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Effects of the bioproducts EcoMic and QuitoMax on some morphological parameters of the *Oriza sativa* crop

Efectos de los bioproductos EcoMic y QuitoMax en algunos parámetros morfológicos del cultivo Oriza sativa

Efeitos dos bioprodutos EcoMic e QuitoMax em alguns parâmetros morfológicos da cultura Oriza sativa

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ABSTRACT
The objective of the research was to evaluate the effects of the EcoMic® and QuitoMax® bioproducts on some morphological parameters of the Oriza sativa cv. INCA LP-7", the research was carried out on the Dionisio Roque farm, in the Guane municipality, on a leached yellowish Ferralitic soil, from January to May 2022. A randomized block experimental design was used with eight treatments and four replicates. The morphological variables, plant height and number of suckers per seedling were evaluated at 60 and 90 days after planting. Data were statistically processed through descriptive analysis of variance of simple classification and comparisons of means, according to Duncan's test, using SPSS ver.

22.0 for Windows. With the application of QuitoMax® 20 days after the transplant in a culture of Oriza sativa cv. INCA LP-7, a greater increase in the average value of plant height was obtained at 90 dat with respect to 60 dat of 26.02 cm, showing significant statistical differences with the rest of the treatments, including the control. The number of suckers per seedling showed a greater increase in its mean value at 90 dat compared to 60 dat in the E+Q60 treatments; Q40 and E+Q20, in figures of 1.77; 1.77 and 1.75, respectively, without significant statistical differences between them, but with respect to the control.
Keywords: bioproducts; biostimulants; morphological variables; EcoMic®; QuitoMax®

RESUMEN

El objetivo de la investigación fue evaluar los efectos de los bioproductos EcoMic® y QuitoMax® sobre algunos parámetros morfológicos del cultivo de *Oriza sativa*, la investigación se realizó en la finca de Dionisio Roque, en el municipio Guane, sobre un suelo Ferralítico amarillento lixiviado, en los meses de enero a mayo de 2022. Se utilizó un diseño experimental de bloques al azar con ocho tratamientos y cuatro réplicas. Fueron evaluadas las variables morfológicas altura de la planta y número de hijos por plantón a los 60 y 90 días de la plantación. Los datos fueron procesados estadísticamente a través del análisis descriptivo de varianza de clasificación simple y comparaciones de medias, según Prueba de Duncan. Con la aplicación de QuitoMax® a los 20 días después del trasplante en cultivo de *Oriza sativa,* se obtuvo un mayor incremento en el valor medio de altura de la planta a los 90 ddt con respecto a los 60 ddt de 26,02 cm, mostrando diferencias estadísticas significativas con el resto de los tratamientos, incluyendo al testigo. El número de hijos por plantón mostró un mayor incremento en su valor medio a los 90 ddt con respecto a los 60 ddt en los tratamientos E+Q_{60}; Q_{40} y E+Q_{20}, en cifras de 1,77; 1,77 y 1,75, respectivamente, sin diferencias estadísticas significativas entre ellos, pero sí con respeto al testigo.
Palabras clave: bioproductos; bioestimulantes; variables morfológicas; EcoMic®, QuitoMax®.

RESUMO

O objetivo da pesquisa foi avaliar os efeitos dos bioprodutos EcoMic® e QuitoMax® sobre alguns parâmetros morfológicos do cultivo de Oriza sativa, a pesquisa foi realizada na propriedade de Dionisio Roque, no município de Guane, sobre um solo Ferralítico amarelado lixiviado, nos meses de janeiro a maio de 2022. Foi utilizado um desenho experimental de blocos aleatórios com oito tratamentos e quatro réplicas. Foram avaliadas as variáveis morfológicas altura da planta e número de filhos por plantão aos 60 e 90 dias do plantio. Os dados foram processados estatisticamente por meio da análise descritiva de variância de classificação simples e comparações de médias, segundo Teste de Duncan. Com a aplicação de QuitoMax® 20 dias após o transplante em cultura de Oriza sativa, foi obtido um aumento maior no valor médio da altura da planta a 90 ddt em relação a 60 ddt de 26,02 cm, mostrando diferenças estatisticamente significativas com o restante dos tratamentos, incluindo a testemunha. O número de filhos por plantão apresentou um aumento maior no valor médio de 90 ddt em relação aos 60 ddt nos tratamentos E +Q60; Q40 e E+Q20, em números de 1,77; 1,77 e 1,75, respetivamente, sem diferenças estatísticas significativas entre eles, mas com respeito à testemunha.
Palavras-chave: bioprodutos; bioestimulantes; variáveis morfológicas, EcoMic®, QuitoMax®.

INTRODUCTION

In recent years, it has become clear that there is a need to develop available sustainable technologies for food production that enhance the activity of soil

microbiota and the use of microorganisms, reducing external inputs and energy consumption (Morejón et al., 2021), among other aspects that integrate the concept of sustainability.

Rice (*Oryza sativa* L.) is one of the cereals with the highest production worldwide, together with wheat, meat and fish, and constitutes the basis of human nutrition; 75 % of the world's population includes it in their diet and in some cases it can exceed the consumption of other cereals (Domínguez et al., 2021). In Cuba, it constitutes the main source of carbohydrates in the diet of the population, with an approximate consumption of 670 000 t per year, even the national production only satisfies a little more than 50% of the needs.

The average agricultural yield remains close to 3 t.ha, lower than the world average, which is due to different causes, among which are: planting outside the optimal season, poor cultural care, lack of irrigation, continuous salinization of soils and damage caused by pests (MINAG, 2020).

Even when good results are obtained with the technologies or methodologies used in production, there are still some cracks that weaken and make rice harvests unstable. The use of production technologies inherited from the conventional agricultural model promotes monoculture with enormous amounts of agrotoxins, however, traditional and environmentally viable production models have allowed alternatives such as biofertilizers (García et al., 2023).

Such is the case of QuitoMax, a liquid bioproduct based on chitosan that works as an activator of innate resistance and physiological conditions of plants. Through preventive applications, it protects crops against potential pathogens and positively influences plant growth. It is a commercial product of the National Institute of Agricultural Sciences (INCA), currently in experimental field conditions, promising results are obtained in rice (Reyes et al., 2019).

On the other hand, the biofertilizer EcoMic allows increasing the uptake of atmospheric nitrogen and incorporating it into plants, it is a solid inoculant containing propagules of mycorrhizal-arbuscular fungi with biological stability, which live in symbiosis with the root of plants. In addition to offering protection against root pests, it has a significant impact on crop yields (Trocones et al., 2020).

The application of EcoMic® and QuitoMax® bioproducts at different times of the vegetative cycle of rice and the evaluation of their effectiveness on some morphological parameters, contributes to the search for less aggressive materials with the environment, a task in all areas of human activity due to the high levels of contamination present throughout the planet.

MATERIALS AND METHODS

The experiment was conducted with the rice crop, under field conditions, the area of the CCSF Secundino Serrano was selected (Figure 1), the soil of the area is Ferrallitic yellowish leached. The research period covered the months of January to May 2022.

Figure 1. Photo of the farm of small producer Dionisio Roque Castro. **Source**: Taken by the author.

Experimental design.

A completely randomized block experimental design was used in the rice crop with eight treatments and four replicates as shown in Table 1. The number of plants evaluated per replicate was 10, the plot size for each of the treatments studied was 5 m^2, so that one replicate of the experiment had dimensions of 200 m2, covering a total experimental area of 800 m^2.

Table 1. Experimental design. **Legend**: T: control treatment; Q20: application of QuitoMax 20 days after transplanting; Q40: application of QuitoMax 40 days after transplanting; Q60: application of QuitoMax 60 days after transplanting; E: application of EcoMic at the time of transplanting.

I	II	III	IV
T	Q60	E	Q40
E	Q40	E+Q20	Q60
E+Q20	Q20	E+Q40	Q20
E+Q40	E+Q60	E+Q60	E
E+Q60	E+Q40	T	E+Q20
Q20	E+Q20	Q60	E+Q40
Q40	E	Q40	T
Q60	T	Q20	E+Q60

Source: elaborate by the author.

Research methods and techniques used

The following methods were used for the development of this research: Theoretical methods; historical-logical methods; Empirical methods that allowed the measurements of the morphological variables of the crop under study, the observation of the environment to have criteria of the variations of the biodiversity in the environment of the agroecosystem under study and the cultural attentions to the crop under study that were executed according to the regulations of its Technical Instructions.

Morphological variables evaluated

The morphological variables that were evaluated during the research were the following: plant height at 60 and 90 days after transplanting (cm) and the number of offspring per seedling at 60 and 90 days after transplanting (u).

Statistical treatment used.

The data were statistically processed according to the experimental design used, so they were processed through a descriptive analysis of variance of simple classification. An increment analysis was also carried out among the morphological variables evaluated, as well as an analysis of variation of growth of the treatments with respect to the control. In all cases, comparisons of means were made according to Duncan's Tenth Multiple Range test. The statistical package used was SPSS ver. 22.0 for Windows.

RESULTS AND DISCUSSION

Plant height behavior at 60 days after transplanting

As shown in Figure 2, the behavior of the height of the rice plant can be observec 60 days after.

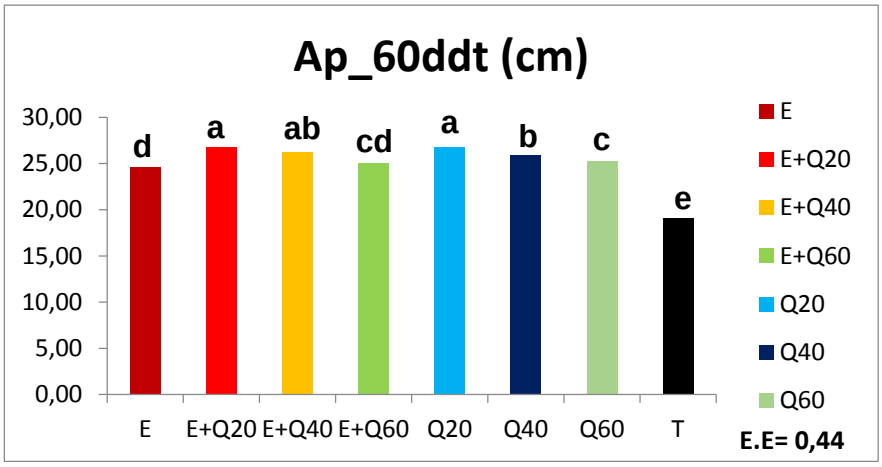

Figure 2. Plant height 60 days after trasplanting. **Nota**: Different letters show significant differences between treatments for * = *P* < 0,05 according to Duncan's test.

There were significant statistical differences between the treatments with EcoMic® bioproducts, QuitoMax® and the control treatment. The treatments Q20 (application of QuitoMax® 20 days after transplanting) and E+Q20 (combination of application of EcoMic® at the time of transplanting and QuitoMax® 20 days after transplanting), the mean values ranged between 26.82 and 26.78 cm, showing no significant statistical differences between them. In the control treatment, the mean value was 19.11 cm.

Avila et al. (2020) found similar results, when treating rice seeds and foliar application of chitosan, other authors (Miranda et al., 2022; Calero et al., 2022) have obtained between 45 and 47.5 % when evaluating this cultivar and comparing it with others obtained for low water and fertilizer supplies.

The bioproducts that were applied promote plant growth and development, in addition to improving plant metabolism and physiological conditions, as well as protection against potential pathogens.

Plant height performance after 90 days

When analyzing the behavior of rice plant height 90 days after transplanting, a significant statistical difference was observed among the treatments studied, as shown in Figure 3.

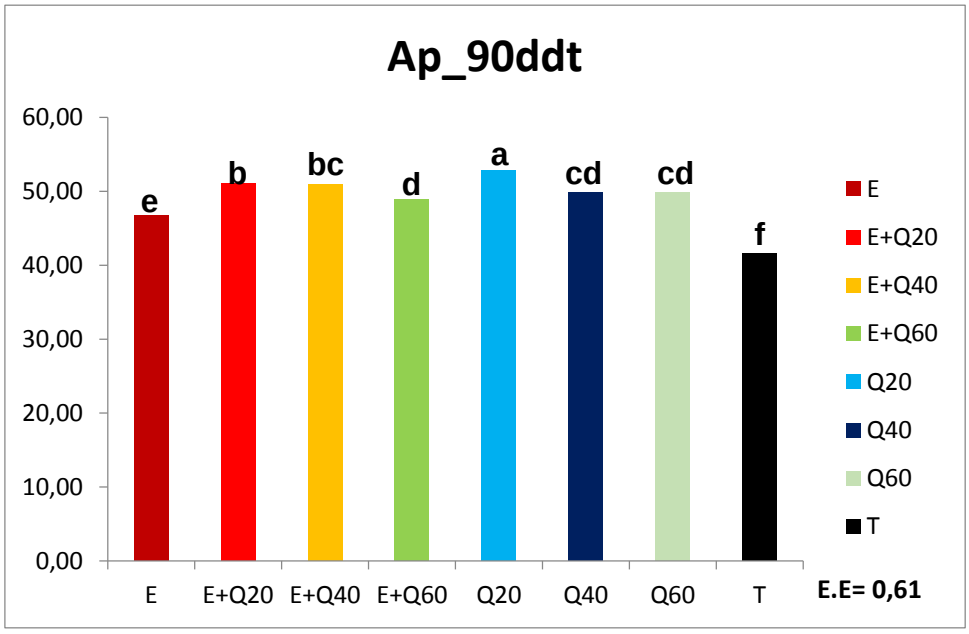

Figure 3. Plant height at 90 days after transplanting. **Nota**: Different letters show significant differences between treatments for * = P< 0.05 according to Duncan's test.

The best treatment was Q20 (QuitoMax® application 20 days after transplanting) with a mean value of 52.84 cm, followed by treatment E+Q20 (combination of EcoMic® application at transplanting and QuitoMax® 20 days after transplanting) whose mean value was 51.13 cm, with significant statistical differences between them. The control treatment (T) had the worst performance with a mean value of only 41.67 cm.

Rodriguez-Pedroso et al. (2020) found similar results for stem diameter, demonstrating the positive action of QuitoMax® on this growth variable. In the research, the highest values in stem diameter corresponded to the treatments where the seeds were soaked with concentrations of 0.5 and 1.0 g L-1 of the biostimulant, with respect to the treatment with the lowest evaluated concentration of the product (0.1 g L-1) and the control.

Behavior of the number of offspring

As shown in Figue 4, the behavior of the number of children per seedling can be observed 60 days after the rice trasplant.

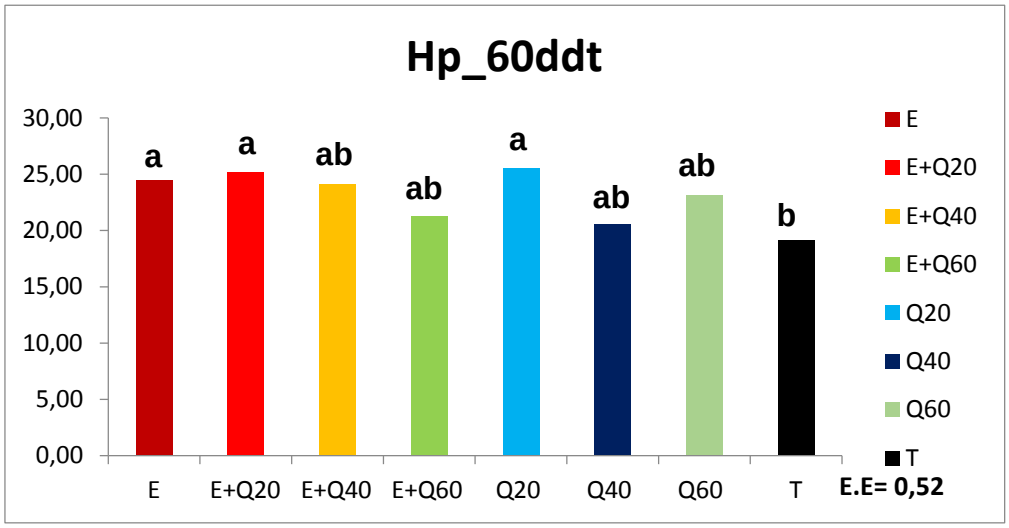

Figure 4. Number of offspring per seedling 60 days after transplanting. **Nota:** Different letters show significant differences between treatments for* = P< 0.05 according to Duncan's test.

In the behavior of the number of offspring per seedling at 60 days after transplanting, it was observed that treatments Q20 (Application of QuitoMax® at 20 days after transplanting), E+Q20 (combination of application of EcoMic® at transplanting and QuitoMax® at 20 days after transplanting) and E (Application of EcoMic® at transplanting) stood out, with mean values of 25.53; 25.15 and 24.43 sons per seedling, despite not showing significant statistical differences with the rest of the treatments where EcoMic® and QuitoMax® bioproducts were applied in their different study variants, but with respect to the control treatment (T), which showed the lowest mean value of only 19.13 sons per seedling.

Behavior of the number of offspring per seedling 90 days after rice transplanting.

As shown in Figure 5, the behavior of the number of offspring per seedling 90 days after rice transplanting, maintains a similar trend in terms of the number of offspring per seedling for the different treatments studied. The treatments Q20 (Application of QuitoMax® at 20 days after transplanting), E+Q20 (combination of EcoMic® application at transplanting and QuitoMax® at 20 days after transplanting), E (Application of EcoMic® at transplanting) and E+Q40 (combination of EcoMic® application at transplanting and QuitoMax® at 40 days after transplanting) stand out with mean values of 27.17, 26.90, 25.77 and 25.77, respectively; 26.90, 25.77 and 25.58 offspring per seedling.

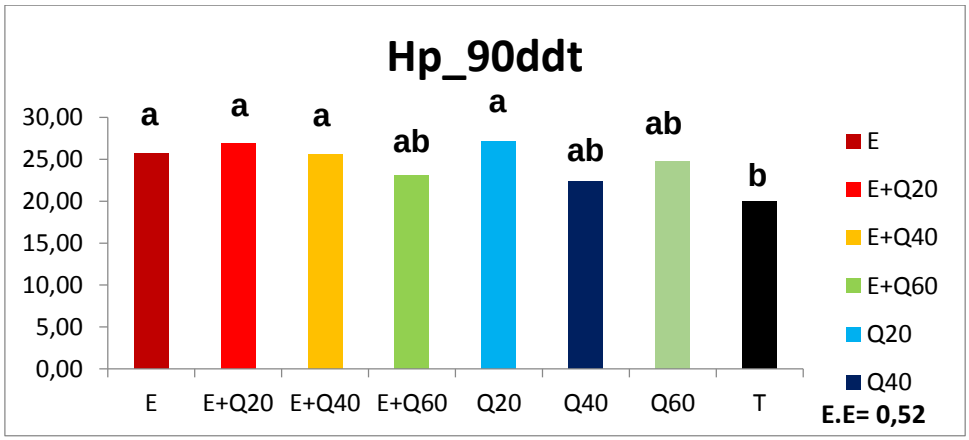

Figure 5. Number of offspring per seedling at 90 days after transplanting. **Nota**: Different letters show significant differences between treatments for* = P< 0.05 according to Duncan's test. **Leyenda**: However, with the control treatment (T), there was a significant difference, which had a mean value of only 19.93 offspring per seedling.

The favorable results of the treatments applied with respect to the control led us to affirm that the application of EcoMic®and QuitoMax®causes a positive effect on offspring per seedling 90 days after transplanting; recent research has demonstrated the efficiency of these bioproducts (Morejón et al., 2021; Ruiz et al., 2021).

Variation in rice growth with respect to the control

Figure 6 shows the behavior of growth variation with respect to the control (T) 60 and 90 days after transplanting in rice plants fertilized with EcoMic® (E) and QuitoMax® (Q).

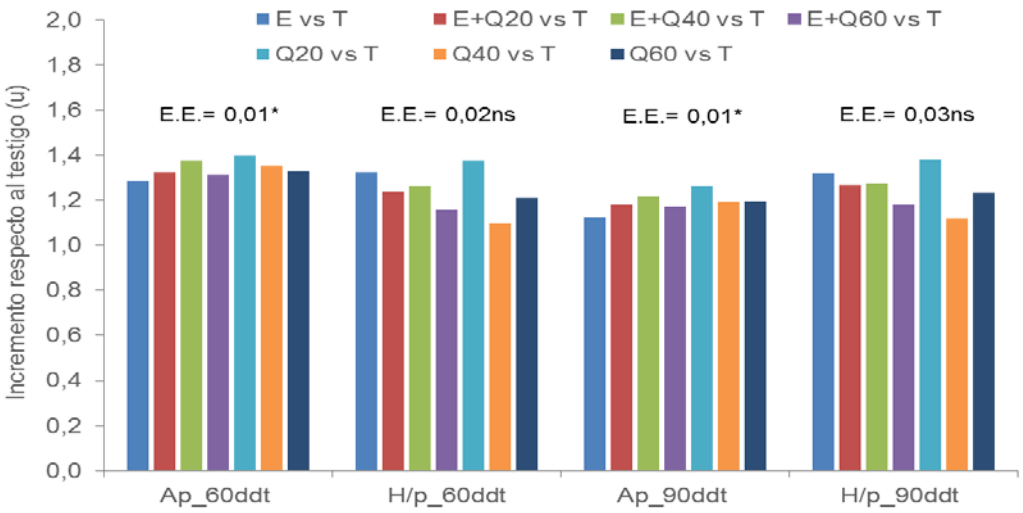

Figure 6. Variation of growth with respect to the control (T) at 60 and 90 days after transplanting in rice plants fertilized with EcoMic® (E) and QuitoMax® (Q). **Nota**:* Significant differences for * = P< 0.05 according to Duncan's test.

Figure 6 shows the increase in plant growth with respect to the control treatment (T), with significant statistical differences for plant height 60 and 90 days after transplanting. On the other hand, an increase is observed with respect to the control treatment (T), without significant statistical differences, for the number of offspring per seedling at 60 and 90 days after transplanting.

In the case of plant height, at 60 days after transplanting, this increase ranged between 1.28 and 1.40 cm. At 90 days after transplanting, the values ranged between 1.12 and 1.26 cm, and at 60 days after transplanting, the values ranged between 1.10 and 1.38 offspring per seedling, while at 90 days after transplanting, the increase ranged between 1.12 and 1.38 offspring per seedling.

The favorable response of the indicators evaluated with the application of QuitoMax allowed the stimulation of the physiological processes of the plants, increasing the size of the cells, improving their efficiency, in absorption and assimilation of nutrients, tolerance to biotic and abiotic stresses and the agronomic characteristics of the plants (Bécquer et al., 2019).

The results obtained allow explaining the variation of the evaluated variables (plant height, number of offspring) in relation to the plants that were not applied bioproducts, may be due, fundamentally to the formation of extraradical mycelium that facilitates the absorption of water and nutrients by the plants (Ruiz et al. 2021), although it may be associated with the exudation by the fungus of growth hormone and a better nutritional status of the plants (García et al. 2023; Morejón et al. 2021), if we take into account that the height and the number of offspring are related to the roots in order to provide elaborated substances.

On the other hand, this effect could also be related to the ability of the product to act as an antitranspirant by causing a partial or total closure of the stomata, favoring the water status of the plant and other physiological processes that contribute to increase biomass production and agricultural yield, while reducing water losses in plants (Díaz et al., 2021; Calero et al., 2020;).

The use of bioactive products compatible with the environment is one of the main challenges of modern agricultura. The application of chitosan and its derivatives represents a promising alternative due to its nature, its biological activity and the ease of obtaining. The mechanisms of action and efficiency of chitosan in agriculture, under laboratory conditions and in controlled environments, have been studied and used in many countries, and must be applied to different crops, including rice.

CONCLUSIONS

With the application of QuitoMax® 20 days after transplanting in Oriza sativa, a greater increase of 26.02 cm was obtained in the mean value of plant height at 90 ddt with respect to 60 ddt, showing significant statistical differences with the rest of the treatments, including the control.

The number of offspring per seedling showed a greater increase in its mean value at 90 ddt with respect to 60 ddt in treatments E+Q60; Q40 and E+Q20, in figures of 1.77; 1.77 and 1.75, respectively, without significant statistical differences among them, but with respect to the control.

The use of EcoMic combined with QuitoMax has a positive effect on rice cultivation, favors plant growth, allows controlling the use of chemicals and corroborates the use of biofertilizers.

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AUTHORS' CONTRIBUTION

MEMT.: elaboration of the methodology, bibliographic review, text writing and revision.

MIE.: experiment, statistic analysis and text writing.

FBM.: general revision, manuscript adjustment, translation.

CONFLICTS OF INTEREST

The authors declare no conflicts of interest regarding the publication of this paper.