

ABSTRACTS OF THESIS

Abstracts of doctoral theses of six professors from the Agrarian University of Havana, Cuba (Dariellys Martínez-Balmori, Ernesto Ramos-Carbajal, Mayra Arteaga-Barrueta, Yanoy Morejón-Mesa, Liane Portuondo-Farías, Gustavo Reinel Alonso-Brito)

RESÚMENES DE TESIS

Resúmenes de tesis doctorales de seis profesores de la Universidad Agraria de La Habana, Cuba (Dariellys Martínez-Balmori, Ernesto Ramos-Carbajal, Mayra Arteaga-Barrueta, Yanoy Morejón-Mesa, Liane Portuondo-Farías, Gustavo Reinel Alonso-Brito)

Abstracts of Doctoral Theses from Six Professors of the Agrarian University of Havana, Cuba

Resúmenes de tesis doctorales de seis profesores de la Universidad Agraria de La Habana, Cuba

Caracterização molecular da matéria orgânica durante a vermicompostagem

Molecular Characterization of Organic Matter during Vermicomposting

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Tutor: Luciano Pasqualoto-Canellas

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RESUMO. Nos sistemas orgânicos de produção o uso de matéria orgânica estabilizada tem papel central na ciclagem de nutrientes. A vermicompostagem de resíduos acelera o processo de estabilização e contribui, por sua vez, com a preservação do meio ambiente. Além disso, os vermicompostos têm sido usados como fonte de matéria-prima renovável para extração de substâncias do tipo húmicas utilizadas como promotores de crescimento vegetal e também como veículo de introdução de microrganismos benéficos em sistemas de produção agrícola. O conhecimento da composição molecular da matéria orgânica estabilizada pela vermicompostagem é fundamental para o aprimoramento desses processos biotecnológicos. O objetivo deste trabalho foi avaliar a composição química da matéria orgânica durante a vermicompostagem de diferentes resíduos orgânicos: esterco (E), bagaço de cana-de-açúcar + esterco (BC), torta de girassol + esterco (TG), mistura de esterco, bagaço de cana e torta de girassol (BCTG) e torta de filtro (TF). Amostras com 0, 30, 60 e 120 dias de maturação foram caracterizadas pela espectroscopia de infravermelho com refletância difusa (DRIFT), pirólise *off-line* assistida com hidróxido de tetrametilamônio (TMAH) seguido da cromatografia gasosa e espectrometria de massas (Pi-CG-EM) e fracionamento químico com solvente orgânico. De maneira geral, foi observado decréscimo dos sinais correspondentes às substâncias alquílicas, peptídicas e de carboidratos e aumento seletivo no sinal de aromáticos durante a vermicompostagem. O índice de hidrofobicidade (HB), calculado a partir de bandas de absorção específicas no espectro DRIFT variou ao longo do processo, sendo a ordem no último tempo (120 dias): TF>BCTG>TG>BC>E. A caracterização molecular dos compostos orgânicos presentes nos resíduos foi realizada com a técnica da pirólise *off-line* acoplada à espectrometria de massas e foram identificados mais de 300 compostos principalmente os derivados de ligninas, de carboidratos, de proteínas, ácidos e alcoóis graxos, compostos terpênicos e hidrocarbonetos, cujas abundâncias relativas mudam de acordo com o avanço da estabilização da matéria orgânica. Os resultados obtidos indicaram que a caracterização da composição química da matéria orgânica pode ser realizada pela análise dos produtos da pirólise sem a necessidade da extração sequencial.

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Palabras-chave: Vermicompostagem, DRIFT, TMAH, Pirólise *off-line*.

ABSTRACT. In organic production systems, the use of organic matter stabilized by vermicomposting of different residues increases every day, contributing to environmental preservation. The hydrophobicity of the organic matter has been linked to various events, like their reactivity to the environment and its relationship with biochemical and physiological activity of plants and microorganisms. The aim of this study was to evaluate the molecular characteristics of different vermicompost and its transformation during the vermicomposting process. The vermicompost produced from livestock and agro-industry waste were: cattle manure (E), sugarcane bagasse and cattle manure (BC), sunflower cake and cattle manure (TG), sugarcane bagasse, sunflower cake and cattle manure (BCTG) and filter cake (TF). Samples of vermicomposting in different stages of maturation (0, 30, 60 and 120 days) were characterized by infrared spectroscopy of diffuse reflectance (DRIFT), chemical fractionation with organic solvent and *off-line* pyrolysis with tetramethylammonium hydroxide followed by gas chromatography and mass spectrometry (Py-GC-MS). In general, a decrease was observed for alkyl, peptide and carbohydrate molecule signals, and slight increase in aromatic molecule signals during vermicomposting, although it was not possible to establish the same pattern of behavior therein. The spectroscopic analysis was used in calculating the index of hydrophobicity (HB) and in the final time (120 days) the order was: TF>BCTG>TG>BC>E. By the technique of pyrolysis, compounds were identified in the organic matter residues which were derived from lignin, carbohydrates, proteins, fatty acids and alcohols, terpen compounds and hydrocarbons, whose relative abundance change with the advancement of maturation. Our results indicated that the characterization of molecular composition of organic material is possible by the analysis of pyrolysis products without the need to perform a sequential extraction.

Keywords: Vermicomposting, DRIFT, TMAH, *off-line* pyrolysis.

Fundamentación de parámetros de diseño y operación de sondas destinadas al sensoramiento continuo de la resistencia a la penetración del suelo

Foundations of Design Parameters and Operation of Probes for Continuous Sensing of Resistance to Soil Penetration

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RESUMEN: Se llevó a cabo una investigación teórico-experimental dirigida a la fundamentación de parámetros geométricos y de operación de sondas para el sensoramiento continuo de la resistencia a la penetración en un suelo Ferralítico Rojo Lixiviado, típico de Cuba. Para cumplir este objetivo se desarrollan, a partir del análisis del equilibrio de fuerzas en la interacción sonda-suelo, sendos modelos matemáticos conceptuales (para sondas cónicas y prismáticas) que describen esta interacción y que permiten calcular la resistencia a la penetración obtenida por sondas de diferentes formas geométricas, en función de las propiedades físicas y físico-mecánicas del suelo y de los parámetros geométricos de la sonda. En la fase experimental de la investigación se obtienen relaciones funcionales medianamente fuerte o fuerte entre la tensión interna del suelo compactado y el índice de cono ASABE ($R^2 = 0,62$ a $0,86$), así como una débil relación entre la tensión interna y la densidad volumétrica seca ($R^2 = 0,12$ a $0,41$). Asimismo se determinó que la sonda en forma de cuña prismática con ángulo de 30° y área de la base de 520 mm^2 , avanzando horizontalmente a una velocidad no superior a $0,7 \text{ m/s}$, separada de la barra soporte de la sonda una distancia igual o mayor a 110 mm y con un diámetro del vástago no superior a los 10 mm , constituye la mejor alternativa para la estimación del estado de compactación del suelo a través del sensoramiento horizontal y continuo de la resistencia a la penetración.

Palabras clave: modelo matemático, compactación, tensión, índice de cono

ABSTRACT. A theoretical-experimental research was carried out aimed at the foundation of geometric parameters and the operation of probes for the continuous sensing of the resistance to penetration in a leached Ferralitic Red soil, typical of Cuba. To achieve this objective, from the analysis of the balance of forces in the probe-soil interaction, two conceptual mathematical models (for conical and prismatic probes) were developed. They describe this interaction and allow calculating the resistance to penetration obtained by probes from different geometric

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shapes, depending on the physical and physical-mechanical properties of the soil and the geometrical parameters of the probe. In the experimental phase of the investigation, moderate strong or strong functional relationships are obtained between the internal tension of the compacted soil and the ASABE cone index ($R^2 = 0.62$ to 0.86), as well as a weak relationship between internal stress and the dry volumetric density ($R^2 = 0.12$ to 0.41). It was also determined that the prismatic wedge-shaped probe with angle of 30° and base area of 520 mm^2 , advancing horizontally at a speed no higher than $0.7 \text{ m} \cdot \text{s}^{-1}$, separated from the support bar of the probe a distance equal to or greater than 110 mm and with a diameter of the shank not exceeding 10 mm , is the best alternative for estimating the state of compaction of the soil through the horizontal and continuous sensing of the resistance to penetration.

Keywords: mathematical model, compaction, tension, cone index

Liplant: Alternativa para la producción ecológica del tomate (*Solanum lycopersicum* Linneo) y conservación del medio edáfico

Liplant: Alternative for the Organic Production of Tomato (*Solanum lycopersicum* Linnaeus) and Conservation of the Edaphic Environment

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RESUMEN. Dentro de las acciones reflejadas en la Proyección Estratégica del Programa Integral de Cultivos Varios del Ministerio de la Agricultura de Cuba se encuentra el incremento de la productividad ecológica de las hortalizas, particularmente el cultivo de tomate (*Solanum lycopersicum* L.), sin afectar el medio agroecológico donde se desarrollen. Por lo cual un productor exitoso de las próximas décadas deberá tener a su disposición alternativas, técnicas y métodos confiables que lo garanticen. En este sentido, la aplicación de Liplant (obtenido con bajo costo a partir de vermicompost para concentrar sustancias con alta actividad biológica en bajas concentraciones), pudiera ser una de las alternativas que contribuya a este propósito. Con este fin, el objetivo propuesto en esta investigación estuvo orientado a evaluar los efectos de la aplicación del Liplant sobre la productividad biológica y agrícola en el cultivo de tomate en condiciones de producción y en la conservación y/o mejora de propiedades físicas, físico-químicas y biológicas de suelos Ferralíticos Rojos Lixiviados, así como en la preservación de la calidad de las aguas de lixiviación. En condiciones de laboratorio se realizaron pruebas de aplicaciones equivalentes al uso del Liplant entre uno y dos años, con las diluciones de concentración más elevadas utilizadas en los cultivos. Los resultados indicaron efectos positivos sobre la productividad biológica de las plántulas en la etapa de semillero con la inmersión de las semillas, se acortó el período de obtención de las mismas con una calidad superior respecto a las no tratadas, resultó ser más promisoría la mayor dilución (1:40 v:v), al conseguir semejantes resultados con menor utilización del producto. Con la aplicación foliar de las diluciones de Liplant en las variantes utilizadas se logró el incremento de la productividad agrícola del cultivo, al duplicar los rendimientos con mayor calidad de los frutos y preferencia por parte de los consumidores, se aumentaron las ganancias y la eficiencia económica; ejercieron una acción favorable en la conservación y en la mejora de las propiedades que determinan en la fertilidad de los suelos Ferralíticos Rojos Lixiviados, y en la preservación de las aguas de lixiviación. La combinación de la dilución 1:40 aplicada a las semillas con dos aplicaciones foliares de 1:30 (v:v) en la etapa de plantación, tuvo la mayor repercusión al ser el tratamiento más eficiente económicamente de los aplicados. Los resultados obtenidos con el procedimiento desarrollado con carácter multidisciplinario permitieron evaluar los efectos de la inserción del Liplant al sistema productivo de una finca y a nivel de laboratorio, los cuales lo sugieren como una alternativa ecológica viable y eficiente para incrementar la producción tomatera y la protección de los recursos en los agrosistemas donde se aplique, acorde a los requerimientos de una agricultura sostenible.

Palabras clave: Extracto de vermicompost, agricultura sostenible, *Solanum lycopersicum* L., bioestimulante, conservación del suelo.

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Prof. Titular, PhD en el programa de Ciencias Agrícolas. Universidad Agraria de La Habana, Mayabeque, Cuba, 2014.

ABSTRACT. Among the actions proposed by the Strategic Projection of the Integral Program of Cultivars of the Ministry of Agriculture of Cuba are the increase of the ecological productivity of the vegetables, particularly of the tomato crop (*Solanum lycopersicum* L.) without damage to the agroecological environment where it develops. Thus, a successful producer in the coming decades may have varied alternatives, techniques or reliable methodologies that would guarantee this purpose. In this sense, the application of Liplant (low cost product from vermicompost to concentrate substances with high biological activity that is applied in low concentrations) could represent one of the possible alternatives to be used. The objective of this research was to evaluate the effects of the application of Liplant on the biological and agricultural productivity of tomato cultivars in production conditions and on the conservation and improvement of the physical, chemical and biological properties of Red Ferrallitic soils, as well as in the preservation of leaching water quality. In the laboratory, application tests equivalent to the use of Liplant, since one to two years, were performed with the dilutions of the highest concentration applied in the cultivar under study. The results showed a positive effect on the biological productivity of the seedlings in the sowing stage. The period of obtaining them with higher quality than the rest of untreated seeds was reduced and the best dilution was (1:40 v:v), due to similar results were obtained with less use of the product. With the application of Liplant dilutions in the proposed variants, an increase in the agricultural productivity of the cultivar was obtained by doubling the yields with a higher fruit quality and preference by the consumers. In fact, an increase in the economic efficiency was obtained and a favorable action was observed in the conservation and improvement of the properties that determine the fertility of the Red Ferrallitic soils, as well as in the preservation of the leaching waters. The 1:40 dilution used in the seeds with two foliar applications at 1:30 (v:v) at the planting stage had the greatest response as the most economically efficient treatment of those used. The results obtained in the developed procedure, with a multidisciplinary character, allowed evaluating the effects of including Liplant in the productive system and at the laboratory level, which suggest it as a viable and efficient ecological alternative for the increase of tomato production and for the protection of resources in agro-systems where it is applied, according to the requirements of a sustainable agriculture.

Keywords: Extract of vermicompost, Sustainable agriculture, *Solanum lycopersicum* L., Biostimulant, Soil conservation.

Determinación de la composición racional del complejo cosecha-transporte del arroz con la aplicación de la teoría del servicio masivo en la Empresa Agroindustrial de Granos "Los Palacios"

Determination of the Rational Composition of the Harvest-Transport Complex of Rice with the Application of the Theory of Mass Service in the Agroindustrial Grain Company "Los Palacios"

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RESUMEN. La presente investigación se realizó en la EAIG "Los Palacios", durante las campañas 2010-2014; investigándose el complejo cosecha-transporte del arroz en época poco lluviosa; con el objetivo de determinar su composición racional; empleando para ello la Teoría del Servicio Masivo. Durante el proceso investigativo se realizó la caracterización de la entidad y de las tecnologías mecanizadas empleadas en dicho proceso y la evaluación tecnológica y de explotación de las cosechadoras NEW HOLLAND TC-57 y del tractor NEW HOLLAND TS-6020 con dos remolques IMECA. Como resultado de la investigación se creó el sistema automatizado SAORCE-CTR, para la determinación de la composición racional del complejo, obteniéndose que al emplearse la cantidad racional de medios de transporte en cada una de las variantes de transportación, las pérdidas económicas totales por paradas se reducen entre 1,88... 22,37 peso/h (3,2...23,6%) para campos con rendimientos agrícolas de 3,2t/ha; de igual forma para campos con rendimientos agrícolas de 3,7 t/ha, las mismas se reducen entre 1,47... 54,49 peso/h (2,4...41,4%) y para campos con rendimientos agrícolas de 4,2 t/ha, se reducen entre 5,51... 168,32 peso/h (8,3...67,1%). También se determinó que al no considerarse el tiempo invertido en gestión y búsqueda de piezas, el coeficiente de fiabilidad de explotación en su variante cronométrica aumenta en un 18 % y el coeficiente de fiabilidad de explotación en su variante de costo oscila entre 0,92...0,93, evidenciándose que la aparición de fallas se

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reduz si se realizan las actividades de mantenimiento planificadas y se dispone de un inventario de piezas adecuado en la brigada de cosecha.

Palabras clave: evaluación, cosechadora, tecnología, operación, mecanizado.

ABSTRACT. The present research was carried out in "Los Palacios" Enterprise, during the 2010-2014 campaigns. The complex harvest-transport of rice in dry season was investigated with the objective of determining its rational composition, using the Theory of Massive Service. During the research process, the characterization of the entity and the mechanized technologies used in the process and the technological and operation evaluation of the NEW HOLLAND TC-57 and the NEW HOLLAND TS-6020 tractors, with two IMECA trailers, were carried out. As a result of the investigation, SAORCE-CTR automated system was created to determine the rational composition of the complex. It was obtained that, when using a rational amount of means of transport in each of the transportation variants, the total economic losses due to stops are reduced between 1.88 and 22.37 Cuban peso/h (3.2 ... 23.6%) for fields with agricultural yields of 3.2 t/ha. Likewise for fields with agricultural yields of 3.7 t/ha, they are reduced between 1.47 and 54.49 Cuban peso /h (2.4 ... 41.4%) and for fields with agricultural yields of 4.2 t/ha, they are reduced between 5.51 and 168.32 Cuban peso /h (8.3 ... 67.1%). It was also determined that, not considering the time spent in management and search of parts, the operating reliability coefficient in its chronometric variant increases by 18% and the operation reliability coefficient, in its cost variant, oscillates between 0.92 and 0.93, evidencing that the appearance of faults is reduced if the planned maintenance activities are carried out and an adequate inventory of parts is available in the harvest brigade.

Keywords: evaluation, harvester, technology, operation, machining.

Frutose 1,6 bifosfato regula o consumo de oxigênio e formação de H₂O₂ pela via glicolítica associada à membrana externa mitocondrial de batatas (*Solanum tuberosum*)

Fructose 1,6 Bisphosphate Regulates the Consumption of Oxygen and H₂O₂ Formation by Glycolytic Pathway Associated with Mitochondrial Outer Membrane in Potatoes (*Solanum tuberosum*)

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RESUMO. Uma das primeiras vias metabólicas a ser esclarecida e melhor entendida do ponto de vista regulatório foi a glicólise, que de forma geral inclui uma sequência de reações enzimáticas que converte uma molécula de glicose em duas moléculas de piruvato ($\text{glicose} + 2 \text{NAD}^+ + 2 \text{ADP} + 2 \text{P}_i \rightarrow 2 \text{piruvato} + 2 \text{NADH} + 2 \text{ATP} + 2 \text{H}_2\text{O} + 2 \text{H}^+$). No caso de células vegetais, a molécula de glicose pode ser degradada tanto no citosol como no cloroplasto a partir da quebra da sacarose ou amido, onde vários intermediários como a diidroxiacetona fosfato, fosfoenol piruvato e piruvato são intercambiáveis entre esses compartimentos. Estudos feitos nos últimos anos revelam a existência de enzimas glicolíticas ativas na superfície da mitocôndria, processo altamente regulado a partir de um reparticionamento destas enzimas dependentes da demanda de piruvato. Neste trabalho foi avaliado se a glicólise associada à mitocôndria depende somente do *pool* de piruvato existente ou se outros substratos da via glicolítica são importantes neste processo. Baseando-se nesta hipótese foi testado se a adição do composto intermediário frutose 1,6 bifosfato seria capaz de gerar NADH glicolítico, que serviria como substrato para a respiração mitocondrial. Foi demonstrado que a adição de frutose 1,6 bifosfato em um meio de respiração contendo mitocôndrias isoladas de tubérculos de batata modificou o balanço NAD-redox para oxidação ou redução, dependendo das concentrações tanto da frutose 1,6 bifosfato, como de Antimicina A (inibidor do complexo III) ou FCCP (ionóforo de H⁺), modulando o fluxo dos elétrons no sistema transportador de elétrons e o consumo de oxigênio, provavelmente por duas vias distintas (rota da oxidase alternativa ou via complexo III). Foi comprovado que este é um comportamento próprio de mitocôndrias isoladas de batata que pode ser generalizado para célula vegetal, já que em mitocôndrias de cérebro de rato não foram observadas variações no consumo de oxigênio nas mesmas condições experimentais. Outros resultados mostraram variações no estado redox do sistema transportador de elétrons e no consumo de oxigênio quando adicionados substratos para o complexo I ou complexo II, respectivamente. Na presença de frutose 1,6 bifosfato, ADP e piruvato-malato ou succinato foi observada uma

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inibição no consumo de oxigênio que pode ser produto da competição pelo ADP entre a via glicolítica associada à membrana mitocondrial e a fosforilação oxidativa. A frutose 1,6 bifosfato em associação com o ADP também mostrou uma modulação no sistema transportador de elétrons diminuindo notavelmente a produção de H₂O₂, efeito que pode ser explicado pela formação de supercomplexos respiratórios, que resulta em uma alta eficiência no fluxo dos elétrons, bem como associação com enzimas superóxido dismutases que regulam a produção de O₂⁻. Finalmente, foram encontrados dois sítios de afinidade (alta e baixa afinidade) em mitocôndrias de batata para o NADH, que em uma concentração de 150 μM provocou uma brusca queda da produção de H₂O₂ e variações no consumo de oxigênio, indicando que esta é a concentração de NADH que modula o sistema transportador de elétrons.

Palavras chave: Frutose-Bifosfatase, Glicólise, Mitocôndrias, Transporte de Elétrons, Consumo de Oxigênio, NADPH Desidrogenase.

ABSTRACT. One of the first metabolic pathways to be clarified and better understood regarding the regulation is glycolysis, which includes a sequence of enzymatic reactions that convert one glucose molecule into two molecules of pyruvate (glucose + 2 NAD⁺ + 2 ADP + 2 P_i → 2 pyruvate + 2 NADH + 2 ATP + 2 H₂O + 2 H⁺). In the case of plant cells, the glucose molecule can be degraded both in cytosol and in the chloroplast from sucrose or starch break, where several intermediates, such as dihydroxyacetone phosphate, phosphoenol pyruvate and pyruvate are interchangeable between these compartments. Recent studies show the existence of active glycolytic enzymes on the surface of mitochondria, a highly regulated process through the repartitioning of these enzymes that depends on the pyruvate demand. In the present study, it was evaluated if the mitochondria associated glycolysis solely depends on the existing pyruvate pool or if other glycolytic pathway substrates are important in this process. Based on this hypothesis, it was tested if the addition of fructose 1,6 biphosphate intermediate would be capable of generating glycolytic NADH that would fit as a substrate for mitochondrial respiration. It was shown that, the addition of fructose 1,6 biphosphate in a respiration medium containing isolated potato tubers mitochondria, modified NAD-redox balance for oxidation or reduction, depending on the concentrations of both fructose 1,6 biphosphate, Antimycin A (inhibitor of complex III) or FCCP (H⁺ ionophore), by modulating the electron flow in the electron transport system and oxygen consumption, probably by two different routes (alternative oxidase route or via complex III). It was demonstrated that this is a specific behavior of isolated potato mitochondria that can be generalized to the plant cell, once in rat brain mitochondria, there were not observed changes in oxygen consumption at the same experimental conditions. Additional results showed changes in the redox state of the electron transport system and oxygen uptake when added complex I or complex II substrates, respectively. In the presence of fructose 1,6 diphosphate, ADP and pyruvate-malate or succinate, it was observed an inhibition in oxygen consumption that may be result of a competition between mitochondrial membrane associated glycolytic pathway and oxidative phosphorylation for ADP. Fructose 1,6-bisphosphate, combined with ADP, also showed a modulation of the electron transport system, remarkably decreasing production of H₂O₂, an effect that can be explained by the formation of respiratory supercomplexes, which result in a high efficiency in the flow of electrons, as well as associations with superoxide dismutase enzymes, that regulate the O₂⁻ production. Finally, it was found two affinity sites (high and low affinity) to NADH in potato mitochondria, where at 150 μM of NADH, a sharp decrease in H₂O₂ production and variations in oxygen consumption were observed, indicating that this is the NADH concentration that modulates the electron transport system.

Keywords: Fructose-Bisphosphate, Glycolysis, Mitochondria, Electron transport, Oxygen Consumption, NADPH Dehydrogenase.

Predicción probabilística del escurrimiento y la pérdida de sedimentos para eventos extremos de precipitación en la subcuenca V aniversario, río Cuyaguajeje

Probabilistic Prediction of Runoff and Sediment Loss for Extreme Events of Precipitation in the Sub-basin "5to. Aniversario", Cuyaguajeje River

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Prof. Titular, PhD en el programa de Ciencias Técnicas. Universidad Agraria de La Habana. Mayabeque, Cuba, 2018.

RESUMEN. La predicción de variables hidrológicas y de erosión, relacionada a eventos extremos de precipitación, es un tema de gran importancia para las organizaciones encargadas de la protección o defensa de la sociedad y su medioambiente. La variabilidad climática actual, afectada principalmente por los azotes del Cambio Climático, propone escenarios y retos difíciles para el estudio de estos fenómenos. En Cuba, los estudios de respuesta hidrológica a las grandes precipitaciones, han estado dirigido a las simulaciones determinística, siendo menos explorado el enfoque probabilístico. Particular interés, se presta a la modelación de los sedimentos en suspensión, dadas las severas condiciones de erosión en la región de estudio y gran parte del país. El objetivo de esta investigación es: mejorar a partir de la utilización de la modelación y técnicas probabilísticas, la predicción del escurrimiento y la pérdida de sedimentos ante eventos extremos de precipitación en la subcuenca V Aniversario del río Cuyaguaje, afectada por fuertes problemas de erosión. El elemento fundamental en esta estrategia fue el modelo de simulación, KINEROS2, el cual fue calibrado y validado con el uso de series de lluvia, escurrimiento y gasto sólido, e información de suelo y su uso. Las predicciones de los niveles de retorno fueron realizadas a través del análisis de valores extremos para los máximos anuales de precipitación. Un modelo estocástico fue usado para generar las posibles realizaciones sintéticas de un evento con periodo de retorno de 50 años. Estas realizaciones fueron corridas de vuelta en el modelo de simulación, para obtener la predicción probabilísticas del escurrimiento y la pérdida de sedimentos ante un evento de esta magnitud en la región de estudio. En el estudio fueron descritas las relaciones lluvia-escurrimiento-sedimento en la subcuenca V Aniversario a través de las curvas características. La distribución de máximos ajustada correspondió a una función teórica EV2 (Fréchet) con factor de forma de 0.38. El estudio permitió determinar las distribuciones de picos y volúmenes totales de escurrimiento y gasto sólido, como respuestas de un evento que tiene un periodo de recurrencia promedio de 50 años.

Palabras clave: variables hidrológicas, erosión, medioambiente, Cambio Climático.

ABSTRACT. The prediction of hydrological and erosion variables, related to extreme events of precipitation, is a topic of great importance for organizations responsible for the protection or defense of society and its environment. The current climate variability, affected mainly by the scourges of climate change, proposes difficult scenarios and challenges for the study of these phenomena. In Cuba, the hydrological response studies to the great precipitations, have been directed to the deterministic simulations, being less explored the probabilistic approach. Particular interest is given to the modeling of sediments in suspension, given the severe erosion conditions in the study region and a large part of the country. The objective of this research was to improve, the prediction of runoff and the loss of sediments in extreme precipitation events, in "5to Aniversario" sub-basin of Cuyaguaje River, affected by strong erosion problems, by means of modeling and probabilistic techniques. The fundamental element in this strategy was the simulation model, KINEROS2, which was calibrated and validated with the use of rain, runoff and solid waste series, and soil information and its use. The predictions of the return levels were made through the analysis of extreme values for the annual maxima of precipitation. A stochastic model was used to generate the possible synthetic realizations of an event with a return period of 50 years. These realizations were run back in the simulation model, to obtain the probabilistic prediction of runoff and sediment loss in an event of this magnitude in the study region. In the study, the rainfall-runoff-sediment relationships in "5to Aniversario" sub-basin were described through characteristic curves. The adjusted maximum distribution corresponded to a theoretical function EV2 (Fréchet) with a form factor of 0.38. The study allowed the determination of peak distributions and total volumes of runoff and solid waste, as responses of an event that has an average recurrence period of 50 years.

Keywords: hydrological variables, erosion, environment, climate change.