

Rice crop yield and its effect with copper chelate and ozonated water

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Abstract

The golden apple snail (*Pomacea canaliculata*) (Lamarck) is the pest that has caused the most problems in recent years in rice crops. This pest has significantly reduced the productivity of rice worldwide. The present work was carried out on the Salitre-Baba highway, at km 38 in the province of Guayas, Ecuador 2020. It was an experimental trial at the field level, where different doses were applied (one liter of copper chelate + ozonated water/hectare) and (two liters of copper chelate + ozonated water/hectare). For this, a randomized complete block design (RCBD) and 4 treatments, 1 control, and 4 repetitions were used. Once the rice was harvested, statistical data related to yield were collected. The results show that the yield is not affected by the application of copper chelate and ozone and although there was no significant difference between all treatments, it was observed that the best treatment was T4, which corresponds to the dose of 2 L ha⁻¹ of copper chelate mixed with ozonated water with 2 ppm concentration, where the yield was 3 827.5 ±877.8 kg ha⁻¹, higher compared to T5 (control), which reflected a yield of 1 488.7 ±596.4 kg ha⁻¹ significantly lower due to the presence and effects of the snail. It was concluded that copper chelate with ozonated water can control the golden apple snail in rice crops, and an increase in grain yield was observed.

Keywords:

agroecological infestation, chelated copper, ozonated water.



Rice (*Oryza sativa* L.) is the most important cereal crop and primary energy source for more than half of the world's population and production of this staple food is expected to double by 2050 (Ray *et al.*, 2013; Sheikh *et al.*, 2019). With increasing demand for food, technological innovations in rice production will be critical to stabilizing food security (Liu *et al.*, 2019).

In 2018, the area sown with rice nationwide was 301 853 ha. Rice production in Ecuador is mainly carried out in the Coastal Region, in the provinces of Guayas and Los Ríos, which concentrate 70% and 26% of production, respectively (INEC, 2019).

The pest that has caused the most problems in recent years is the golden apple snail (Carvalho, 2019). The golden apple snail, *Pomacea canaliculata* (Lamarck), is considered among the 100 worst invasive species in the world (Global Invasive Species Database, 2013).

Rice grain yield is determined by panicles per unit area, spikelets per panicle, percentage of spikelet filling, and grain weight. A higher grain yield is obtained by increasing panicles per unit area or spikelets per panicle in favorable environments (Bagheri *et al.*, 2018; Li *et al.*, 2019).

In addition, pesticides affect animal and plant biodiversity, food networks, and aquatic and terrestrial ecosystems. Copper (Cu^{+2}) is a molluscicide effective against the golden apple snail and is allowed in organic plantations due to its low toxicity. Ozone is a molecule with a high electrochemical potential and therefore capable of affecting the cell membranes of living organisms (Alwi, 2017; da Silva *et al.*, 2019; Pandiselvam *et al.*, 2019; Landa *et al.*, 2019). The objective of this research was to determine the effect of copper chelate plus ozonated water on the control of apple snails.

Place of study

The trial was carried out on the lands of the 'Delia María' Farm on the Salitre-Baba highway, km 38 in the province of Guayas, Ecuador. It is located at 79° 81' 00" west longitude, 01° 83' 12" south latitude. The area of the farm has an annual rainfall of 1 200 mm, is located at an altitude of 8 m, the average annual temperature is 25 °C with an average annual relative humidity of 80%. The soil of the trial lands is clayey and has a pH of 6.1. These lands were ceded by the owners in order to carry out the studies.

Plant material

We worked with rice of the INIAP-14 variety. The vegetative cycle of this variety is 113- 117 days. The trial was divided into plots, each corresponding to an experimental block. The experimental unit on the 'Delia María' farm is a plot of 5 x 5 m, which is equivalent to 25 m², the total area of the trial was 25 m x 25 m= 625 m² and the useful area of the trial was 25 m² (useful area of the plot) x 20 plots= 500 m². The treatments under study (Table 1) were grown under a pool system. For each treatment, a total of 50 snails were placed. The study was carried out with five treatments, in which the dose of 1 L and 2 L ha⁻¹ of copper chelate and the influence of ozone on rice crop yield were evaluated.

Table 1. Copper chelate and ozonated water treatments used in the study.

Treatment	Dose
T1	1 liter of copper chelate/200 L of water/ha
T2	2 liters of copper chelate/200 L of water/ha
T3	1 liter of copper chelate + ozonated water (C= 2 ppm)/ha
T4	2 liters of copper chelate/ozonated water (C= 2 ppm)/ha
T5	Ozonated water (C= 2 ppm)

Experimental design

The method used in the trial was field experimental, for which a randomized complete block design (RCBD) with a 5% Duncan significance test was used. The results were analyzed by the Infostat statistical program. It is based on the application of copper chelate in different concentrations (1 and 2 L ha⁻¹) and its combination with ozone (2 ppm) to know if there are toxicity effects of these molluscicides in the plant through the results of the rice grain yield. The ozone was produced by a 20 g ha⁻¹ ozone generator, connected to a 99.99% oxygen tank and the ozonation process was by bubbling with a silicon carbide diffuser stone.

The results correspond to the second phase of the project (Table 2), which is based on determining the yield of the crop under the application of copper chelate and knowing if there are toxic effects on rice plants. The first phase was to study the action of copper chelate and ozone in the golden apple snail. The results obtained show that copper does not exert any negative effect on the crop but is lethal to the snail.

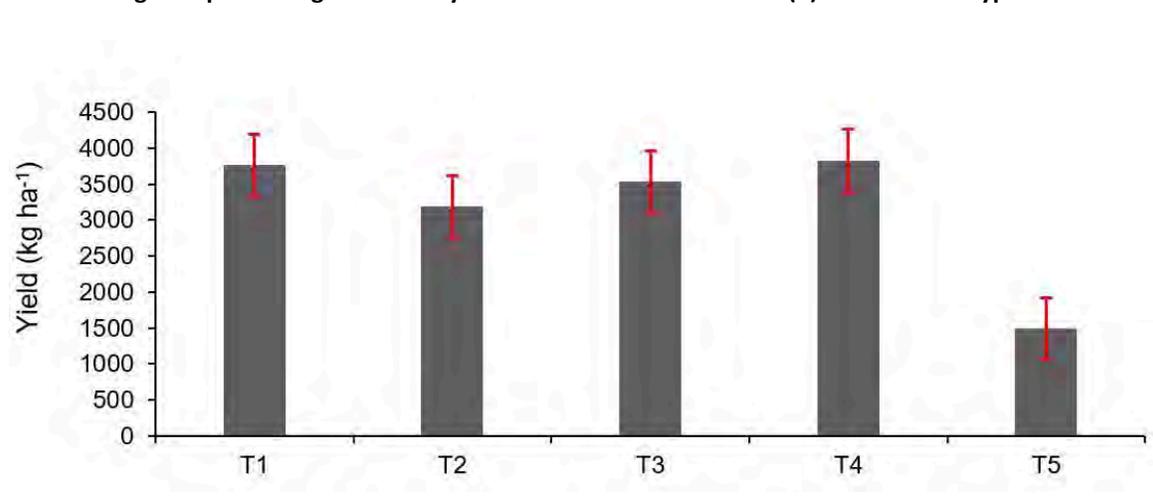
Table 2. Yield data of the different copper chelate and ozonated water treatments applied to rice.

Repetition	T1 (kg ha ⁻¹)	T2 (kg ha ⁻¹)	T3 (kg ha ⁻¹)	T4 (kg ha ⁻¹)	T5 (kg ha ⁻¹)
R1	4 075.5	3 439.66	3 327.39	3 587.37	1 471.67
R2	4 503.19	1 887.54	4 039.6	2 915.62	1 519.85
R3	2 663.37	3 643.27	3 421.02	3 887.34	751.74
R4	3 819.62	3 779.62	3 367.39	4 919.51	2 211.6
X	3 765.4 ±787a	3 187.5 ±833.7a	3 538.9 ±336.03a	3 827.5 ±877.8a	1 488.7 ±596.4b

X= average; Duncan's test alpha= 0.05; error= 530 314; 3 160; df= 15. Means with a common letter are not significantly different ($p > 0.05$). Values of average represent the mean ± standard deviation.

The results indicate that applying different doses of copper chelate does not affect the yield of the rice crop as the treatments applied with copper are statistically the same; only in the control treatment (T5) is a lower yield (1 488.7 kg ha⁻¹) reflected (Figure 1), which was probably due to the effect of the damage caused by the snail. In addition, it was observed that there is no evidence of toxicity in the normal development of the plant and in the optimal crop yield.

Figure 1. Yields of the different treatments of copper chelate and ozonated water applied to rice. Rectangles representing treatment yields are illustrated with bars (±) of calculated typical error.



The T4 treatment [two liters of copper chelate + ozonated water (C= 2 ppm)] presented the best result, with a yield of 3 827.5 kg ha⁻¹. Previous studies indicate that the application of chelate-associated micronutrients increases plant yields (Dass *et al.*, 2017; Ma *et al.*, 2019). Ozone also

increases yield, which is due to the influence of ozone on the plant, as it is indicated that ozone has an oxygenating power higher than normal oxygen and therefore improves the respiratory process at the cellular level.

Therefore, the combination of copper chelate products and ozonated water at 2 ppm, although not significant, has an influence on rice yield of 3 827.5 kg ha⁻¹.

Conclusions

The yield of the rice crop was determined in the studied plots under field conditions after the application of the solution of Cu chelate and ozonated water. It was shown that copper chelate with ozonated water can control the golden apple snail in the rice crop, and an increase in yield in the grain was observed. The result of this trial indicates that the application of different doses of copper chelate affects the mortality of the golden apple snail (*Pomacea canaliculata*) in the rice crop, without affecting its production, it is also concluded that treatment 4, which corresponds to 2 L of Cu chelate/200 liters of ozonated water (2 ppm), is the most effective.

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Journal Information
Journal ID (publisher-id): remexca
Title: Revista mexicana de ciencias agrícolas
Abbreviated Title: Rev. Mex. Cienc. Agríc
ISSN (print): 2007-0934
Publisher: Instituto Nacional de Investigaciones Forestales, Agrícolas y Pecuarias

Article/Issue Information
Date received: 01 January 2024
Date accepted: 01 February 2024
Publication date: 12 February 2024
Publication date: January 2024
Volume: 15
Issue: 1
Electronic Location Identifier: e3412
DOI: 10.29312/remexca.v15i1.3412

Categories

Subject: Investigation note

Keywords:

Keywords:

agroecological infestation
chelated copper
ozonated water

Counts

Figures: 1

Tables: 2

Equations: 0

References: 14

Pages: 0