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EFFECT OF QUITOMAX® ON THE INDICATORS OF GROWTH, PHENOLOGY AND YIELD OF COWPEA (*Vigna unguiculata* L.)

EFECTO DEL QUITOMAX® EN LOS INDICADORES DEL CRECIMIENTO, FENOLOGÍA Y RENDIMIENTO DE HABICHUELA (*Vigna unguiculata* L.)

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ABSTRACT

The application of biostimulant in agricultural practices is a promising alternative to the use of chemical pesticides that harm the health of man and the environment. The objective of this work was to evaluate the effect of the foliar application of the biostimulant Quitomax at concentrations of 200, 400, and 600 mg·ha^{-1} on some phenological phases of cowpea plants, as well as indicators of growth and agricultural yield of this legume. The sowing was done directly, in a double row with a planting frame of 0.70 x 0.40 m on a bio-fertilizer substrate and sandy soil. The application of Quitomax was carried out at the beginning of flowering. A randomized block experimental design with four replicates per treatment was used. The growth indictors, length and diameter of the pods, pods by plants, fresh pod mass and grains by pods, as well as the yield were evaluated. It was found that the highest concentration of Quitomax applied 600 mg. ha^{-1} produced significantly cowpea plants with higher growth and yield indicators than the rest of the treatments.
Key words: biostimulant, chitosan, legume

RESUMEN

La aplicación de bioestimulante en las prácticas agrícolas es una alternativa promisoria al uso de plaguicidas químicos que dañan la salud del hombre y el medio ambiente. El objetivo de este trabajo fue evaluar el efecto de la aplicación foliar del bioestimulante Quitomax a las concentraciones 200, 400, y 600 mg·ha^{-1} sobre algunas la fase fenológica de plantas de habichuela, así como indicadores del crecimiento y el rendimiento agrícola de esta legumbre. La siembra se realizó de manera directa, a doble hilera con un marco de plantación de 0.70 x 0.40 m sobre un sustrato de bioabono y suelo arenoso. La aplicación del Quitomax se realizó a inicio de floración. Se empleó un diseño experimental de bloques al azar con cuatro réplicas por tratamiento. Se evaluaron los indicadores del crecimiento largo y diámetro de las vainas, vainas por plantas, masa fresca de las vainas y granos por vainas, así como el rendimiento agrícola. Se encontró que la mayor concentración de Quitomax aplicada de 600 mg/ha produjo significativamente plantas de habichuela con mayores indicadores de crecimiento y rendimiento que el resto de los tratamientos.
Palabras clave: bioestimulante, quitosano, legumbre

INTRODUCTION

The cowpea (*Vigna unguiculata* L.) is a highly recommended food for human health because it is a legume rich in fibers, proteins, minerals such as iron and potassium, and low in calories and fats (USDA, 2017). However, this crop implies the excessive use of agrochemicals that grows alarmingly in Latin America (Reyes and Cortez, 2017).

The yield is in general, the fundamental aspect to take into account when evaluating a crop, the problem of its variation being a relatively complex phenomenon, since it involves the effect of external factors on the physiological processes, the interrelation of these and their dependence on internal factors determined by the genetic constitution of the plant.

Currently the search for environmentally less aggressive materials is a continuous task in all areas of human activity due to the high levels of pollution present throughout the word. In agriculture this work is twice complicated, because, on the one hand, materials must be produced in order to achieve their specific effect on the plant or its products; on the other hand, they need to be eliminated without disturbing effects on the environment (Beltrán *et al*., 2004). In this sense, the application of biofertilizers and biostimulants to crops is a prioritized strategy in the search to improve and / or preserve the physical, chemical and biological conditions of soils, increase the agroproductive potential and substitute imports (Martínez *et al.,* 2010). In agriculture there is a range of biostimulant products with the capacity to increase the growth and yield of crops (Abu-Muriefah, 2013).

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In this sense, the need to reduce this intensive use of chemical products in agriculture has led to the search for more sustainable alternatives for agricultural production, such as the use of organic fertilizers (Reyes-Pèrez *et al.,* 2017; 2018), beneficial microorganisms (Cisneros *et al*., 2015; Hernández, 2015); growth regulators (Arancibia *et al.,* 2017); bioactive products (Terry *et al.,* 2014) and biostimulants such as chitosan (Hadwiger, 2013; Torres *et al.,* 2018).

It is necessary to signify that Quitomax has been widely used, due to its biological potential, mainly due to its antimicrobial activity, ability to induce defensive responses (Falcón *et al*., 2011) and tolerance to abiotic stresses (Guan *et al*., 2009), in addition to promote the growth and development of several species (Pichyangkura y Chadchawan, 2015). Quitomax is a liquid formulation based on chitosan 4g. L^{-1}, 0.5% acetic acid and 0.07% potassium ions that have shown yield stimulating effects and their components, in different crops such as potatoes and beans (Morales *et al.,* 2015; 2016).

The objective of the present study was to evaluate the foliar application of Quitomax at different concentrations in the phenology, growth indicators and agricultural yield of cowpea, the Lina variety.

MATERIALS AND METHODS

The study was carried out in the period between December 2013-March 2014, at "La Playita" Experimental Center in the Technical University of Cotopaxi, La Maná (WGS 84: S 0°56'27" and W 79°13'25"), Ecuador. Seeds of cowpea var. Lina were used. Sowing was carried out directly, in a double row, at a distance between plants of 0.25 m, in traditional beds of 1 m wide and 10 m long, using an area of 50.4 m^2 with a planting frame of 0.70 x 0.40 m, located at ground level on an organic substrate consisting of biofertilizer and soil of sandy loam type, according to the latest genetic classification of soils, whose chemical characteristics are shown in Table 1.

Table 1. Chemical composition of soil.
Tabla 1. Composición química de suelo.

Parameters	Unit of measurement	Soil	Abundance
pH	-	5,8	-
Nitrogen	ppm	18	Low
Phosphor	ppm	8,0	Low
Potassium	Meq 100 mL	0,60	High
Calcium	Meq 100 mL	7,0	Medium
Magnesium	Meq 100 mL	1,1	Medium
Sulfur	ppm	14	Medium
Zinc	ppm	1,7	Low
Copper	ppm	6,9	High
Iron	ppm	108	High
Manganese	ppm	4,0	Low
Boron	ppm	0,24	Low
Organic material	%	4,2	Medium
Ca/Mg index	Mg	6,3	-
Mg/K index	-	1,83	-
Ca+Mg/K index	-	13,50	-
Sand	%	49	-
Silt	%	43	-
Clay	%	8	-

It can be observed that the soil used could be considered of low fertility due to its nitrogen and phosphorus levels, although all treatments were in equal conditions.

The bioactive product produced was carried out at the Department of Physiology and Biochemistry of the National Institute of Agricultural Sciences (INCA), in Cuba. It was applied by foliar spray at the beginning of flowering (F) at 200, 400, 600 mg. ha^{-1}. The foliar spraying was done with a Matabi backpack of 16 L capacity, moistening the plants well in the early hours, after the dew had disappeared.

A randomized block design with four replicates per treatment was used. For the estimation of the variables that stimulate plant growth, five plants were selected at random by replication. To each of the sampled plants, 40 and 50 days after sowing (DDS) de following determinations were included: massive flowering, massive fruiting, and height of the plants (cm) and the diameter of the pods (mm). The number of pods per plant was evaluated in the green pods state, with full kernels, counting directly in the selected plants.

At the time of harvest, the following were determined: fresh pod biomass (g) and agricultural yield (kg/m^2). The data were processed statistically through a variance analysis and means were compared by Tukey test with an error of 0.05. The obtained data was transformed for fitting into Normal distribution when necessary, by the expression $X=\sqrt{n}$ for the count of the number of pods. Analysis were carried out with the statistical program Statistica® (StatSoft Inc2011).

RESULTS AND DISCUSSION

The foliar application of Quitomax in cowpea plants had not effect on the duration of the phenological phases: massive flowering and massive fructification (Table 2). Nevertheless, a tendency was observed of shorter times in both phases for plants treated with chitosan compared with the control treatment. Chitosan application accelerates plant metabolism (Malerba and Cerana, 2016) but also forms a transparent film on leaves surfaces, which was thicker as greater the chitosan concentration. This film is semipermeable to gases and also increase the stomatal closure mediated by the abscisic acid (Irriti *et al*., 2009) leading to a prolongation of phenological phases. However, in this work this effect was not found in the cowpea plants maybe because chitosan concentration was not enough high to provoke a complete film on the leaves.

Table 2. Effect of Quitomax on the onset of massive flowering and fructification.
Tabla 2. Efecto del Quitomax en el inicio de la floración y fructificación masiva.

Quitomax treatments (mg/a^{-1})	Massive flowering (days)	Massive fructification (days)
To	45	52
200	40	45
400	42	48
600	44	49

This result is not in agreement with those reported by other authors who have found that the application of chitosan can shorten and improve the flowering process in ornamental flowers (Chen *et al*., 2016) or lengthen the duration of the cultivation cycle in other according with the chitosan concentration used (Ohta *et al*., 2004).

On the other hand, the application of Quitomax at the different concentrations tested caused differences in the growth indicators evaluated: length and diameter of the pods, pods per plant, fresh pod mass and grains per pods (Table 3).

Table 3. Effect of Quitomax on indicators of growth and yield.
Tabla 3. Efecto del Quitomax sobre indicadores de crecimiento y rendimiento.

Quitomax treatments (mg/ha)	Length of the pods (cm)	Diameters of the pods (mm)	Pods per plant	Fresh biomass of pods (g)	Grains per pod	Yield (kg/m²)
To	26.5c	4,2c	23,7c	1,8c	14,2c	2,12c
200	30,5b	5,3b	28,6 b	3,1 b	21,3 b	3,2 b
400	31,4b	5,4b	29,4b	3,0 b	22,5b	3,4b
600	36,5 a	6,5 a	33,5 a	4,1 a	27,5 a	4,54 a
ESx	0,14	0,02	0,45	0,05	0,16	0,04

Values within the same column with same letter(s) are not significantly different at $p = 0.05$ (Tukey´s HSD multiple range test)

In all cases, the treatments that received Quitomax at any concentration (200, 400 or 600 mg/ha) had significantly better growth indicators than the control treatment, without application. In addition, the treatment that received the highest concentration of Quitomax (600 mg/ha) was the best of all. The appreciable difference in all indicators between the best treatment and the control should be highlighted. In that sense, the difference in the length of the pods was statistically significant with 10 cm, 36.5 cm by 26.5 cm, while the difference in pods per plant was also significant with 33.5 by 23.7.

Another important aspect was the fresh mass of the pods with 4.1 g for only 1.8 g in the control while the grains per pods were 27.5 for the treated plants and 14.2 for the untreated ones. All these results in the growth indicators had a significant impact on the yield where production doubled with 4.54 kg per 2.12 kg of the control.

These results achieved can be explained taking into account that chitosan, the active ingredient of Quitomax, has been shown as plant biostimulant. This polymer increase enzymatic mechanisms in plants and fruits (Gutiérrez-Martínez *et al.,* 2017) related to the presence of different molecules and antioxidant systems that leads to the stimulation of growth and development of plants treated with these molecule (Pichyangkuraa y Chadchawanb, 2015).

Results obtained in this work are in agreement with others reported by Mondal *et al*. (2013) working with *Vigna radiata*. These authors found an increase in growth indicators of this species such as the dry mass of plants and height among others. Other authors (Morales *et al*., 2015 y Morales *et al*., 2016) applying Quitomax in beans and potatoes have also found significant improvements in productive indicators of these crops. It should be noted that the use of low concentrations (200-600 mg ha^{-1}) discards any fertilizing effect that Quitomax can provide taking into account the characteristics of the soil used (Table 1). However, the presence of chitosan as an active ingredient reinforces the hypothesis of biostimulant action.

CONCLUSIONS

The application of Quitomax at any concentration had not effect on the cowpea phenophases duration. The highest concentration of Quitomax applied 600 mg/ha produced cowpea plants significantly with higher growth and yield than the rest of the treatments. The highest dose of applied Quitomax doubled the yield of the Lina variety cowpea compared with control treatment.

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