Journal of Experimental Agriculture International

40(5): 1-6, 2019; Article no.JEAI.50999
ISSN: 2457-0591
(Past name: American Journal of Experimental Agriculture, Past ISSN: 2231-0606)

Efficient Microorganisms Applied to the Soil and in Cover on the Quinoa Crop

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Authors' contributions

This work was carried out in collaboration among all authors. Authors ACF, EPS and DRH designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors PAF and RP managed the analyses of the study and managed the literature searches. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/JEAI/2019/v40i530376
Editor(s):
(1) Dr. Abdel Razik Ahmed Zidan, Professor, Hydraulics and Water Resources, Mansoura University, Egypt.
Reviewers:
(1) Rahul Datta, Mendel University, Brno, Czech Republic.
(2) Amr Saad Shams, Agricultural Research Center, Egypt.
Complete Peer review History: http://www.sdiarticle3.com/review-history/50999

Original Research Article

Received 15 June 2019
Accepted 19 August 2019
Published 14 September 2019

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 to 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 block 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 to 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) increases 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; biofertilizers; organic agriculture.

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1. INTRODUCTION

Quinoa (*Chenopodium quinoa* Willd.) is an annual grain species 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 [2]. 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 [2]. 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 physical-chemical properties [3].

In the organic production system, many fertilization alternatives are used, such as the fertilization with cover crops, organic fertilizers made from animal wastes, worm compounds, composts, stone powder, Bokashi and the use of efficient microorganisms [3]. The choice of which should be used is often made based on what the producer has, thus, there is not a rule [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 have a biological composition that is still commercially unknown, but studies have shown that it has more than 10 genus 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 re-mineralization process, acting as regulators of nutrients by means of the organic matter decomposition and cycling of nutrients, being, thus, source and drain of nutrients for the plant's development [7]. The use of the EM compound does not only help in the supply of nutrients, but also reduces the production costs [8].

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 acts 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 [7].

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

2. MATERIALS AND METHODS

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 21ºC, being the minimum of 15ºC and the maximum of 28ºC.

The experimental design used was of randomized blocks, in a factorial scheme (4x2) +1 additional treatment that was considered the main control because it consisted in the cultivation of quinoa only, without the application of EM-4, with three replicates. The first factor was 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 through the 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.

Prior to the experiment, the soil, with a clayey textyre, was sieved to remove aggregates bigger than 0,5 cm. Being posteriorly classified as Oxisol. After sieved, it was mixed in a concrete mixer to mix it with the base fertilizer (100 kg ha^{-1}

of P, 100 kg ha^{-1} of K and 30 kg ha^{-1} of N). For all treatments, including the control, it was added the equivalent to 2 t ha^{-1} of a bokashi compound, and 6 t ha^{-1} of chicken bed. After homogenized, 8 kg of soil was weight and put into each pot. Before sowing, in each pot was added the biofertilizer EM-4 to 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, totalizing 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 [7].

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 6 seed per pot at a 2 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, the following parameters were evaluated: 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% of 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 65ºC until they reached a constant mass. After dry, they were weighted to obtain the production per pot. After the inflorescence was harvested, all aerial parts were removed by cutting the plants at ground level.

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 obtainment 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 65ºC 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 [9].

3. RESULTS AND DISCUSSION

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

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 to the soil or via foliar were observed (Fig. 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.

Corroborating with these results, Muller and Meinerz [10], did not find meaningful effects in the maize production after its seeds were inoculated with EM-4. Ronzelli Junior et al. [11] also have not found an 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. [12], even without working with quinoa, observed satisfactory results from the application of EM at the dose of 0,3% for the height of basil plants.

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

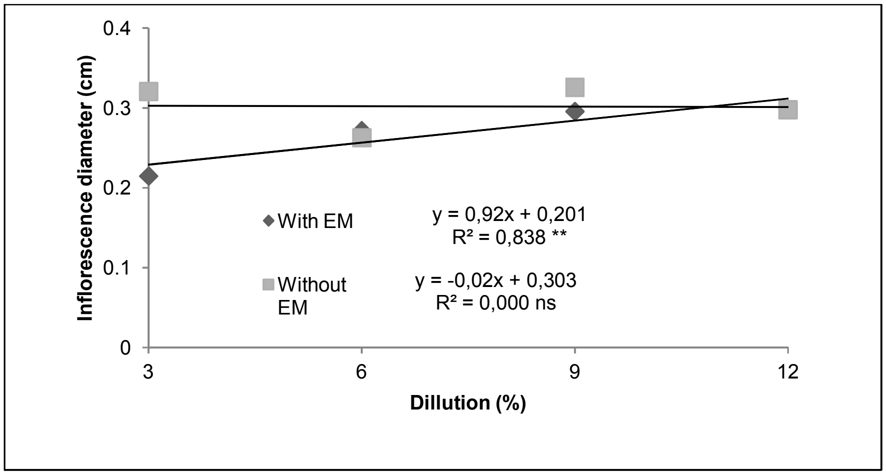
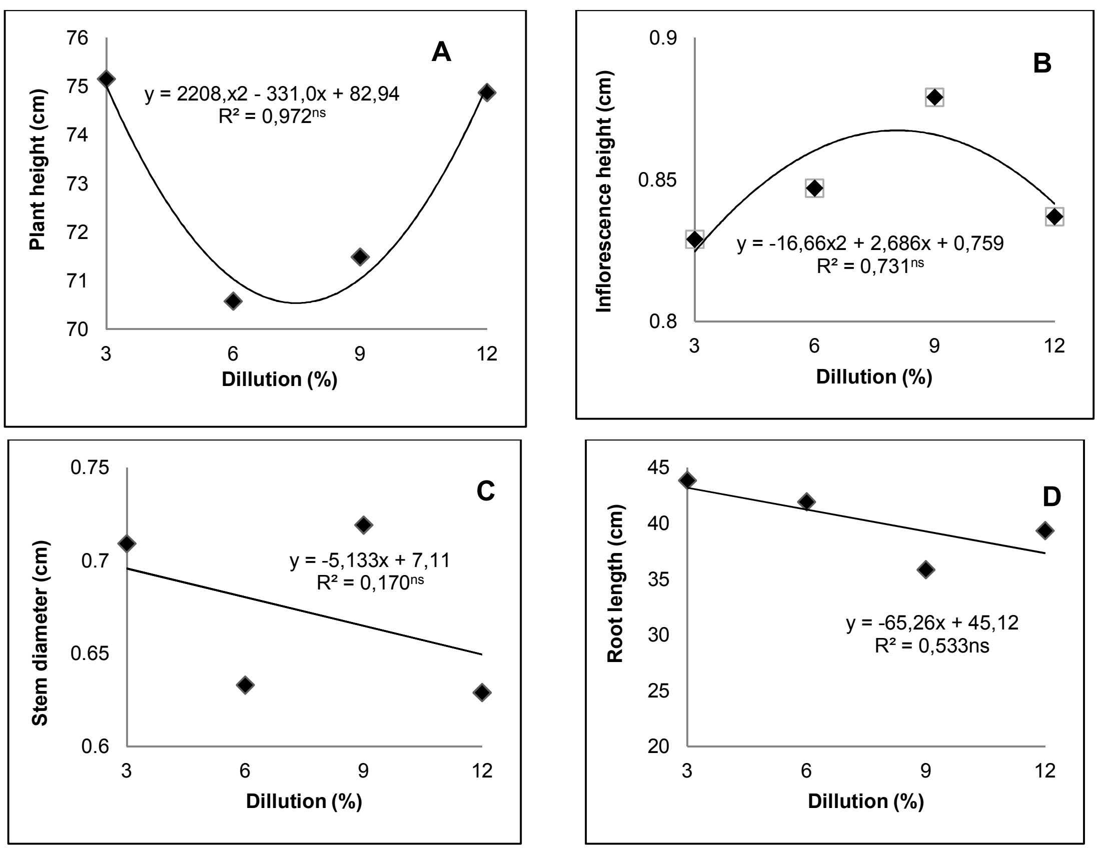


Fig. 1. Inflorescence diameter of quinoa plants submitted to doses of EM-4 applied on the soil, and with or without application of EM-4 in cover



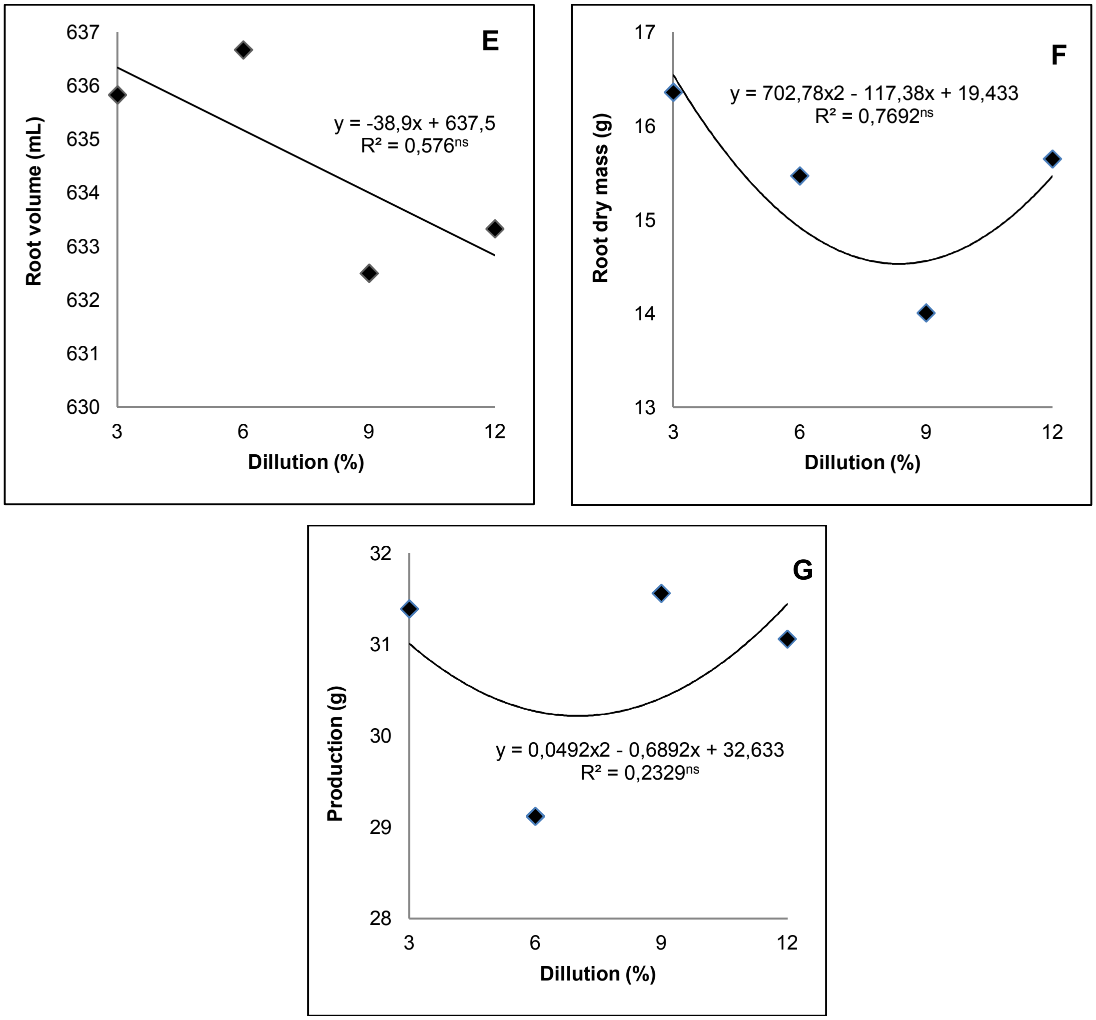


Fig. 2. Average results for plant height (A), inflorescence height (B), stem diameter (C), root length (D), root volume (E), root dry mass (F), production per pot (G) of quinoa under application of different doses of EM

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 per pot (Prod) of quinoa plants submitted or not to the application of EM

	PH	SD	IH	ID	RL	RV	RDM	Prod.
	-----------------------cm-----------------------					mL	---------g---------	
Factorial	73,02^{ns}	0,67^{ns}	8,84^{ns}	2,88^{ns}	40,22^{ns}	634,58^{ns}	15,38^{ns}	30,78a
Control	69,92	0,66	9,31	3,11	34,93	630,00	16,41	21,92b
Lsd	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≤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 soil microbiota dynamics, solubilizing nutrients trough biological processes or even by fixating atmospheric nitrogen [13]; or thus increasing the enzymatic activity. Sharma et al. [6] 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 [14], who found variations from 70,5 up to 90,75 cm when sowed in different seasons, being it a natural characteristic of the crop and, due to the propitious environment it was grown, which had enough light and water, conditions that are required by all plants for a good development [15].

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.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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Peer-review history:
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