diversity of microorganisms in the product acted in the dynamic of the soil microbiota, solubilizing nutrients through biological processes or even by fixating atmospheric [12]; or thus increasing the enzymatic activity. Sharma et al. [5] also observed the efficiency of the EM-4 in enhancing the soil enzymatic activity, generating a greater number of flowers and a greater pigment content in *Tagetes* sp. and *Calendula* sp.

Plant height of quinoa plants was similar to the one observed by [13], who found variations from 70,5 up to 90,75 cm when sowed in different seasons.

#### 4. CONCLUSION

The results show that the use of Efficient Microorganisms (EMs) increased the production in 40%, independent of the dose used, when compared to the control. The foliar application of EM via foliar, or on the soil did not influence the production components and the production of quinoa.

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