

Calibration of fertilizers for application of AGROMENAS - G and NEREA to sugarcane

Calibración de fertilizadoras para la aplicación de AGROMENAS - G y NEREA a caña de azúcar

 Omar González-Cueto^{1*},  Alain Hernández-Solares²,  Elvis López-Bravo¹,
 Juan Carlos González-Nuñez³,  Ibey Gato-Martínez³,  Maykel Cruz-Díaz¹ and  Laura García-Pedraza¹

¹Universidad Central "Marta Abreu" de las Villas, Departamento de Agronomía, Santa Clara, Villa Clara, Cuba. E-mail: elvislb@uclv.edu.cu, maykelcd@uclv.edu.cu, lgpedraza@uclv.edu.cu

²Universidad Central "Marta Abreu" de las Villas, Centro Universitario de Corralillo, Villa Clara, Cuba. E-mail: ahsolares@uclv.cu

³Empresa Agroindustrial Azucarera George Washington, Santo Domingo, Villa Clara, Cuba. E-mail: juancgonzalez@washington.azcuba.cu, ivey.gato@washington.azcuba.cu

*Author for correspondence: Omar González-Cueto, e-mail: omar@uclv.edu.cu

ABSTRACT: FMCM-1 and TATU fertilizer spreaders are used for sugarcane fertilization in Cuba. The objective of this research was to calibrate the FMCM-1 and TATU fertilizer spreaders for the high-productivity application of NEREA fertilizer and AGROMENAS - G organo mineral fertilizer. The methodology included the experimental calibration of the delivery rate in kg min⁻¹ of the fertilizer spreaders and the determination of the effective field capacity during the application of both fertilizers, using known methods. The experimental calibration showed that for AGROMENAS - G, the FMCM-1 only delivers 25,56 kg min⁻¹ and the TATU fertilizer spreader 19,37 kg min⁻¹, both below the flow rate required to meet the application dose, reaching only 34% and 26% respectively. In the case of NEREA, although a flow rate of 37,33 kg min⁻¹ is required, the FMCM-1 delivers 17,37 kg min⁻¹ and the TATU 13,97 kg min⁻¹, which represents less than 50% of the required flow rate. The effective field capacities for the application of NEREA (0.29 and 0.36 ha h⁻¹) and AGROMENAS - G (0.20 and 0.27 ha h⁻¹), working at the speeds that allow the standard delivery dose, are lower than the usual capacity of 0.78 ha h⁻¹ achieved at 7 km h⁻¹. This compromises compliance with production plans and the timely fertilization of sugarcane shoots.

Keywords: fertilizer spreader FMCM-1, fertilizer spreader TATU, effective field capacity, flow rate.

RESUMEN: Las fertilizadoras FMCM-1 y TATU son utilizadas para la fertilización de la caña de azúcar en Cuba. El objetivo de esta investigación fue calibrar las fertilizadoras FMCM-1 y TATU para la aplicación del fertilizante NEREA y del abono órgano mineral AGROMENAS - G con alta productividad. La metodología incluyó la calibración experimental del caudal de entrega en kg min⁻¹ de las fertilizadoras y la determinación de la capacidad efectiva de trabajo durante la aplicación de ambos fertilizantes, mediante métodos conocidos. La calibración experimental evidenció que para AGROMENAS - G, la FMCM-1 solo entrega 25,56 kg min⁻¹ y la fertilizadora TATU 19,37 kg min⁻¹, ambas por debajo del caudal necesario para cumplir la norma de aplicación, alcanzando solo el 34% y 26% respectivamente. En el caso de NEREA, aunque se requiere un caudal de 37,33 kg min⁻¹, la FMCM-1 entrega 17,37 kg min⁻¹ y la TATU 13,97 kg min⁻¹, lo que representa menos del 50% del caudal requerido. Las capacidades de trabajo efectivas para la aplicación de NEREA (0,29 y 0,36 ha h⁻¹) y de AGROMENAS - G (0,20 y 0,27 ha h⁻¹), trabajando a las velocidades que permiten la dosis de entrega normada, son inferiores a la capacidad habitual de 0,78 ha h⁻¹ lograda a 7 km h⁻¹. Esto compromete el cumplimiento de planes de producción y la fertilización oportuna de los retoños cañeros.

Palabras clave: fertilizadora FMCM-1, fertilizadora TATU, capacidad de trabajo efectiva, caudal de entrega.

INTRODUCTION

One of the causes of the decline in the yield of sugarcane (*Saccharum* Spp.) in Cuba (32.8 t ha⁻¹ in 2022 (ONEI, 2024)), and the availability of this raw material for sugar production has been the impossibility, due to the country's economic situation, of applying the necessary fertilizers, in the appropriate quantity and at the right time.

Fertilizers, amendments and manures, based on minerals such as zeolites or others, are used to improve the physical conditions and increase the production capacity of soils (Lourenzoni *et al.*, 2024, Quilici-Freschi *et al.*, 2024, Terry-Alfonso *et al.*, 2024, Ruiz-Sánchez *et al.*, 2025). In Cuba, they have been used in crops such as lettuce, tomato, coffee, corn, sugarcane and others (Volverás-Mambuscay *et al.*, 2020, Arias-Cedeño *et al.*, 2021,

Received: 04/04/2025

Accepted: 01/10/2025

The authors of this work declare no conflict of interests.

Author contributions: Conceptualization: O. González. Data curation: E. López, J.C. González, I. Gato. Formal analysis: O. González, E. López. Investigation: A. Hernández, J.C. González, I. Gato. Methodology: O. González, M. Cruz, L. García. Supervision: O. González, J.C. González, I. Gato. Validation: E. López, M. Cruz, L. García. Roles/Writing, original draft: O. González, E. López. Writing, review & editing: O. González.

The mention of trademarks of specific equipment, instruments or materials is for identification purposes, there being no promotional commitment in relation to them, neither by the authors nor by the publisher



This is an open access article under terms of the license Creative Commons Attribution-NonCommercial (BY-NC 4.0).
<https://creativecommons.org/licenses/by-nc/4.0/>



Espinosa et al., 2021, Medina et al., 2021, Del Campo-Rodríguez et al., 2022, Del Valle, 2022, Valdés-Zayas et al., 2023, Terry-Alfonso et al., 2024). In this context, mineral or organ mineral fertilizers such as NEREA and AGROMENAS - G stand out, having been successfully applied to various crops (Velázquez-Garrido et al., 2013, Saborit-Reyes et al., 2021, Del Valle, 2022, Viñals-Núñez and Bustamante-González, 2022, Niebla, 2023, Rodríguez-Fuentes and Caisés-Ávalos, 2023, Terry-Alfonso et al., 2024). These products, made from natural and mineral resources, with minimal chemicals, offer an alternative to chemical fertilizers, allowing an agroecological approach that benefits the environment, the economy and soil health (Velázquez-Garrido et al., 2013, Rodríguez-Fuentes and Caisés-Ávalos, 2023, Rodríguez-Fuentes and Rodríguez-Iznaga, 2025).

AGROMENAS are formulations containing various minerals and NPK fertilizers or peat or other organic matter, these were developed by Centro de Investigaciones para la Industria Minero Metalúrgica (CIPIMM) (Velázquez-Garrido et al., 2013). NEREA is a fertilizer based on natural zeolite, developed by the Instituto de Ciencia y Tecnología de Materiales (IMRE) of the Universidad de La Habana. What distinguishes NEREA from the blended of NPK fertilizers with zeolite is that nutrients that plants require are introduced in a stable and homogeneous manner within the zeolite particles, before incorporating the zeolite into the soil (Rodríguez-Fuentes and Rodríguez-Iznaga, 2025).

The Empresa Geominera del Centro currently produces both AGROMENAS-G and NEREA. These products are available; however, they are in low demand by producers and are not used in sugarcane cultivation. To investigate the application of these two fertilizers in sugarcane, the Universidad Central "Marta Abreu" de las Villas is coordinating a research project under the National Program for Development of the Sugarcane Agroindustry, funded by the Ministry of Science, Technology, and Environment. This project is entitled "Increasing sugarcane (*Saccharum* spp.) production through the use of organ mineral fertilizers and a domestically produced biostimulant." This research is part of this project.

Applying these fertilizers to sugarcane poses an additional challenge: the large area devoted to its cultivation. Therefore, mechanical application of these products is essential. Fertilizer and fertilizer-spreading machines are generally designed for a nominal dosage range that can vary depending on the type of fertilizer used, which requires calibration for each specific application (Márquez, 2011, Reyes-Aroca et al., 2012).

The application of agrochemicals to the soil, and specifically fertilizers, is based on the dosage "D" or quantity of product applied per unit of surface area (kg ha⁻¹), which depends on the following factors (Boto, 2006):

- the flow rate "Q" or machine delivery, the amount of product supplied by the fertilizer spreader per unit of time, kg min⁻¹;

- the forward speed "v" or operating speed of the fertilizer spreader, km h⁻¹;
- the working width of the machine "a", m.

The delivery dose per unit area is obtained by equation 1

$$D \text{ (kg/ha)} = \frac{600 \text{ Q (kg/min)}}{v \text{ (km/h)} a \text{ (m)}} \quad (1)$$

The fertilizer flow rate, depending on the application dose for a given forward speed and working width, is obtained according to equation 2.

$$Q \text{ (kg/min)} = \frac{D \text{ (kg/ha)} v \text{ (km/h)} a \text{ (m)}}{600} \quad (2)$$

Fertilizer spreader productivity during operating time, or effective field capacity (EFC), is affected by forward speed, working width, and the fertilizer spreader's field efficiency (E). The latter depends on hopper capacity and flow rate. Generally, $E = 0,5 \div 0,7$ (Ortiz-Cañavate et al., 2012). Effective field capacity can be determined using equation 3.

$$EFC \text{ (ha/h)} = 0.1 \text{ v a E} \quad (3)$$

For the application of chemical fertilizers, such as those commonly used in sugarcane, fertilizer spreaders such as the FMCM-1 and TATU are used in Cuba. These machines have distribution systems designed for application of maximum flow rates between 250 and 550 kg ha⁻¹. The application dose for AGROMENAS - G is 4000 kg ha⁻¹, and for NEREA is 2000 kg ha⁻¹. These are high application rates due to the composition of the products. Therefore, it is necessary to investigate whether the FMCM-1 and TATU fertilizer spreaders are capable of delivering AGROMENAS - G and NEREA fertilizers at the requested application rates and with high productivity. Based on these elements, the following research is conducted with the objective of calibrating the FMCM-1 and TATU fertilizer spreaders for application of NEREA fertilizer and the AGROMENAS - G organ mineral fertilizer with high productivity.

MATERIALS AND METHODS

The work was carried out at the Empresa Agroindustrial Azucarera George Washington, located in the Santo Domingo municipality, Villa Clara, from June to August 2024. Two aggregates were studied: one formed by the YTO 1604 tractor and the FMCM-1 fertilizer spreader, and the other formed by the MTZ 80 tractor and the TATU fertilizer spreader.

The calibration aimed to determine whether both fertilizer spreaders could apply the planned doses of 4000 kg ha⁻¹ of AGROMENAS - G and 2000 kg ha⁻¹ of NEREA. First, the flow rate (kg min⁻¹) that each fertilizer spreader must distribute to meet the planned dose was calculated using equation 2. To do this, a working width of 1.6 m and a forward speed of 7 km h⁻¹ were established, values that correspond to the application of conventional fertilizer with both machines.

The calibration was carried out in the company's main workshop. Initially, the YTO 1604 tractor and the FMCM-1 fertilizer spreader were used; a few days later, the MTZ 80 tractor and the TATU fertilizer spreader were used. Both spreaders are powered by a hydraulic motor fed by the tractor's hydraulic pump.

The metering mechanisms were adjusted for maximum fertilizer flow rate. On the FMCM-1, this involved setting the screw distributors to maximum rpm. On the TATU fertilizer spreader, the drive chain was positioned on the sprocket combination that provides maximum delivery.

The engine speed of both tractors was maintained at 1 500 rpm, corresponding to field application speed. The hoppers were filled with fertilizer, and sacks were placed in the discharge chutes to collect the delivered material (Figure 1). The fertilizer spreader ran for one minute, and the fertilizer collected in each sack was weighed. This procedure was repeated five times, and the average weight was calculated.



Figure 1. Positioning of the bags in the discharge tubes of the fertilizer spreader FMCM-1.

Using the data obtained, the working speed (solving v in equation 2) at which the aggregates must operate to apply the planned fertilizer application doses (4000 kg ha⁻¹ of AGROMENAS - G and 2000 kg ha⁻¹ of NEREA) was determined, with a flow rate equal to the one measured experimentally. The effective field capacity of the aggregates was also calculated (equation 3), considering the determined forward speed and a field efficiency of 70%.

RESULTS AND DISCUSSION

The flow rate, in kg min⁻¹, determined by equation 2 that both fertilizers must deliver to meet the planned dose, is 74.66 kg min⁻¹ for AGROMENAS - G and 37.33 kg min⁻¹ for NEREA.

Table 1 presents the results of the AGROMENAS - G weighing, obtained at the outlet of each of the two metering mechanisms of each fertilizer spreader, for one minute. The average flow rate at the outlet of the FMCM-1 was 25.56 kg min⁻¹, while that of the TATU fertilizer spreader reached 19.37 kg min⁻¹.

Table 1. Flow rate of AGROMENAS - G in one minute, in each of the two fertilizer outlets

FMCM-1			TATU		
Outlet 1	Outlet 2	Total	Outlet 1	Outlet 2	Total
kg	kg	kg	kg	kg	kg
12,97	14,33	27,3	8,19	11,54	19,73
12,92	11,94	24,86	8,59	11,12	19,71
12,63	12,68	25,31	8,81	10,33	19,15
13,09	12,8	25,89	8,65	10,24	18,89
12,19	12,27	24,46	8,78	10,62	19,4
		25,56			19,37

Similarly, Table 2 presents the results of NEREA's weighing at each of the two fertilizer outlets. The average flow rate was 17.37 kg min⁻¹ for the FMCM-1 and 13.97 kg min⁻¹ for the TATU fertilizer.

Table 2. NEREA delivery flow rate in one minute, in each of the two fertilizer outlets

FMCM-1			TATU		
Outlet 1	Outlet 2	Total	Outlet 1	Outlet 2	Total
kg	kg	kg	kg	kg	kg
8,39	9,08	17,47	8,56	8,02	14,88
9,42	8,95	18,37	6,29	7,5	13,79
8,51	8,70	17,21	5,89	7,18	13,07
8,51	8,73	17,24	6,40	8,00	14,40
8,22	8,37	16,59	5,92	7,79	13,71
		17,37			13,97

The flow rate required for both fertilizer spreaders to meet the application dose, operating at a forward speed of 7 km h⁻¹ and with a working width of 1.6 m, is 74.66 kg min⁻¹ for AGROMENAS - G and 37.33 kg min⁻¹ for NEREA. However, experimental calibration showed that for AGROMENAS - G, the FMCM-1 delivers only 25.56 kg min⁻¹ and the TATU fertilizer spreader 19.37 kg min⁻¹; that is, neither reaches the flow rate required to comply with the application dose. The FMCM-1 distributes approximately 34% of the required flow rate, while the TATU only 26%. In the case of NEREA, the results are similar: both fertilizer spreaders deliver less than 50% of the regulated flow, with 17.37 kg min⁻¹ for the FMCM-1 and 13.97 kg min⁻¹ for the TATU.

In order to comply with the application doses (4000 kg ha⁻¹ of AGROMENAS - G and 2000 kg ha⁻¹ of NEREA), given the experimental flow rates, both aggregates would have to reduce their forward speed. Solving the speed in equation (2), it was determined that the aggregate formed by the MTZ 80 tractor and the TATU fertilizer spreader must advance at 1.81 km h⁻¹ to apply AGROMENAS - G and at 2.61 km h⁻¹ for NEREA. In the case of the aggregate with the FMCM-1, the necessary speed is 2.4 km h⁻¹ for AGROMENAS - G and 3.25 km h⁻¹ for NEREA.

The evaluated aggregates, when applying conventional chemical fertilizer (for which these fertilizer spreaders are designed), develop a forward speed of 7 km h⁻¹ and reach an effective field capacity of 0.78 ha h⁻¹, which is equivalent to 6.24 ha in an eight-hour work shift.

Given the large area of sugarcane harvested daily during the season, optimizing the productivity of groups of fertilizers spreaders is essential. Increasing effective field capacity depends primarily on achieving higher ground speeds and high field efficiency, considering that the working width is limited by the machine's structure.

High field efficiency values are obtained depending on the characteristics of the terrain. This increases as the field length increases, up to approximately 400 or 500 meters. Field efficiency increases to a lesser extent for lengths longer than this (Castillo-Rodríguez et al., 2021, González-Cueto et al., 2021). Likewise, maintaining adequate work organization, which minimizes time lost in filling hoppers, is essential. To achieve this, fertilizer delivery must be guaranteed in the necessary volumes and times, avoiding interruptions due to lack of inputs. Grisso et al. (2012) highlight those auxiliary processes directly impact field capacity and efficiency, and in this case, hopper filling is one of those critical processes.

Fertilizing with AGROMENAS - G and NEREA at the forward speeds determined in this study allows the established application doses to be met without modifying the metering mechanisms. However, if these forward speeds are used, the effective field capacity for AGROMENAS - G would be only 0.20 ha h⁻¹ with the TATU fertilizer spreader and 0.27 ha h⁻¹ with the FMCM-1. For NEREA application, the capacity would be 0.29 ha h⁻¹ with the TATU and 0.36 ha h⁻¹ with the FMCM-1. These values indicate very low productivity during the exploitation period, which jeopardizes compliance with production plans and the timely fertilization of sugarcane shoots.

Therefore, the low effective field capacity during the application of AGROMENAS - G and NEREA, given the flow rate determined in the calibration, advises against the use of these fertilizer spreaders in their current conditions. It is recommended to modify the metering mechanisms to increase the flow rate and thus be able to apply the application dose at higher speeds, which would increase the effective field capacity. Another alternative is the use of fertilizer spreaders capable of reaching higher flow rates, such as the ID David fertilizer trailers, which have been successfully used in AGROMENAS - G applications in corn and sweet potato crops (González-Cueto et al., 2023).

CONCLUSIONS

- The experimental calibration find out that for AGROMENAS - G, the FMCM-1 only delivers 25.56 kg min⁻¹ and the TATU fertilizer spreader 19.37 kg min⁻¹, both below the flow rate required to meet the application dose (kg ha⁻¹), reaching only 34% and 26% respectively. In the case of NEREA,

although a flow rate of 37.33 kg min⁻¹ is required, the FMCM-1 delivers 17.37 kg min⁻¹ and the TATU 13.97 kg min⁻¹, which represents less than 50% of the required flow rate.

- The effective field capacities for the application of NEREA (0.29 and 0.36 ha h⁻¹) and AGROMENAS - G (0.20 and 0.27 ha h⁻¹), working at the forward speeds that allow the application dose, are lower than the usual capacity of 0.78 ha h⁻¹ achieved at 7 km h⁻¹. This compromises compliance with production plans and the timely fertilization of sugarcane ratoons.
- It is proposed to modify the metering mechanisms of both fertilizer spreaders to increase the flow rate, allowing the application dose to be applied at a higher forward speed and achieving greater effective field capacity. Another solution would be to use fertilizer spreaders that provide higher flow rates, such as the ID David fertilizer trailers or others.

ACKNOWLEDGMENTS

The research that led to the results presented in this publication received funding from the International Funds and Projects Management Office of the Ministry of Science, Technology, and Environment of the Republic of Cuba, under code PN3602LH002-087.

REFERENCES

- ARIAS-CEDENO, Q.; LÓPEZ-SÁNCHEZ, R.; SAINZ-ROSALES, L. R.; VERDECIA-CASANOVA, M. V.; EICHLER-LÖBERMANN, B.: Potencial fertilizante de cenizas de bagazo de caña de azúcar de industrias azucareras. *Revista Cubana de Química*, 33, 452-466, 2021. 2224-5421,
- BOTO, J. A.: La mecanización agraria. Principios y aplicaciones, Universidad de León, León, 2006.
- CASTILLO-RODRÍGUEZ, J. A.; ÁVALOS-CLAVELO, J. L.; GONZÁLEZ-CUETO, O.; SÁNCHEZ-VALLE, S.; ACEVEDO-DARIAS, M.; LEÓN-SILVERIO, Y.; LÓPEZ-BRAVO, E.; SALCERIO-SALABERRY, R. A.; BETANCOURT-RODRÍGUEZ, Y.: Factores que influyen en el rendimiento de cosechadoras de caña de azúcar, en Villa Clara. *Revista Ingeniería Agrícola*, 11, 27-34, 2021. <https://eqrcode.co/a/czjoV9>.
- DEL CAMPO-RODRÍGUEZ, Y.; ROMERO-JIMÉNEZ, A. M.; BARRERA-GARCÍA, A.: Efecto fertilizante de costras biológicas del suelo y cachaza, sobre el cultivo de maíz (*Zea mays*, l.). *Revista Científica Agroecosistemas*, 10, 6-14, 2022. 2415-2862,
- DEL VALLE, A.: Uso de Agromena y EcoMic como fertilizante alternativo en la producción de tomate (*Solanum lycopersicum* L.) en los Cultivos Protegidos. Tesis de Especialista en Fruticultura Tropical, Universidad de Matanzas, 2022.
- ESPINOSA, W.; RÍOS, C.; DÍAZ, T.: Producción ecológica del tomate *Solanum Lycopersicum* L. (var. Campbell 28) con el uso de zeolita natural mezclada con estiércol vacuno. *Centro Agrícola*, 48, 23-27, 2021.

- GONZÁLEZ-CUETO, O.; CASTILLO-RODRÍGUEZ, J. A.; ÁVALOS-CLAVELO, J. L.; LÓPEZ-BRAVO, E.; HERRERA-SUÁREZ, M.; SALCERIO-SALABERRY, R. A.: ANALYSIS OF THE FIELD EFFICIENCY OF SUGARCANE HARVESTERS. *INMATEH-Agricultura Engineering*, 63, 301-308, 2021.
- GONZÁLEZ-CUETO, O.; SALCERIO-SALABERRY, R. A.; SORIANO-ALONSO, E. Y.; MERLÁN-MESA, G.; LÓPEZ-BRAVO, E.; HERRERA-SUÁREZ, M.: Caracterización de la fertilizadora ID-David para la aplicación mecanizada del abono órgano mineral Agromena-G. *Revista Ciencias Técnicas Agropecuarias*, 32, 1-4, 2023.
- GRISSE, R. D.; HANNA, M. H.; TAYLOR, R. K.; VAUGHAN, D. H.: Machinery productivity estimates from seed tenders *Poljoprivredna Tehnika XXXVII* 81 - 91 2012.
- LOURENZONI, R. C.; DOS REIS, L. L.; BATISTA, D. F. O.: Características agrônômicas de cultivares de banana com a utilização de fertilizante organomineral potássico. 17º JORNADA CIENTÍFICA E TECNOLÓGICA E 14º SIMPÓSIO DE PÓS-GRADUAÇÃO DO IFSUL-DEMINAS, 16, 2024. 2319-0124,
- MÁRQUEZ, L.: La tecnología en abonadoras de proyección. Parte 1. La uniformidad de distribución. . *Agrotecnica*, 3, 38-44, 2011.
- MEDINA, P.; GONZÁLEZ, C.; MORALES, M.: Uso de biofertilizantes para una producción más rentable y sustentable de caña de azúcar en México, *Biofábrica Siglo XXI. C3-BIOECONOMY*, Revista de Investigación y Transferencia en Bioeconomía Circular y Sostenib, 2, 81-100, 2021.
- NIEBLA, A.: Evaluación del efecto estimulador del fertilizante órgano-mineral Agromena en plántulas de henequén en condiciones de vivero. Tesis de Ingeniero Agrónomo, UNIVERSIDAD DE MATANZAS, 2023.
- ONEI. Anuario estadístico de Cuba 2023. Edición 2024, Oficina Nacional de Estadísticas e Información, La Habana, 2024.
- ORTIZ-CAÑAVATE, J.; BARREIRO, P.; DIEZMA, B.; GARCIA, F. J.; GIL, J.; MOYA, A.; ORTIZ, C.; RUIZ, M.; RUIZ, L.; VALERO, C.: Las máquinas agrícolas y su aplicación, Mundi-Prensa, Madrid, 2012.
- QUILICI-FRESCHI, J. V.; FAE, R.; FONSECA-SOUZA, C.: Fertilizante de liberação controlada de nutrientes na produção sustentável de repolho irrigado: um estudo experimental. *Ciência, Tecnologia & Ambiente*, 14, 2024. <https://doi.org/10.4322/2359-6643.14271> .
- REYES-AROCA, J. F.; BERRIOS-ARAYA, D. F.; ORTEGA-BLU, R. A.; ESQUIVEL-FLORES, W. D.: Calibración estática de un sistema de control automático de tasa variable de fertilizante. *Agrociencia*, 46, 51-62, 2012.
- RODRÍGUEZ-FUENTES, G.; CAISÉS-ÁVALOS, A.: NEREA Productos zeolíticos para la agricultura. La Habana: IMRE, Universidad de la Habana, 2023.
- RODRÍGUEZ-FUENTES, G.; RODRÍGUEZ-IZNAGA, I.: Are NEREA zeolitic nanostructured materials equal to NPK fertilizers mixed with natural zeolites? *Advancements in zeolites and micro-meso porous hierarchical materials*. IGI Global Scientific Publishing, 2025.
- RUIZ-SÁNCHEZ, M.; DÍAZ-LÓPEZ, G. S.; MUÑOZ-HERNÁNDEZ, Y.; RODRÍGUEZ-PÉREZ, R.; MIRANDA-CABALLERO, A.; DOMÍNGUEZ-VENTO, C.; GIL-OLAVARRIETA, A. R.: Aplicación foliar del biofertilizante CBFert® en dos sistemas de producción de arroz con bajo insumo de fertilizante. *Cultivos Tropicales*, 46, 2025.
- SABORIT REYES, R.; MENESES-DARTAYET, P.; CAÑIZARES-SIERRA, A.: Efecto del foliar Nerea Plus -U, sobre los rendimientos del cultivo del arroz. *Revista Infociencia*, 25, 36-48, 2021. ISSN 1029-5186
- TERRY-ALFONSO, E.; CARRILLO-SOSA, Y.; RUIZ-PADRÓN, J.: Agromenas: nuevo fertilizante eficiente para el cultivo del tomate (*Solanum lycopersicum* L.). *Cultivos Tropicales*, 45, 2024. 0258-5936, <https://cu-id.com/2050/v45n1e03> .
- VALDÉS-ZAYAS, D.; RODRÍGUEZ-GONZÁLEZ, L.; ARBOLÁEZ-ORTIZ, A.; CARRERA-SOTERO, O. L.; POMARES-ORTEGA, U. C.; HERNÁNDEZ-QUESADA, M. C.: Efecto combinado de cascarilla de arroz carbonizada con fertilizante de liberación controlada en el desarrollo de posturas de *Coffea arábica* L. Variedad "Isla 6_14". *Temas agrarios*, 28, 82-94, 2023. 0122-7610, <https://doi.org/10.21897/rta.v28i1.3347> .
- VELÁZQUEZ-GARRIDO, M.; MONTEJO, E.; ALFONSO, E.; ALONSO, J. A.; FIGUEREDO, V.; RODRÍGUEZ, A.; VILLAVICENCIO, B.; PUENTES, D.; FERNÁNDEZ, N.; ESTRADA, J.: Alternativas de empleo de las agromenas en la producción de alimentos X CONGRESO CUBANO DE GEOLOGÍA. La Habana, 2013.
- VIÑALS-NÚÑEZ, R.; BUSTAMANTE-GONZÁLEZ, C.: Utilización de la Nerea® como componente del sustrato en la producción de posturas de cafetos. *Café Cacao*, 21, 2022. 1680-7685, <https://cu-id.com/0356/v21e04> .
- VOLVERÁS-MAMBUSCAY, B.; GONZÁLEZ-CHAVARRO, C. F.; HUERTAS, B.; KOPP-SANABRIA, E.; RAMÍREZ-DURÁN, J.: Efecto del fertilizante orgánico y mineral en rendimiento de caña panelera en Nariño, Colombia. *Agronomía Mesoamericana*, 31, 547-565, 2020.