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DISTRIBUTION OF CROWN GALL, *Agrobacterium tumefaciens* AND ROOT-KNOT NEMATODES, *Meloidogyne* spp. ATTACKING DIFFERENT ECONOMIC CROPS IN EGYPT [DISTRIBUCIÓN DE LA AGALLA DE LA CORONA, *Agrobacterium tumefaciens* Y NEMATODOS AGALLADORES, *Meloidogyne* spp. QUE ATACAN A DIFERENTES CULTIVOS DE IMPORTANCIA ECONÓMICA EN EGIPTO].

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Crown gall bacterium, *Agrobacterium* sp. and root-knot nematodes, *Meloidogyne* spp. are widely spread in temperate countries and can be directly isolated from infested soils. Crown gall disease, caused by soil-borne tumorigenic bacteria *A. tumefaciens*, is a worldwide tumor-forming disease that leads to the removal of infected plants in many countries. Combined infection of *A. tumefaciens* and *Meloidogyne* spp. increases the frequency and severity of crown gall disease symptoms and stimulates root-knot nematode reproduction

on host plants and soil. In five Egyptian governorates, extensive field surveys were conducted to identify and determine the geographic distribution and incidence/severity of both *A. tumefaciens* and *Meloidogyne* spp. on different economic crops during three growing seasons (2020-2023). A total of 550 soil and root samples were collected from the rhizosphere of different surveyed fields. The surveyed governorates and their respective numbers of soil samples were as follows: Alexandria 140, El-Behera 240, Kafr El-Sheikh 90, Marsa Matruh 50, and Sinai 30 samples. The nematode survey study indicated that *M. incognita* was found to be very common in the collected soil samples with a frequency of occurrence (FO) reaching almost 94% in all the surveyed locations and with population densities (PD) ranging from 40 – 1,010, 60 – 1,540, and 100 – 7,680 in the 2021, 2022, and 2023 growing seasons, respectively. During the bacterial survey study, we noticed the presence of crown gall disease symptoms “knots” on the surveyed economic plants roots which included: apple, apricot, beans, clover, grapevine, guava, mango, citrus, peach, pepper, pomegranate, prunus, tomato, and wheat. Thirty-two isolates of *Agrobacterium* were isolated from tumors found on the infected roots. Distribution of

these isolates reached 50.4, 73.7, and 69.5% in the 2021, 2022, and 2023 growing seasons, respectively. There were slight morphological and physiological differences between the collected *Agrobacterium* isolates, and results indicated that there are 28 isolates that initiate the production of tumorous tissues on carrot slices. During the survey study, symptoms were examined to determine the incidence and severity of crown gall on the infected plants. Data revealed that the most affected economic plants by the two pathogens with high disease incidence and severity were grapevine and guava trees especially those cultivated in the El-Behera governorate which varied from 71% and 86.3% in severity percentages, respectively. The obtained data conclusively indicates that *Agrobacterium* and *Meloidogyne* are considered a serious threat to different fruit trees and crops under variable climatic conditions and need further developmental and implemented control measures.

TOXICOLOGICAL EFFECTS OF SELECTED AGROCHEMICALS AND PHYSICAL FACTORS ON *Caenorhabditis elegans* AS A MODEL ORGANISM [EFECTOS TOXICOLÓGICOS DE ALGUNOS AGROQUÍMICOS SELECCIONADOS Y FACTORES FÍSICOS EN *Caenorhabditis elegans* COMO ORGANISMO MODELO].

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The free-living, bacterial feeding nematode *Caenorhabditis elegans* is a major model organism in environmental toxicology,

developmental biology, neurobiology, host pathogen interactions, aging research, and pharmacology. Its fast-reproductive cycle, transparent body, short lifespan, high progeny, self-fertilizing hermaphrodites, easy maintenance in the laboratory, known cell lineages, and fully sequenced genome (*C. elegans* is the first multicellular organism that has a completely sequenced genome, 1998). The value of *C. elegans* as a model system stems from key facts such as the conservation of basic cellular mechanisms between *C. elegans* and higher organisms. The morphology, lifespan, development, reproduction, and certain behaviors such as locomotion of *C. elegans* are consistent under normal conditions and are common endpoints used as indicators for toxicological studies. Abnormalities in the standard biology and behaviors of *C. elegans* can be used as a bioindicator of toxic responses due to the exposure to various chemical compounds and environmental stressors. Results from our research showed that *C. elegans* can be used to monitor and study the effects of toxic chemicals and physical environmental factors on its biology and behavior. Several phytochemicals were screened for their nematocidal effects. Mortality caused by the exposure varied from very high, moderate to very low in the different tested chemicals. The different toxic effects of long-term exposure at low concentrations to commonly used food coloring azo dyes were investigated. The azo dyes chrysoidine G and disperse orange 3 caused severe lifespan defects. Chrysoidine G, sudan I, and dispersed orange 3 exposure resulted in reproductive defects, and significantly reduced brood size, locomotion, and pharyngeal pumping. The stress responses to azo dye exposure suggested severe toxicity, which was evident in several endpoints such as locomotion, pharyngeal pumping, reproduction, lifespan, and generation of reactive oxygen species (ROS). *C. elegans*

was also used as a bioindicator for exposure to pesticides and heavy metals. Synchronized *C. elegans* adult hermaphrodites were exposed (lifetime exposure) to sublethal doses of the organic and inorganic pesticides, pentachlorophenol, bromacil, disodium methyl arsenate and phenyl mercuric acetate. Lipids were extracted and analyzed using gas chromatography/mass spectrometry. Fatty acid profiles were different among the tested chemical compounds treatments relative to the control. It was also found that changes in the fatty acid profiling were associated with the level of the generated reactive oxygen species (ROS). *C. elegans* was then used to test the effect of Light-Emitting Diode (LED) lights on its biology and behaviors. LED light sources with high-blue enriched white LED light (high blue spectrum of visible light), had an adverse effect on *C. elegans*' development, reproduction, lifespan, locomotion, and increased the generation of reactive oxygen species (ROS).

ATTAINABLE MANAGEMENT OF *Meloidogyne incognita* OF TOMATO FAVORED BY Si COMMERCIAL FORMULATIONS [MANEJO ALCANZABLE DE *Meloidogyne incognita* DE TOMATE PREFERIDO POR FORMULACIONES COMERCIALES Si].

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Three agricultural Silicon constituted formulations (El-ghanem, H-Silicate, and Silica Leap Plus) were assessed for their efficacy against the galling incidence on tomato caused by the root-knot nematode,

Meloidogyne incognita. The study involved a bipartite experiment which commenced in the laboratory with the exposure of *M. incognita* juveniles to three concentrations of the Si formulations (1, 2 and 4 ml/L) for 24, 48, 72 and 96 hours, followed by a greenhouse trial using the exposed juveniles to inoculate potted tomato plants. The H- Silicate at 4 ml/L produced the least galling per root for all four pre-inoculation exposure times, with the highest galling reduction percentage (93.15%) resulting from 4 ml/L and 72 hours exposure time. The least effective treatment for gall reduction (2.10%) was El-ghanem at 2 ml/L and 96 hours exposure time. Horticulturally, the applied treatments had almost no negative impacts, with generally positive plant growth parameters in response to some treatments. This study suggests that the use of silicon for nematode management has potential to reduce the need for more hazardous tactics.

EVALUATION OF THE NOVEL USE OF 'BANANA FIBRE PAPER TECHNOLOGY' FOR THE MANAGEMENT OF PLANT-PARASITIC NEMATODES ON ROOT AND TUBER CROPS [EVALUACIÓN DEL USO NOVEDOSO DE LA 'TECNOLOGÍA DE PAPEL DE FIBRA DE BANANO' PARA EL MANEJO DE NEMATODOS PARÁSITOS DE PLANTAS EN CULTIVOS DE RAÍCES Y TUBÉRCULOS].

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Plant-parasitic nematodes play a vital role in crop growth and productivity of cassava and yam. Chemical nematicides can be effective, but often need to be applied at high application rates, which are costly and additionally pose a risk to human health, and the environment. Cassava and yam field trials were conducted in Nigeria and the Republic of Benin, West Africa to determine the efficacy of banana fiber impregnated with a low dosage of the nematicidal compound – Abamectin (ABA), using cassava cv. TM 30572 and yam cv. Toubeka. The study compared the use of the abamectin-impregnated paper with untreated paper versus normal farmer practice (no paper). Sprouting of cassava was not significantly affected by the paper, cassava stem girth was significantly greater when wrapped with ABA-treated banana paper improving crop strength and stability. At harvest the number of cassava and yam tubers and tuber weight were significantly higher in ABA-treated banana paper plots. Root-knot nematode (*Meloidogyne* spp.) densities were also significantly lower in treated-paper cassava plots, by up to 56% and the yam nematode (*Scutellonema bradys*) densities and damage lower on yam tubers. Our study demonstrates that banana fiber paper, when treated with very low dosages of abamectin, can protect vegetatively propagated root and tuber crops, such as cassava and yam, against soil borne nematode infections and result in increased yield.

EFFICACY OF ELICITORS OF RESISTANCE TO ROOT-KNOT NEMATODE *Meloidogyne incognita* ON TABLE GRAPE IN PERU [EFICACIA DE ELICITORES DE RESISTENCIA AL NEMÁTODO DEL NÓDULO DE LA RAÍZ, *Meloidogyne incognita* EN UVA DE MESA].

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Peru is currently the world leader in table grape exports. The expansion in areas of this crop in sandy desert soils has consequently increased the damage by plant-parasitic nematodes where *Meloidogyne* is the more important species. The objective of the study was to evaluate the efficacy of products that induce plant defense against infections by *Meloidogyne incognita*, as an alternative to the use of nematicides. The trial was conducted in a commercial table grape field for 2 consecutive crop seasons. Seven treatments were evaluated: T0: control, T1: benzothiadiazole, T2: mannano oligosaccharide, T3: jasmonic acid, T4: chitosane, T5: glycine betaine and T6: oxamyl. Except for oxamyl, which was applied only once via the irrigation system, the other treatments were applied 3 times every 20 days via foliar spray. The evaluations were carried out every 20 days after each application. In each evaluation two parameters were evaluated: number of second-stage juveniles (J2) in 100 cm³ of soil and percentage of root damage. The results obtained 60 days after the first application showed that the best treatment was oxamyl, and among the defense inducers, benzothiadiazole and mannano oligosaccharide reduced the number of *M. incognita* J2 in 100 cm³, and jasmonic acid reduced the percentage of root damage. These products represent an alternative to

the use of nematicides or a complement to these in the management of the disease.

DIVERSITY AND MOLECULAR PHYLOGENY OF THE GENUS *Paratylenchus* FROM FLORIDA AND OTHER LOCALITIES [DIVERSIDAD Y FILOGENIA MOLECULAR DEL GÉNERO *Paratylenchus* DE FLORIDA Y OTRAS LOCALIDADES].

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Pin nematodes (*Paratylenchus* spp.) are world widely distributed polyphagous root parasites having different life cycles and feeding habits. Some of them can cause damage to a wide range of plants. A remarkable diversity of pin nematode species was found in soil samples collected during nematology surveys in Florida and other states of the USA, Canada, and Spain, with a total of 14 valid species and three undescribed species. Using integrative taxonomy, six valid species, two new species described in this study and two undescribed taxa were identified from Florida. They included: *Paratylenchulus acti*, *P. aquaticus*, *P. goldeni*, *P. paralatescens*, *P. minutus*, *P. straeleni* and *Paratylenchus* sp. Florida 1 and 2. In other

states of USA, *P. goldeni*, *P. hamatus*, *P. hamicaudatus*, *P. holdemani*, and *P. pedrami* were found in California, *P. minutus* in Hawaii, *P. goldeni* in Oregon and Washington, and one new species was described from a population from Alaska. Outside the USA, *P. projectus* was detected in soil samples from Canada and Spain, and *P. holdemani* and *Paratylenchus* sp. from Spain. Phylogenetic relationships of the genus *Paratylenchus* were reconstructed using the D2-D3 expansion segments of 28S rRNA, ITS rRNA and COI gene sequences. The consensus tree inferred from the combined alignment of sequences of these three genes from 67 valid *Paratylenchus* species, showed that *Paratylenchus* species were distributed among four major clades and that the species with obese females clustered in two major clades in the phylogenetic trees.

SUPPRESSION OF CITRUS NEMATODE *Tylenchulus semipenetrans* WITH MORINGA (*Moringa oleifera*) LEAF EXTRACT [SUPRESIÓN DEL NEMATODO DE LOS CÍTRICOS *Tylenchulus semipenetrans* CON EXTRACTO DE HOJA DE MORINGA (*Moringa oleifera*)].

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Tylenchulus semipenetrans is an economically important pest of citrus crops. In this study, the *in vitro* and *in vivo* effect of methanolic, ethanolic, and aqueous *M. oleifera* extracts was tested on the development of *T. semipenetrans*. The effect of *M. oleifera* extract on juvenile mortality was assessed at 24, 48, and 72 h intervals at three different concentrations (S, S/2, S/4). Fresh leaf methanolic extract

produced the highest *in vitro* juvenile mortality at “S” concentration after 72 h. Ethanolic *M. oleifera* extract showed the highest reduction in invasion and development of *T. semipenetrans* on *Citrus jambhiri* at 1, 6, and 12 weeks. The plant biomass including plant height, root length, and the number of leaves were also increased. At week 1 only the first-stage juvenile, at week 6 third- and fourth-stage juveniles, while at week 12 fourth-stage juveniles were observed, immature and mature females were present. *In vivo*, the protective and curative effect of *M. oleifera* extracts on reproductive parameters and plant growth revealed that protective application was more effective to reduce the reproduction of *T. semipenetrans* and improved plant growth. Protective application of methanolic extract showed the highest reduction in reproductive parameters; juveniles/100mL soil, females/g root, and juveniles/g root, and enhanced plant height, root length, and the number of leaves. Therefore, it can be concluded that *M. oleifera* can be used to control *T. semipenetrans*.

AN INITIAL ASSESSMENT OF EFFECT OF NEMATODE ANTAGONISTIC FUNGI ON THE BEET CYST NEMATODE *Heterodera schachtii* AND PLANT GROWTH [UNA EVALUACIÓN INICIAL DEL EFECTO DE HONGOS ANTAGONISTAS DE NEMATODOS EN EL NEMATODO QUÍSTE DE LA REMOLACHA *Heterodera schachtii* Y EL CRECIMIENTO DE LAS PLANTAS].

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The agricultural sector is significantly impacted by plant-parasitic nematodes (PPNs), which cause yearly losses that are estimated to be up to 120 billion. The application of different management strategies is being used to control PPNS such as the use of resistant and tolerant cultivars. While biological control is an alternative and effective management strategy that needs to be studied more extensively. Numerous recently discovered endophytic fungi have been reported to infect the females and eggs of endoparasitic nematodes. This study was conducted to examine the interaction of *Ljuhya vitellina*, *Niesslia gamsii*, and two Pleosporalean strains *Polydomus karssenii* and JKI72728 against the beet cyst nematode *Heterodera schachtii* and their effect on sugar beet under greenhouse conditions. These fungi were originally isolated from infected eggs of the cereal cyst nematode *Heterodera filipjevi* and showed an antagonizing nature against nematode eggs under *in vitro* conditions. A pot experiment was conducted under controlled greenhouse conditions with different treatments and controls. Each treatment had 10 replicates and the experiment was repeated 2 times. The temperature was set to 20°C:18°C (day: night) and the photoperiod was set to 16 hours. The experiment was finalized after 4 months, plants were uprooted, and formed cysts/females were extracted from each pot. Growth parameters including plant height, shoot height, root length plant dry/fresh weight, and biomass were recorded. In another experiment, auxin production levels

of the fungal strains were tested using Salkowski colorimetric assay to determine whether indole-3-acetic acid (IAA) is produced. The results displayed those plants inoculated with the Pleosporalean strain *Polydomus karssenii* and the strain *N. gamsii* had an increase in total biomass and the root biomass of sugar beet, while plants inoculated with the Pleosporalean strain *Polydomus karssenii* and nematode displayed a significantly higher shoot biomass. Two of the four fungi (*Ljuhya vitellina*, *Niesslia gamsii*) showed levels of IAA production. The fungal strains indicated that they can be a source of other phytohormones that influence plant growth promotion.

PTI-BASED CALLOSE DEPOSITION PLAYS A ROLE IN POTATO-NEMATODE INTERACTIONS [LA DEPOSICIÓN DE CALLOSA BASADA EN PTI JUEGA UN PAPEL EN LAS INTERACCIONES PAPA-NEMATODO].

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When root-knot nematodes (*Meloidogyne* spp.) infect plant roots, they trigger basal plant defense responses, which is often called PAMP-triggered immunity (PTI). Some of the hallmarks of PTI include defense gene expression and enhanced callose deposition. Nematodes secrete molecules called effectors, some of which can facilitate parasitism by suppressing PTI. For example, the Gleason lab previously characterized an effector from *Meloidogyne hapla* called Mh265. This effector was localized to the esophageal glands of the nematode and was highly expressed during pre- and early parasitic life stages. Transgenic Arabidopsis plants constitutively expressing Mh265 were

more susceptible to nematode infections. The transgenic plants expressing Mh265 also exhibited a reduction in elicitor induced callose deposition. The link between the effector, increased host susceptibility, and reduced callose deposition inspired us to investigate the role of callose deposition in plant-nematode interactions. When wild-type Arabidopsis plants (Col-0) were treated with 2-deoxy-D-glucose (DDG), an inhibitor of callose synthases, the plants were more susceptible to *M. hapla* compared to the untreated controls. We then expanded our approach to potato, a major crop in Washington, and found that DDG treatments significantly enhanced the susceptibility of potatoes to root-knot nematodes. There are several callose synthase genes (Glucan Synthases, GSLs) in potato. Because Arabidopsis GSL5 plays a significant role in PTI-based callose synthesis, we focused on its potato homolog StGSL5. Two independent stgsl5 potato knockdown lines were generated, and these lines showed enhanced susceptibility to *M. hapla*. Preliminary microscopic evaluations of the nematode giant cells in the GSL5 knockdown potatoes showed that were similar in size to the giant cells in wild-type potato. The long-term goal of the study is to utilize the information in order to manipulate host natural defenses, which can be utilized as a form of nematode control in economically important crops like potato.

ELUCIDATION OF THE NEMATICIDAL MODE OF ACTION OF 3-OCTANOL ON THE ROOT-LESION NEMATODE *Pratylenchus penetrans* [ELUCIDACIÓN DEL MODO DE ACCIÓN NEMATICIDA DEL 3-OCTANOL SOBRE EL NEMATODO DE LA LESIÓN RADICULAR *Pratylenchus penetrans*].

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The root-lesion nematode (RLN), *Pratylenchus penetrans*, is one of the most severe plant-parasitic nematodes (PPN), responsible for productivity losses in a significant number of plant hosts. The chemical control of these PPNs relies on fumigants and non-fumigants compounds, which offer systemic protection. Such control methods are costly and hazardous to the environment and to humans. Compounds naturally produced by plants may play an important role in nematode control. The aim of this study is to analyze the molecular response of *P. penetrans* to the nematicidal agent 3-octanol (C₈H₁₈O) using a de novo transcriptome assembly approach. Previous work showed that 3-octanol is a strong nematicide of *P. penetrans* causing 100% mortality in standard direct contact for 24h. The mode of action of this nematicide was studied at sub-lethal exposure for 30 min. Overall, the aliphatic alcohol 3-octanol induced the activation of detoxification mechanisms of *P. penetrans* with up-regulation of metabolic pathways related with metabolism of xenobiotics by CP450, steroid hormone synthesis, retinol metabolism, drug metabolism among others, while affecting ascorbate and aldarate metabolism, starch/sucrose metabolism and several signaling pathways related with cellular immune

response. Understanding the defense mechanisms of *P. penetrans* against natural nematicides can lead to development of tailor-made control solutions.

***Leptolaimus petrelense* N. SP. (PLECTIDA: LEPTOLAIMIDAE), A NEW NEMATODE SPECIES FROM THE PETREL LAGOON, CENTRAL CHILE [*Leptolaimus petrelense* n. sp. (PLECTIDA: LEPTOLAIMIDAE), UNA NUEVA ESPECIE DE NEMATODO DE LA LAGUNA PETREL, CHILE CENTRAL].**

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In a survey done in January 2023, sediment, and soil samples were taken for a broad study of the health state of the Petrel lagoon in the estero San Antonio (river) and their banks (Coordinates at -34.381696, -71.998171) in central Chile. Among other things, the nematode community structure was studied, and we could observe a high number of *Leptolaimus* nematodes all around the wetland. Using morphological examination, we determined that this nematode was an undescribed species. The description of the new nematode *Leptolaimus petrelense* n. sp. is presented. This new nematode is characterized by their annulated cuticle (annuli 1.5–1.8 µm wide at mid-body) with no ornamentation. Lateral field present, consists of single ala (two incisures), 2.1–2.3 µm wide at mid-body; originating just below the level of the basal bulb (in the pharynx-intestine junction) and extending posteriorly to the

first third of the tail length. Distinct pores in sublateral position scattered over the body. Anterior most body pore very distinct and always located below the amphidial aperture. Labial region rounded, lips fused. Inner and outer labial sensilla indistinct. Cephalic sensilla setiform, equal to 2.0 - 3.3 μm in length. Amphidial fovea round, located between 9-13.3 μm from the anterior end. Pharynx muscular, with uniformly thickened lumen, with distinct oval basal bulb, valvular apparatus absent. Anterior cylindrical part of pharynx subdivided by three breaks, cylindrical metacarpus and narrow isthmus. Tail similar in shape in both sexes (curved ventrally in male and straight in females), elongate-conoid proximally and subcylindrical distally. Spinneret functional. The males are 877-1043 μm long, ventrally curved upon fixation with several somatic setae scattered along the whole body. Reproductive system diorchic with anterior testis outstretched, and the posterior one reflexed. Spicules paired, symmetrical. Accessory apparatus composed by four pre-cloacal tubular supplements are always present with no alveolar supplements.

REACTION OF *Capsicum* spp. GENOTYPES TO *Meloidogyne enterolobii* [REACCIÓN DE GENOTIPOS DE *Capsicum* spp. A *Meloidogyne enterolobii*].

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The nematodes of the *Meloidogyne* genus cause galls and have several species already identified. However, *M. enterolobii* has been highlighted due to its high

polyphagy and aggressiveness. The aim of the present study was to evaluate the host suitability of 66 *Capsicum* spp. genotypes to *M. enterolobii* in order to identify genetic resistance. The genotypes were evaluated under greenhouse conditions in a completely randomized design (CRD), with 10 replications. Seedlings were prepared in trays and transplanted 30 days after germination. Inoculation was performed one day after transplanting using 4,000 eggs + second-stage juveniles (J2) of *M. enterolobii*/plant. Sixty days after inoculation, nematodes were extracted from the roots to determine the nematode population density (PD = nematodes/g of root) and the Reproduction Factor (RF) by dividing the final population by the initial population (RF = Fp/Ip). Genotypes with RF < 1.0 were considered resistant to *M. enterolobii*. Seventeen *Capsicum* genotypes with resistance to *M. enterolobii* were identified, consisting of 10 genotypes belonging to *C. annuum*, three genotypes to *C. chinense*, two genotypes to *C. baccatum* and two genotypes to *C. frutescens* species. The population density of nematodes among genotypes with resistance ranged from 4 to 2,069 nematodes/g and in genotypes with susceptibility, it ranged from 516 to 2,452 nematodes/g of roots.

TRADE OFFS BETWEEN RESISTANCE BREAKING AND FITNESS COST IN ROOT-KNOT NEMATODES [COMPENSACIONES ENTRE LA RUPTURA DE LA RESISTENCIA Y EL COSTO DE APTITUD EN NEMATODOS AGALLADORES].

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Root-knot nematodes (RKNs), are among the most devastating pathogens of crops, causing substantial yield and economic losses worldwide. These parasitic organisms can infect over a hundred different plant species and can evade plant defense mechanisms by secreting a concoction of effectors. For decades, the *Mi-1* resistance gene has been effective in detecting and inhibiting RKNs in tomatoes. However, the underlying mechanisms by which *Mi-1* detects these pathogens remain largely unknown. In recent years, resistance-breaking populations have emerged in both greenhouse and field settings, posing a threat to the potency and effectiveness of the *Mi-1* gene and, consequently, the tomato industry. We used two strains of *M. javanica*, one strain VW4, which is recognized by *Mi-1*, and another strain, VW5, which was selected from VW4 and can overcome resistance mediated by *Mi-1*. Utilizing the newly constructed reference genome for *M. javanica* (VW4), we compared genomes of VW4 and VW5 and identified an approximately 650 kb region that is present in VW4 but missing in VW5. This missing region contains ten protein-coding genes, three of which encode putative effectors and are currently being tested as potential avirulence genes for *Mi-1*. In addition, we have conducted a series of infection assays on different host plants lacking *Mi-1*, and the results revealed a significantly lower egg count in VW5 when compared to VW4. We plan to expand these assays by testing additional *M. javanica* resistance-breaking strains collected from fields all over California to determine if this trade-off is consistent across other strains. Overall, our results suggest that although VW5 can overcome *Mi-1*, there is a trade-off in the form of compromised reproduction. This research helps to better understand the

mechanism and components of *Mi-1* and develop strategies for addressing resistance-breaking populations.

FLORIDA STRAWBERRIES BEYOND THE UNITED STATES: HOW EGYPT BECAME A GLOBAL LEADER IN STRAWBERRY PRODUCTION [FRESAS DE LA UNIVERSIDAD DE FLORIDA MÁS ALLÁ DE LOS EE. UU.: “CÓMO EGIPTO SE CONVIRTIÓ EN UN LÍDER MUNDIAL EN LA PRODUCCIÓN DE FRESA].

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Egypt's Mediterranean climate provides for profitable strawberry production. Three main regions, El Beheira, Al Qalyubia and Ismailia governorates and three emerging regions, Sharqia, Dakahlia and Menofia governorates have suitable climate year-round and have fertile soils. Cultivars used by Egyptian strawberry growers are bred by the University of Florida (UF) and introduced by EMCO CAL GROUP during the past three decades. These cultivars can be grown under the hot climate conditions of September which allows production in Egypt to start in early November resulting in production of high yields. This time period coincides with a reduction in fresh strawberry volume on the worldwide market and thus higher prices for Egyptian grown strawberries. The cool season in Egypt stretches into the early spring, allowing a long export window to Europe, the Middle East, and other countries in Asia and Africa. The current total hectares of strawberries grown in Egypt is about 17,000 ha or more with

a total production of 471,000 MT in 2022. Before 1990, Egyptian growers grew frigo fruiting plants (dormant frozen bare root plants) of high-chill strawberry cultivars that were produced by nurseries in high-chill locations outside of Egypt. These frigo fruiting plants were shipped into Egypt and were planted from early September until mid-October - producing fruit from mid-February until May. The average total production under this system was around 3 MT/ha. Later, the EMCOCAL Group transformed the Egyptian strawberry industry by introducing the UF low and zero chill winter strawberry cultivars as frigo bare root mother plants in mid-March early April for propagation inside of Egypt to produce fresh green plants in low and zero chill nursery conditions. The resulting fruiting plants were planted in September/October (same time as the old high-chill cultivars), but they started producing fruit in November (3 months earlier than the old high-chill cultivars). With this new market window, better fruiting plant economics, phytosanitary security, and at least a 91% yield increase per ha, Egypt became a dominant player in the high value winter strawberry market in the EU and Middle East. The EMCOCAL Group's continual flow of new UF strawberry cultivars into Egypt has ensured that the Egyptian industry has remained strong. The Egyptian export market currently includes over 72 countries for individually quick-frozen (IQF) products. The total IQF export increased from 97,000 MT in 2018 to 246,000 MT in 2022. Egypt is leading the world in IQF exports since 2019 with almost 55% total world export of which 52% exported to EU countries, 15.3% to the Middle East and the remainder to other countries. The total fresh exports ranged from 29,000-43,000 MT during the last 5 years. Currently, Egypt exports fresh strawberries to 52 countries with 35 % to the EU, 54% to the

Middle East and 11% to other countries. Nematodes are one of the most important economic pest problems, infecting strawberry plants in both nursery and production fields. Although limited research has been done, the most common plant-parasitic nematode genera identified in strawberry fields in Egypt are *Meloidogyne*, *Ditylenchus*, *Hoplolaimus*, *Pratylenchus*, *Trichodorus*, *Tylenchorhynchus*, and *Xiphinema* species.

SCHISTOSOMIASIS CONTROL: THEODOR BILHARZ INSTITUTE'S CONTRIBUTIONS [CONTROL DE LA ESQUISTOSOMIASIS: CONTRIBUCIONES DEL INSTITUTO THEODOR BILHARZ]

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Theodor Bilharz Research Institute (TBRI) is a nonprofit governmental medical research institute, affiliated with the Ministry of Higher Education and Scientific Research. The TBRI mission is to promote R&D for prevention and management of endemic diseases and their complications. TBRI research members, in addition to the medical services they offer, are true originators of research. Research wise, production of home-made antigen detection kits for diagnosis and cure monitoring of active schistosomiasis, a locally produced mAb in-field applicable diagnosis of schistosomiasis and the development of mAb gold-based lateral flow assay for CSA detection were achieved. TBRI shared in the 'WHO Schistosome Genome Project', the development of successful recombinant DNA vaccines. Regarding specific chemotherapy, members showed equal efficacy and bioavailability of the local

praziquantel (PZQ) brand Distocide compared to the foreign one, thus, reducing the cost of importing Bitricide. Members demonstrated lack of evidence for the activity of a newly introduced antischistosomal Mirazid, preventing infected Africans from using an ineffective drug and delaying schistosomiasis control. Because schistosomiasis control has been centered on a single drug PZQ, new schistosome isolates with variable sensitivity were identified, revealing the need for alternatives. Existing drugs are targeted to save cost, and effective derivatives of PZQ were discovered using an innovative, scalable cheaper synthetic approach. Trials to improve PZQ utilized a novel nano-delivery system, achieving a reduced drug ED50 and availing a chance to increase the dose. In an EU sponsored project, some imidazole compounds such as phosphodiesterase inhibitor 10 A, demonstrated antischistosomal potential against the egg with equipotent activities against immature and mature worms. Meanwhile, the Schistosome Biology Supply Center screened 9,000 compounds, using an in vitro adult worm assay in a WHO/TDR* Drug Discovery Network. Control of the snail intermediate host was targeted using biological and chemical approaches in laboratory and simulated field conditions. Medical services such as cystectomy to manage bilharzial bladder cancer involved 600 cases since 1985. Transurethral urinary bladder resection comprised > 2,000 cases. With respect to hepatosplenic schistosomiasis, the endoscopy and hepatic coma resuscitation units provided injection sclerotherapy and band ligation for bleeding varices and care for patients with end stage liver disease. The current low schistosomiasis prevalence in Egypt approaches elimination. However, recent findings of active transmission foci along the Nile riverbanks of greater Cairo, an overall 13% prevalence in some hot spots in Lower Egypt governorates, and

declining PZQ efficacy in some African countries such as Côte d'Ivoire should be proactively addressed. The Special Program for Research and Training in Tropical Diseases, is a global program of scientific collaboration that helps facilitate, support and influence efforts to combat diseases of poverty. It is co-sponsored by the United Nations Children's Fund (UNICEF), the United Nations Development Program (UNDP), the World Bank and the World Health Organization (WHO).

***Meloidogyne spartinae*: A CLOSER LOOK AT THIS UNIQUE ROOT-KNOT NEMATODE SPECIES [Meloidogyne spartinae: UNA MIRADA MÁS CERCANA A ESTA ESPECIE ÚNICA DEL NEMATODO AGALLADOR].**

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Meloidogyne spartinae was first found infecting roots of cordgrass (*Spartina alterniflora*), a member of the Poaceae family (Grass family) collected in Marineland, Florida, USA in 1958 and described as *Hypsoperine spartinea* in 1965 from a sample of cordgrass collected in South Carolina. In 1968, it was placed in the genus *Meloidogyne* by Whitehead, A. D. This nematode species is known to occur only in the USA. Cordgrass is a common saltwater-tolerant plant of tidal marshes growing where the water has a NaCl level of approximately 2.1%. Ecologically speaking, this is a unique root-knot nematode in that it is the only coastal root-knot nematode species currently known to be found in the intertidal zone and not on sand dunes, as *M. dunensis*, *M. duytsi* and *M. maritima*, which have been described from Europe on sea rocket (*Cakile*

maritima), beach grass (*Elymus farctus*) and marram grass (*Ammophila arenaria*), respectively, with the latter two plant hosts also belonging to the Poaceae family. In addition to Florida, *M. spartinae* has been reported in Georgia, Connecticut, Maine, Massachusetts, North and South Carolina, New Jersey, and New York. Since its description, very little is known about this nematode species. As an attempt to acquire more biological, ecological, taxonomical, and phylogenetic information, cordgrass samples infected with *M. spartinae* were collected at the type locality. Infected roots show circular to ovoid terminal galls, a typical symptom induced by this nematode species. Females don't produce egg masses; eggs are laid freely inside of the galls. Juveniles (J2), males, females, and eggs were clearly visible inside of the galls. Several male and female specimens were regularly observed inside a single gall. Previous studies showed that J2 withstand a wide range of salinity, including 1.0M NaCl for at least 12 days. Species identification performed using morphological analyses were consistent with the original description. The phylogenetic relationship of *M. spartinae* with other *Meloidogyne* spp. are still in progress. However, biochemical analysis performed didn't detect any esterase activity even when using 10 egg-laying females per well (EST= 0), but show malate dehydrogenase activity (N1b), a unique phenotype and reported only for *M. artiella*, *M. fallax* and *M. panyuensis*.

ASSESSING THE EFFICACY OF NEMATICIDES AS AFFECTED BY SOIL CONDITIONS AND APPLICATION METHODS [EVALUACIÓN DE LA EFICACIA DE LOS NEMATICIDAS EN FUNCIÓN DE LAS CONDICIONES DEL SUELO Y LOS MÉTODOS DE APLICACIÓN].

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For decades, methyl bromide was the standard soil fumigant for managing root-knot nematodes (RKN, *Meloidogyne* spp.) worldwide. Since its phase-out due to being an ozone depleter, 1,3-dichloropropene, chloropicrin, and metam-based products have taken its place. Until recently, oxamyl, an old carbamate insecticide/nematicide, was the only non-fumigant nematicide available to growers. In recent years, two new products, fluensulfone (Nimitz®) and fluopyram (Velum®), have become available, and another one, fluazaindolizine (Salibro™) will be available later in 2023. These products have a much better safety profile; however, their efficacy is not always as good and consistent as chemical fumigants due to several factors such as soil type, soil temperature, and application method and timing. Two greenhouse experiments were conducted to test the efficacy of fluopyram, fluensulfone, fluazaindolizine and oxamyl at three soil temperatures (5, 15 and 25°C) against root-knot nematode (*M. javanica*) in pasteurized and natural (unpasteurized) soil. The efficacy of all tested nematicides was greater in pasteurized soil compared to natural soil. Temperature affected the nematicides differently with no effect of soil temperature noted for oxamyl and fluazaindolizine, while fluopyram and fluensulfone had greater efficacy at higher soil temperatures. The effect of the application method (one or two drip tapes) was evaluated for the same nematicides, as well as for the fumigant metam potassium, in four field trials at the GCREC research farm. The field soil is fine sand (> 95% sand) and was naturally infested with *M. javanica*. The crops were cucumber and

squash, which were grown on plastic-mulch raised beds. Nematicide applications via double drip tapes resulted in lower root gall infection (and tend to have higher yield) as compared to a single tape for fluopyram, but no difference was noted between single and double drip tapes for oxamyl and fluazaindolizine. Fluensulfone response was somewhere in between and metam potassium had higher squash yield when applied with double drip tapes. Root-knot infection was higher in cucumber than in squash, and metam potassium had the highest yields and lowest nematode infection compared to other nematicide treatments. Our studies have shown that soil temperature and application methodology can affect the efficacy of new reduced-risk nematicides. More research is needed to further understand and identify what are the best conditions and practices to improve the efficacy and consistency for these new nematicides. This research will further improve their adoption by growers and provide them with safer and more environmentally friendly nematode management options.

MOLECULAR IDENTIFICATION AND MORPHOLOGICAL CHARACTERISTICS OF POTATO CYST NEMATODE ISOLATED FROM OTUZCO AND JULCAN IN LA LIBERTAD-PERU [IDENTIFICACIÓN MOLECULAR Y CARACTERÍSTICAS MORFOLÓGICAS DEL NEMATODO DEL QUISTE DE LA PAPA AISLADO DE OTUZCO Y JULCAN EN LA LIBERTAD-PERÚ].

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Potatoes have the greatest cultivated area in Peru, with approximately 305,000 hectares, accounting for 25% of the agricultural GDP. Growers in the provinces of Otuzco and Julcan in the department of La Libertad report reduced plant development and significant yield losses due to the presence of the potato cyst nematode (*Globodera* spp.). The goal of this study was to identify the *Globodera* spp. species found in the potato growing areas of Otuzco and Julcan in La Libertad, Peru. Soil and root samples were collected from farmers' farms in the research locations for this purpose. The average number of cysts in 100 cc of soil in 5 grams of roots was determined in each location studied. Twenty cysts were collected from each sample and processed to assess the number of striae, the distance between vulva and anus, the diameter and form of the fenestra, and Graneck's radius. Bayesian inference was used to identify the genes using concatenated sequences of COI and ITS markers. The average number of cysts in soil and roots, as well as Graneck's radius, were 612, 15 and 3 in Otuzco samples, and 870, 21 and 2 in Julcan samples, respectively. The sequences were clustered in a separate clade than *Globodera mexicana* and *G. pallida* in the phylogenetic tree, with no indication of recombination between the *Globodera* species documented so far, hence, it is regarded a probable new species harming potato production in Mexico.

EFFECT OF JOINT APPLICATIONS OF ENTOMOPATHOGENIC

NEMATODES AND DIATOMACEOUS EARTH ON MORTALITY OF *Harmonia axyridis* (PALLAS) [EFECTO DE APLICACIONES CONJUNTAS DE NEMATODOS ENTOMOPATÓGENOS Y TIERRA DE DIATOMEAS SOBRE LA MORTALIDAD DE *Harmonia axyridis* (PALLAS)].

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Entomopathogenic nematodes (EPNs) and diatomaceous earth (DE) have been successfully used separately as pest management strategies. There are currently no published studies analyzing their combined effect on insects' mortality, but preliminary observations showed an increase in the mortality of *Harmonia axyridis* (Coleoptera: Coccinellidae) adults treated with DE immediately before their exposure to EPNs. The present study sought to verify that DE increases the control effect of EPNs on the host, decreasing the number of individuals necessary to produce its death. For this, an experiment was carried out where the mortality of *H. axyridis* was measured in treatments that combined the application of DE by spraying a liquid solution on the coccinellids and six doses of IJ of *Heterorhabditis* sp. isolate 32913. The results showed that, although higher mortality was reached in treatments with prior application of DE, there was no significant interaction between factors ($P > 0.05$). However, a significant effect of the DE and EPNs acting separately was observed from 72 h post-application for DE and from 168 h in the case of EPNs ($P < 0.05$). In addition, no significant

difference was observed in the number of IJs that entered the insects in treatments with previous application of DE in comparison with those without application ($P > 0.05$). Both the lethal dose (LD50) and lethal time (LT50) of treatments with and without DE application decreased as the dose of IJs increased. When dissecting the coccinellid corpses either exposed or non-exposed to DE, no significant differences were detected in the percentage of cadavers in which EPNs were found, and in all cases, they were dead, and no IJs exited from the corpses after ten days in White traps. Based on this observation, another experiment was conducted using the hanging drop method with *H. axyridis* or *Galleria mellonella* (Lepidoptera: Pyralidae) hemolymph, where the mortality of IJs in *H. axyridis* hemolymph was significantly higher than in *G. mellonella* hemolymph ($p < 0.05$), which could be the result of a particular efficiency of the *H. axyridis* immune system. The results obtained and the studies derived from this research will make it possible to advance in research lines related to the optimization of the use of EPNs in conjunction with other alternatives included in integrated pest management programs.

ORGANIC BLOOM® IN THE *Meloidogyne javanica* CONTROL AND RESISTANCE INDUCTION IN SOYBEAN [ORGANIC BLOOM® EN EL CONTROL DE *Meloidogyne javanica* Y LA INDUCCIÓN DE RESISTENCIA EN SOJA].

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Nematodes are important pathogens that cause increasing losses in Brazilian agriculture, particularly in the soybean crop. Among them, *Meloidogyne javanica* is one of the main species with widespread occurrence in the country. Thus, the global interest in sustainable agriculture has driven the development of alternative methods for disease control, and in this context, Organic Bloom® is a biofertilizer that combines bioactive amino acids and phytic acid that can be an efficient alternative for controlling these pathogens. Thus, this study aimed to evaluate the potential of Organic Bloom® in controlling *M. javanica* in soybean and its effects on plant defense enzymes. The experiment was conducted in a greenhouse, in a completely randomized design, with eight replications. For the nematode reproduction experiment soybean were submitted to the treatments: Organic Bloom® at a dose of 0.5 L/ha into the furrow; Organic Bloom® at a dose of 0.25 L/ha as seed treatment; Organic Bloom® at a dose of 0.5 L/ha into the furrow + 0.25 L/ha as seed treatment; and, Control without treatment. To evaluate defense-related enzyme activity, soybeans were submitted to the treatments: Organic Bloom® at a dose of 0.5 L/ha into the furrow + 0.25 L/ha as seed treatment; Control without treatment. In all treatments, except control, foliar spraying of Organic Bloom® was performed at a dose of 0.30 L/ha in V4 and R1 soybean growth stages. Each plot consisted of one plant, sown in a pot containing 950 mL of the autoclaved substrate, in a proportion of 1:1 (soil: sand). At four days after germination, the plants were inoculated with 2000 eggs + eventual second-stage juveniles (J2) of *M. javanica*. At 6, 9, and 12 days after inoculation, was evaluated the production of peroxidase (POX), phenylalanine ammonia-lyase (PAL), catalase (CAT), and polyphenol oxidase

(PPO) in the root system of the plants and after 60 days the nematode reproduction was evaluated. All treatments with Organic Bloom® reduced the number of nematodes per gram of root, with maximum control when the product was applied by seed treatment (64.2%). Organic Bloom® product promoted an increase in the specific enzymatic activity of PAL, POX, PPO and CAT, mainly at 6 days after inoculation. It is concluded that Organic Bloom® has the potential to control *M. javanica* in soybean increasing the activity of enzymes related to plant defense.

EFFICACY OF DIMETHYL DISULFIDE (DMDS), INNOVATIVE SUSTAINABLE SOIL TREATMENT VERSUS METHYL BROMIDE IN STRAWBERRIES AND VEGETABLE PRODUCTIONS [EFFICACY OF DIMETHYL DISULFIDE (DMDS), INNOVATIVE SUSTAINABLE SOIL TREATMENT VERSUS METHYL BROMIDE IN STRAWBERRIES AND VEGETABLE PRODUCTIONS].

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Dimethyl disulfide (DMDS) is an innovative and modern technology for sustainable soil treatment which is used before planting to control nematodes, weeds, and soil pathogens. DMDS is a substance which is present naturally in the environment. The efficacy results of DMDS and more particularly for the control of nematodes have been widely published. Methyl bromide was listed

under the Montreal Protocol as a controlled ozone depleting substance in 1992. The control measures, agreed by the Parties at their ninth meeting in Montreal in September 1997, were for phase out of methyl bromide by 1 January 2005 in non-Article 5 countries. For Parties operating under Article 5 of the Protocol (developing countries) the control measures were for a 20% cut in production and consumption, based on the average in 1995-98, from 1 January 2005 and phase out by 1 January 2015. In Mexico, four trials have been carried out in protected crops (cucumber, tomato & strawberry production) in shank and drip application to assess the effectiveness on soil borne pathogens including nematodes in comparison with a mixture of methyl bromide and chloropicrin, MB/C. These trials have been carried out under compliance with Good Experimental Practices by the University of Agronomy of Sinaloa. DMDS at the rates of 300, 400 & 500kg/ha has been compared with MB/C at 500kg/ha. Results of these trials have shown an efficacy for DMDS equal or higher to MB/C and confirm that DMDS, having a favorable toxicological profile, is the alternative to methyl bromide over the world since 2015.

FTA-LAMP BASED BIOSENSOR FOR A RAPID IN-FIELD DETECTION OF *Globodera pallida* - THE PALE POTATO CYST NEMATODE [BIOSSENSOR BASADO EN FTA-LAMP PARA UNA DETECCIÓN RÁPIDA EN CAMPO DEL NEMATODO PÁLIDO DE LA PAPA – *Globodera pallida*].

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The combination of a sensitive and specific magnetoresistive sensing device with an easy DNA extraction method and rapid isothermal amplification is presented in this study targeting the on-site detection of *Globodera pallida*, a potato endoparasitic nematode. FTA (Flinders Technology Associates) cards were used for DNA extraction, LAMP (Loop-mediated isothermal amplification) was the method developed for DNA amplification and a nanoparticle functionalized magnetic biosensor was used for the detection. The combination of these three technologies allowed the detection of *G. pallida* with a detection limit of one juvenile, even when mixed with different ratios of other closely related species. The results reveal the suitability of the magnetic biosensor to detect the LAMP target product and the specificity of the probe, which consistently distinguishes *G. pallida* (DV/Vsensor > 1%) from other cyst nematodes (DV/Vsensor < 1%) regardless the extraction method used. It was confirmed that DNA either extracted with FTA cards or from mixed samples was of enough quantity and quality to detect *G. pallida* whenever present. This work provides insights for a new strategy to construct advanced devices for pathogens in-field diagnostics. LAMP runs separately; however, it can be easily integrated into a single device.

ENHANCING THE EFFICACY OF ENTOMOPATHOGENIC NEMATODES

FOR BIOLOGICAL CONTROL OF *Lobesia botrana* IN VINEYARDS [MEJORA DE LA EFICACIA DE LOS NEMATODOS ENTOMOPATÓGENOS PARA EL CONTROL BIOLÓGICO DE *Lobesia botrana* EN VIÑEDO].

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Entomopathogenic nematodes (EPN) are well-known biological control agents for numerous soil pests. Traditionally, EPN use in vineyards has been poorly explored, mainly because in this agroecosystem, most arthropod pests attack the aboveground area. However, current EPN aerial application technology development and adjuvants have facilitated their expansion to novel crops, including vineyards. The European grapevine moth *Lobesia botrana* (Lepidoptera: Tortricidae) is one of the major pests detected in vineyards worldwide. Expanding the available management tools for this pest aligns with the goals of sustainable agriculture. Recent laboratory studies demonstrated that EPNs can kill various developmental stages of *L. botrana*. We hypothesized that we can provide specific recommendations for field implementation by selecting the best-authorized adjuvant for combination with EPN and unraveling the best timing and area to be applied. Also, determined their possible combined application, exploring the compatibility with agrochemicals commonly used for managing other biotic threats in the vineyards, saving costs to growers. This study aimed to identify the optimal combination of EPN- adjuvant, grapevine

target area, timing (season/temperatures) for controlling *L. botrana*, and compatibility with agrochemicals often used in vineyards. The study involved several components: (i) examining the survival, viability, and adherence on grapevine leaves of EPN-adjuvant mixture (Multi-Us, Maximix, and their combination), (ii) assessing the protective capabilities of the EPN-adjuvant by measuring *L. botrana* mortality and damage reduction on leaves and grapes, (iii) evaluating EPN activity against *L. botrana* at various temperatures (22°C, 15°C, and 10°C) in trunk bark approach, simulating the overwintering period, and (iv) estimating the impact of the combination selected agrochemicals (Sonata, Sulfur, Copper, Ridomil, and Flint) with EPN on their viability and infectivity. All the EPN-adjuvants mixtures were compatible with *S. feltiae* and *S. carpocapsae*. Compared to the no-application treatment, EPN alone or combined with Maximix has significantly increased their control of *L. botrana* larvae (L3) on grapes and leaves, resulting in reduced damage. The study also showed that EPN control on *L. botrana* pupae was reduced as temperatures decreased, with the lowest efficacy observed at 10°C. The addition of Maximix did not enhance the efficacy of EPNs in this scenario of low temperatures. Finally, overall, the agrochemicals Sulfur and Copper might negatively impact the viability of the EPN *S. feltiae*, but infectivity was not affected. This study demonstrated that EPNs are compatible with all the adjuvants tested and several agrochemicals (except Sulfur and Copper in some cases), allowing their combined application in the field. EPN also reduced the damage caused by *L. botrana* larvae on leaves and grapes, alone or combined with Maximix. However, this adjuvant did not enhance its efficacy against *L. botrana* pupae in trunk bark. The study suggests applying EPNs during

sunset and late spring/early autumn when targeting mid-temperatures (22°C-15°C). Further field validation is necessary to implement these findings in practical settings fully.

ENHANCING BIOCONTROL OF TOMATO LEAFMINER (*Tuta absoluta*) USING SPECIALIZED ENTOMOPATHOGENIC NEMATODES AND SYMBIOTIC BACTERIA [MEJORAMIENTO DEL CONTROL BIOLÓGICO DE LA POLILLA DEL TOMATE (*Tuta absoluta*) UTILIZANDO NEMATODOS ENTOMOPATÓGENOS ESPECIALIZADOS Y SUS BACTERIAS SIMBIONTES].

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Entomopathogenic nematodes (EPNs) and their symbiotic bacteria have been investigated as potential biocontrol agents for various pests; however, their efficacy has shown variability in some pests. This study aimed to optimize the effectiveness of EPNs and their associated bacteria against the tomato leafminer. Initially, 12 EPN strains were evaluated, and two strains with the highest and lowest mortality rates on insect larvae were selected. These strains were continuously reared using the pest as a host, and their biocontrol performance was compared to that of their non-specialized population (counterparts bred on *Galleria mellonella*). The symbiotic

bacteria associated with the selected EPNs were isolated from dissected juvenile nematodes and cultured in LB medium supplemented with or without crushed tomato leafminer larvae. The bacterial suspension was assessed by spraying it on tomato leaves and placing it with the pest larvae in Petri dishes. RNA-seq analysis was conducted to identify gene expression changes the bacteria growth treatments induced. Results showed that the selected EPN strains, namely *Steinernema feltiae* CH4 and *Heterorhabditis atacamensis* 31936, exhibited similar and significant efficacy in terms of pest mortality (i.e., 100% efficacy) after eight rounds of infecting tomato leafminer larvae, indicating superior performance of specialized *H. atacamensis* nematodes over their counterparts bred on *G. mellonella*. In the case of symbiotic bacteria, laboratory experiments demonstrated the effective eradication of tomato leafminer larvae (L4) by *X. bovienii* CH4 (derived from *S. feltiae*) and *P. antumapuensis* UCH-936 (derived from *H. atacamensis*), particularly when cultured in LB medium supplemented with the pest larvae. Notably, UCH-936 displayed the highest mortality rates ($P < 0.05$). However, under greenhouse conditions, *P. antumapuensis* UCH-936 showed inadequate insecticidal efficacy in protecting plants from pest damage (incidence and severity) ($P < 0.05$). Transcriptomic analysis revealed a significant upregulation of genes associated with the production of the insecticidal protein TcbA and other infective process genes in the UCH-936 strain, particularly when the culture medium was supplemented with pest larvae. These findings highlight the potential of symbiotic bacteria, especially *P. antumapuensis* UCH-936, as biocontrol agents against tomato leafminer larvae. Moreover, modifying the bacterial multiplication substrate holds promise for enhancing their insecticidal capacity. It

would also be interesting to evaluate these specialized bacteria in nematode-fitness improvement. Further investigations should prioritize improving the efficacy of symbiotic bacteria under greenhouse conditions, including the development of suitable formulations.

SEARCHING FOR NATURAL ENEMIES OF PLANT-PARASITIC NEMATODES IN CALIFORNIA [BÚSQUEDA DE ENEMIGOS NATURALES DE NEMATODOS PARÁSITOS DE PLANTAS EN CALIFORNIA].

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Plant-parasitic nematodes pose a significant threat to agriculture as they feed on plant tissues leading to reduced nutrient uptake and scar tissue formation on the roots. Some of the most destructive nematodes include root-knot nematodes (*Meloidogyne* spp.), lesion nematodes (*Pratylenchus* spp.), and ring nematodes (*Criconeema* spp.). The plant's first line of defense begins in the soil rhizosphere, where an active microbiome can suppress infection by pathogens. While synthetic chemicals, resistant crops, soil solarization, and crop rotation are commonly used to mitigate nematode problems, these methods can be ineffective and harmful to the environment and workers. With toxic nematicides like methyl bromide being phased out, sustainable alternatives are urgently needed. Biological control, which utilizes natural enemies in the ecosystem, is an increasingly favorable option. Promising candidates that naturally antagonize plant-parasitic nematodes may be found in suppressive soils. This

research focuses on identifying a potential biological control agent that targets plant-parasitic nematodes. Starting with almond orchards in California, nematodes will be extract from soil samples, isolate plant-parasitic nematodes, and identify the bacteria associated with these nematodes using 16S rRNA gene sequencing. Additionally, a soil solution will be used to bait bacteria with native nematodes and with lab cultures of *Meloidogyne* spp. After identifying the nematode-associated bacteria; bioassays will be conducted to evaluate nematicidal activity. Finally, I aim to uncover the molecular pathway involved in the biological control agent's nematicidal activity. This project will test the hypothesis that suppressive soils contain microbes that exhibit nematicidal activity by: 1) characterizing nematode-associated microbes in soil, 2) identifying bacteria with antagonistic effects on plant-parasitic nematodes, and 3) understanding the molecular mechanisms of control.

CHARACTERIZATION OF SECONDARY METABOLITES OF *Photorhabdus* BACTERIA OF *Heterorhabditis indica* AND THEIR BIOACTIVITY TEST ON TARGET AND NON-TARGET INSECTS [CARACTERIZACIÓN DE METABOLITOS SECUNDARIOS DE BACTERIAS *Photorhabdus* DE *Heterorhabditis indica* Y SU BIOACTIVIDAD EN INSECTOS DIANA Y NO DIANA].

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Regular application of agrochemicals causes negative environmental impacts and fosters the development of insect resistance. In addition to being

environmentally safe, entomopathogenic nematodes (EPN) and their mutualistic bacteria have the potential to be used as a bio-pesticide with quick action and effective insecticidal characteristics against insect pests. In the present study, the pathogenicity of the most efficacious isolates of *Heterorhabditis bacteriophora* was tested on the larvae of the target insect *Spodoptera litura* and non-target *Apis* sp. The bacteria of all the efficacious isolates were used to produce secondary metabolites. Crude extracts of eight bacterial isolates i.e. EPB-CH5, EPB-CH7, EPB-CH22, EPB-CH23, EPB-CH28 and EPB-CH29 (*Photorhabdus luminescens*); EPB-CH27 (*Pseudomonas* sp.) and EPB-CH30 (*Acinetobacter* sp.) were chemically analyzed by TLC; ATR-FTIR analysis and GC-MS. The isolated compounds from the crude extract of all the isolates except EPB-CH5 i.e., cyclic dipeptide (diketopiperazine derivative) and pyrrolo [1,2-a]pyrazine-1,4-dione; hexahydro- and N-hexadecanoic acid were common with mass/charge ratios (m/z) with area % after GC-MS analyses. Similarly bioactive compound benzaldehyde, 3-[4-(1,1-dimethylethyl)phenoxy]- was found common in isolates EPB-CH23, EPB-CH30, EPB-CH5 and EPB-CH7. Some unique compounds were fractionated from the secondary metabolites from different bacterial strains like D-valine from EPB-CH5, Octadec-9-enoic acid from EPB-CH7; 3-methyl-1,4-diazabicyclo [4.3.0] nonan-2,5-dione, N-acetyl from EPB-CH30; oleic acid and 1,2-benzenedicarboxylic acid from EPB-CH29, phenol, 3,5-bis(1,1-dimethylethyl), dibutyl phthalate, oleic acid, cis-vaccenic acid from EPB-CH28, 1-butanamine, N-(1-propylbutylidene) from EPB-CH27, and heptadecene-(8)-carboxylic acid-(1) and cis-vaccenic acid from EPB-CH23. The bioactivity screening of all the isolated compounds was performed *in vitro* on target (*Spodoptera litura*) and non-target

(*Apis* sp.) insects. In antibacterial screening, EPB-CH30 (*Acinetobacter* sp.) strain extracts showed the highest sensitivity against all the tested bacterial strains CCSUB543 (*Bacillus* sp.), CCSUB459 (*E. coli*), CCSUB174 (*Pseudomonas* sp.) and CCSUB2019 (*Streptococcus* sp.) but had the least susceptibility against the CCSUB543 (*Bacillus* sp.) and CCSUB459 (*E. coli*). In antifungal activity, Crude extract of different bacterial strains inhibited the mycelial growth of fungi *Aspergillus niger* (CCSUF264). Strains EPB-CH29 and EPB-CH30 were highly sensitive. On the contrary, the EPB-CH22 and EPB-CH30 strains had moderate susceptibility, and no Zone of Inhibition was seen in all the studied concentrations. EPB-CH27, EPB-CH28, and EPB-CH30 strain extracts showed the highest activity against targeted insects (*S. litura*) at all concentrations tested (10%, 25%, 50%, 75%, and 100%). Similar results were obtained against non-targeted insects (*Apis* sp.) at all concentrations tested at 24h intervals. Some of the unique bioactive compounds isolated, i.e., D-valine, octadec-9-enoic acid, and oleic acid, having a variety of biological attributes, may be used in pharmaceuticals, agriculture pest control and other applicable branches of bioscience based on their bioactive properties.

MORPHOTAXOMETRICAL AND MOLECULAR IDENTIFICATION OF ENTOMOPATHOGENIC NEMATODES FROM INDIAN SUBCONTINENT [IDENTIFICACIÓN MORFOTAXOMÉTRICA Y MOLECULAR DE NEMATODOS ENTOMOPATOGENOS DEL SUBCONTINENTE INDIO].

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India is the second largest country in terms of population and seventh largest in terms of area in the world. However, from a biodiversity point of view, India is a biodiversity hotspot with diverse species of flora and fauna. Classical taxonomy, based on morphological characters, is extremely important for identification of nematodes to species as morphology of an organism to a great extent, is a clear manifestation of its genetic makeup. Entomopathogenic nematodes (EPNs) have been reported from all continents (except Antarctica) and almost all regions of the world. However, from Indian soils, little diversity of EPN has been reported. Meerut Division (latitude 28.98002 and longitude 77.70636), is considered hub of sugarcane production, which is seriously affected by soil dwelling pests. Few reports of EPNs have been reported from these regions due to lack of experts in this field. Therefore, the present study was conducted for isolation and recognition of the aboriginal isolates of EPNs associated with the soil samples of 4 districts of Uttar Pradesh province, India including the divisions of Meerut, Baghpat, Bulandshahr and Bijnor. A total 860 soil samples were collected and processed for the isolation of EPNs. Out of total collected samples, 41 samples (4.8%) were found positive for EPN species, of which 26 were *Steinernema* and 15 were *Heterorhabditis*. These nematodes were subjected to morphotaxometrical and molecular identification. Based on internal transcribed spacer (ITS) rDNA and D2D3 rDNA sequences, they were identified as *S. abbasi* (11 isolates), *S. siamkayai* (10 isolates), *S. surkhetense* (2 isolates), *S. pakistanense* (2 isolates), *S. hermaphroditum* (1 isolate), *H. indica* (14 isolates) and *H. bacteriophora* (1 isolate). Among these, three species, *S.*

pakistanense, *S. surkhetense* and *S. hermaphroditum* were reported for the first time from Indian soils and *H. bacteriophora* reported for the first time from Uttar Pradesh. A high prevalence of EPNs was observed in Bulandshahr (34%) followed by Meerut (32%), however, in Meerut and Baghpat, 17% prevalence were found in each district. The most dominant species was *S. abbasi* for steinernematids and *H. indica* for heterorhabditids in almost all the districts sampled. Most of the nematode infective juveniles were isolated from agricultural soils and only one isolate from Bijnor (*H. indica* CH15, Accession No. MH203008) was obtained from open fields, while none were obtained from insect bodies directly. The study indicates that soil is a fundamental niche of EPNs, and they are common in cultivable and non-cultivable soils. The GenBank records revealed that *S. abbasi*, *S. pakistanense*, *S. siamkayai* and *H. indica* are widespread in Indian subcontinent, reported from most states within the country, while *S. surkhetense*, *S. hermaphroditum*, and *H. bacteriophora* have fewer GenBank records.

POTENTIAL OF USING ENTOMOPATHOGENIC NEMATODES AND ENTOMOPATHOGENIC FUNGI AS BIOLOGICAL CONTROL AGENTS AGAINST COCONUT RHINOCEROS BEETLE, A KEY PEST OF COCONUT PALMS IN HAWAII [POTENCIAL DE USO DE NEMATODOS Y HONGOS ENTOMOPATÓGENOS COMO AGENTES DE CONTROL BIOLÓGICO DEL ESCARABAJO RINOCERONTE DEL COCO, LA PRINCIPAL PLAGA DEL COCOTERO HAWAIANO].

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Coconut rhinoceros beetle (CRB, *Oryctes rhinoceros*) is a large scarab beetle native to Southeast Asia and a serious pest of palm species, most notably coconut and oil palms. CRB adults damage palms, particularly younger ones, by boring into the center of the crown, where they injure the young, growing tissues and feed on the sap. CRB has been identified by the United States Department of Agriculture (USDA) Animal and Plant Health Inspection Service (APHIS) as one of the most damaging invasive insect pests of coconut and other palm species. In Hawaii, CRB was first confirmed on Oahu in December 2013. Since then, USDA, Hawaii Department of Agriculture (HDOA), University of Hawaii at Manoa, Hawaii Invasive Species Council, and other entities launched the CRB eradication program, the largest invasive species eradication program in Hawaii's history. This presentation reports our latest research updates on biological and, to a lesser extent, chemical control of CRB. Due to the strict regulations on importing biological control agents into Hawaii set by HDOA, our approach for biological control research is to collect locally occurring entomopathogenic nematodes (EPNs) and entomopathogenic fungi (EPF) and then screen them for effective strains in both lab assays and field trials. We collected over 20 EPN strains and over 60 EPF strains from various landscape sites on Oahu. Based on our multiple lab assays, we identified one EPN strain that caused > 60% mortality of CRB larvae and several EPN strains that caused > 30% mortality of CRB larvae. We also identified multiple EPF strains that caused > 70% mortality of CRB larvae in our lab assays. Based on our consequent field experiments, several *Metarhizium* strains resulted in > 40% mortality of CRB larvae, and the commercial *Beauveria* strain

caused almost 70% mortality of CRB larvae in field conditions. Larger-scale EPN and EPF field trials will be conducted as soon as permission from HDOA is obtained. For chemical control, we focus on low-risk systemic insecticides. Based on our multiple lab assays, acephate and imidacloprid were very effective. Based on these lab assay results, we conducted two field experiments using 70 coconut palms for two years. Our field experiment results indicated that imidacloprid was the most effective treatment in field conditions. The CRB eradication program has treated over 3,000 coconut palms on Oahu to date based on our research results. An IPM program, including both biological and chemical controls, is being actively developed to control CRB in Hawaii. Most up-to-date research results will be presented.

**NEMATODE COMMUNITY
ANALYSES AND ECOSYSTEM
HEALTH IN GRAIN ROTATION
SYSTEMS USING NEMATODES AS
BIOINDICATORS [ANÁLISIS DE LA
COMUNIDAD DE NEMATODOS Y
SALUD DEL ECOSISTEMA EN
SISTEMAS DE ROTACIÓN DE
CEREALES UTILIZANDO
NEMATODOS COMO
BIOINDICADORES].**

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Global grain production is of great importance for food security. Although conventional agricultural (CT) practices

(e.g., monocropping, ploughing intensified use of fertilizers and pesticides still dominate, it compromised yield and quality due to adversely impacting soil ecosystem functions and health. The use of ecosystem/soil health-promoting conservation agricultural (CA) practices ('climate-smart agriculture'), e.g., fallowing, crop rotation (including cover crops), intercropping, and minimum/no-tillage became more popular and is increasingly applied by producers. Hence, the impact of CA vs CT practices on soil ecosystem health was investigated for the past 3 years at sites near Bloemfontein and Kroonstad, in the Free State province of South Africa. CT and CA practices were applied including three crop rotation sequences each, with four crops (maize, soybean, sunflower) and cover-crop mixtures. Nematode samples, root and soil, were obtained for community analysis, while biological bioindicators of soil health (nematode-based indices/NBIs), active carbon, and soil respiration were also investigated. Samples were collected during March 2021-2023 from each plot for the respective crops. Nematode root data were subjected to univariate ANOVA analyses, nematode soil data to the NINJA (Nematode Indicator Joint Analysis) faunal analysis and associations among nematodes, bioindicators and selected abiotic parameters studies using multivariate analysis (Canoco 5.0). Plant-parasitic nematode abundance per 20 g roots, viz. total number of eggs, *Meloidogyne* sp. juvenile and mature individuals, *Pratylenchus* sp. and *Rotylenchulus* sp., increased from 2021 to 2023, especially where CA was practiced. Although nematode soil data for the same period indicated that all treatments improved in enrichment and structure, integration of data for nematodes and bio-indicators and selected abiotic parameters will be presented to demonstrate their impact on ecosystem health.

SWEET SUCCESS WITH SWEET POTATOES: BUT WHY? [DULCE ÉXITO CON BATATAS: PERO POR QUÉ?].

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In Africa, smallholder cropping systems are prone to damage by plant-parasitic nematodes, but which is often not recognized as such. For sweet potatoes this is very much the case, perhaps more so than for many crops. Using the novel banana paper technology, we assessed its use with sweet potato to deliver the nematicide fluopyram to manage nematodes and improve production in Kenya. Using a thin 'slip' of paper to enclose vines at planting, low dosages of fluopyram were delivered to the rooting zone. In inoculated pot studies this reduced nematode damage, resulting in better quality and higher yields of tubers. In farmer field plots symptoms of nematode damage on tubers were markedly reduced in paper treated plots, with corresponding improvements in tuber yield. Interestingly, sweet potato weevil damage also appeared lower in paper treated plots, even though no insecticides were applied. These preliminary results provide a promising option for the management of soil-borne pests and pathogens for smallholder farmers. This requires further investigation however, to understand how this appears to be working so well on sweet potato.

UTILIZING KNOWLEDGE OF NEMATICIDE PROPERTIES AND NEMATODE BEHAVIOR TO MAXIMIZE NEMATODE CONTROL [USO DEL CONOCIMIENTO DE LAS PROPIEDADES DE LOS NEMATICIDAS Y EL COMPORTAMIENTO DE NEMATODOS PARA MAXIMIZAR SU CONTROL].

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The decline in use of organophosphate, carbamate, and fumigant nematicides has ushered in a new era of next-generation nematicides and bionematicides. While many of these new technologies show great potential for nematode control, field trials in agricultural settings often yield unexpected results. Each chemistry has unique properties such as adsorption, solubility, and half-life that greatly impact how the chemistry moves in soil and how long it remains active. Similarly, biological control organisms differ in their mobility, activity, selectivity, and other factors that determine how well and under what conditions they work. Additionally, plant-parasitic nematodes differ in their feeding behavior, vertical stratification, mobility, and life cycle that affects if, where, and when they contact the potential control agent. Finally, all the above factors are influenced by the host plant, soil conditions, environmental conditions, and agricultural practices. Clearly, the more that is understood about the properties of the control agent, the behavior of the target nematode, the environment, and agronomic practices the more effective a nematode management strategy can be. Case studies will be used to illustrate how all these factors interplay in field situations. The most efficacious

nematicide only works if it comes in contact with the target nematode at an effective concentration.

MAINTAINING A PLANT-PARASITIC NEMATODE ZOO FOR TEACHING [MANTENIMIENTO DE UN ZOOLÓGICO DE NEMATODOS PARÁSITOS DE PLANTAS PARA LA ENSEÑANZA].

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Most nematode programs maintain greenhouse populations of one or two species of plant-parasitic nematodes that are most important to their research. However, in some cases it is helpful to maintain a variety of PPN cultures for teaching purposes. The University of Florida Landscape Nematology Lab currently maintains cultures of: *Meloidogyne incognita* (2 races), *M. javanica*, *M. enterolobii*, *M. floridensis*, *M. graminis*, *Pratylenchus brachyurus*, *P. hippeastri*, *Rotylenchulus reniformis*, *Heterodera glycines*, *H. trifolii*, *Belonolaimus longicaudatus*, *Hoplolaimus galeatus*, *Dolichodorus miradvulvus*, *Trichodorus obtusus*, *Hirschmanniella dicksoni*, and *Aphelenchoides pseudobesseyi*. In the past we have maintained other PPN species as well. Over the years we have gained considerable insights caring for all these different kinds of PPN under greenhouse conditions that will be shared. Among these insights are how to select the best host plants for culture maintenance and volume production, how to care for nematodes with differing environmental conditions, how to choose plant growth media, how to extract nematode inoculum, and how to manage other pests and pathogens without harming the target nematodes. Additionally, exercises for

using these different kinds of PPN in laboratory instruction will be presented.

SYSTEMS APPROACH TO NEMATODE CONTROL [ENFOQUE DE SISTEMAS PARA EL CONTROL DE NEMATODOS].

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Among the many nematodes threatening potato production in the U.S., the potato cyst nematodes (PCN) *Globodera pallida* and *Globodera rostochiensis*, and the root knot nematodes (RKN) *Meloidogyne chitwoodi* and *Meloidogyne hapla*, continue to pose serious threats to productivity. RKN can infect tubers and cause cosmetic damage that reduces potato market value, whereas PCN are quarantined pests in the U.S. and, if left uncontrolled, can cause 80% yield loss. Since there are few or no potato varieties resistant to PCN or RKN, growers must rely on nematicides as the most effective means for control. Unfortunately, many front-line nematicides have been banned or voluntarily withdrawn from the market while others have suffered supply chain problems. Most nematicides also pose substantial environmental risks to applicators and bystanders, which can lead to disruption of soil biology. Development of potato varieties with nematode resistance, discovery of novel nematicidal compounds, establishment of damage thresholds, and decision support systems are critical needs for management of nematodes. For potato to reach its complete potential as a sustainable crop, a robust strategy for controlling these

devastating pests must be implemented. Recently funded by the NIFA-SCRI program, our goal for this coordinated agricultural project is to develop a systems approach to control plant-parasitic nematodes that threaten the potato industry. To achieve this, our objectives are four pronged: 1) develop decision support tools by fast tracking diagnostic methods and developing predictive models to assist in development of an action plan for farmers dealing with nematode infestations; 2) increase our understanding of plant defenses and use markers to develop resistant varieties; 3) discover and develop novel nematicides; and 4) pass our information on to benefit all sectors that may be impacted by these devastating pests.

NEMATODES IN SOUTH AFRICA – THE PAST, THE PRESENT AND THE FUTURE [NEMATODOS EN SUDÁFRICA: EL PASADO, EL PRESENTE Y EL FUTURO].

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Plant-parasitic nematodes have always been a major problem in agricultural production in South Africa. Previously, the only control strategy in commercial agriculture was chemical control, until a decade ago when farmers started to investigate environmentally more friendly methods to alleviate damage caused by plant-parasitic nematodes. These methods include the practicing of regenerative agriculture as well as the use of alternative or other management strategies including resistant

cultivars, biological control, organic amendments. Because these methodologies are not quick nor easy solutions and take time to result in better economic returns for the farmer, their uptake is slow. To improve the uptake of the above-mentioned practices, many current research projects are focusing on aspects of these methods since many facets have not been investigated under South African conditions. Soil health with special focus on free living nematodes as bioindicators is receiving attention and one aim is to define strategies to improve soil health based on the nematode communities present. Several nematode analytical laboratories in South Africa are providing a soil health status service. Undergraduate training in nematology is limited as it is mainly part of larger modules while post-graduate training is currently available at several universities throughout South Africa. The main topics include taxonomic identification, management of plant-parasitic nematodes, nematode-crop interactions, soil health and entomopathogenic nematodes (EPN). However, when the specialists retire or resign, positions are not filled, resulting in knowledge being lost without any contingency plan in place. It is important to ensure continuity in nematology training and our Nematological Society of Southern Africa (NSSA) is seeking solutions/alternatives to make this possible. Besides official training, short courses in plant-parasitic nematodes, entomopathogenic nematodes and other aspects of nematology are provided on an 'ad hoc' basis. A national extension program exists in South Africa, but extension officers are mainly focused on small-scale agriculture and often do not have time or knowledge to provide the correct solutions to these farmers. Privately run commercial farm associations exist which are responsible for technology transfer through farmers days, study group

meetings and research symposia. This seems to be a more effective way to transfer information to the farming community. The future of nematology will entail ensuring continuous training of young scientists and extension officers, providing new or improved solutions for nematode control through research and implement more effective ways of extension in commercial and smaller scale farming as this is seen as an important gap in the adoption of the new technologies.

SEQUENCING OF ITS-rDNA REGION OF THE SUGAR BEET CYST NEMATODE (*Heterodera schachtii*) POPULATIONS FROM SYRIA [SECUENCIACIÓN DE LA REGIÓN DE ITS-rDNA DEL NEMATODO DEL QUISTE DE LA REMOLACHA AZUCARERA (*Heterodera schachtii*) DE POBLACIONES DE SIRIA].

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Sugar beet is the only source of sugar production in Syria. The sugar beet cyst nematode, *Heterodera schachtii* Schmidt (1871), is one of the most important pathogens that attacks this crop in Syria causing serious yield losses. Molecular identification of ten *H. schachtii* populations collected from different Syrian governorates was performed herein. rDNA of the tested populations was extracted, and ITS-rDNA gene was cut and amplified by using two specific primers and sequenced. The results showed that the ITS gene lengths were alike in all the studied Syrian *H. schachtii* populations (approximately

900 base pairs). The bio-informatic analysis of the Syrian *H. schachtii* populations was compared with those of NCBI (National Center for Biotechnology Information) data. The results assured to be corresponding with 98-99% similarity between the Syrian nucleotide sequences of *H. schachtii* populations and those of NCBI data. Also, there was a big similarity between the studied *H. schachtii* populations, except Dair Azzor populations (two populations) which were somewhat different in certain places along the gene. The phylogenetic tree showed that Dair Azzor populations formed a separate cluster which is slightly different from the other populations.

PLANT-PARASITIC NEMATODES IN FLORIDA STRAWBERRIES – A CONSTANT BATTLE [NEMATODOS PARÁSITOS DE PLANTAS EN FRESAS EN FLORIDA – LA BATALLA CONSTANTE].

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Plant-parasitic nematodes have plagued Florida strawberry growers ever since the crop was introduced in the early 1900s. Currently, strawberry production in Florida is valued at over US\$350 million, and the state accounts for almost all the strawberry winter production in the US. Most strawberry production in Florida occurs in open fields and on plastic-mulch raised beds in combination with drip irrigation. This so-called plasticulture system provides an ideal habitat for sting nematodes (*Belonolaimus longicaudatus*), which are widely distributed in the sandy soils of Florida and are one of the major constraints to overall strawberry production in Florida. Increasingly, also root-knot (*Meloidogyne hapla*), stubby root (*Nanidorus minor*) and lesion (*Pratylenchus penetrans*) nematodes

have been found to cause damage in Florida strawberries. In conventionally managed fields, soil fumigants are applied every season prior to planting, and in most cases this practice ensures good crop establishment and nematode control. Fumigants cannot be applied in the increasing acreage of organic strawberry fields, which currently account for 5-10% of the total area. In recent years, sting nematodes have emerged as one of the most serious and difficult to manage soil borne problems in these organic fields. Several growers have abandoned their organic fields because they are simply unable to manage sting nematodes. Strawberry growers need more tools and options to help manage plant-parasitic nematodes in their fields. This is especially true for organic growers, but also non-organic growers will benefit from incorporating non-chemical nematode management in their fields. Some of these practices are (1) cover crops, (2) biologically-based soil disinfestation methods such as anaerobic soil disinfestation (ASD) and solarization, (3) soil amendments, (4) clean transplants, and (5) organic nematicides. Opportunities and limitations of these different practices will be discussed, as well as the importance of adopting an integrated approach to reduce nematode damage more effectively.

TYMIRIUM TECHNOLOGY TO NEMATODE MANAGEMENT [TECNOLOGÍA TYMIRIUM PARA EL CONTROL DE NEMATODOS].

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Nematode management in tropical countries is complex, due to the continuous cultivation of susceptible plants. Plant

protection with nematicides is very important for good stand establishment and early root formation. In this context, Tymirium Technology is a new chemical nematicide, whose active ingredient is the cyclobutrifluram, that acts on succinate dehydrogenase (SDH inhibition), preventing ATP synthesis. This research was conducted to evaluate the performance of Tymirium Technology against *Meloidogyne incognita*, *M. javanica* and *Pratylenchus brachyurus* control. The trials were conducted on a greenhouse in three different years (2023: soybean x *M. incognita* and *P. brachyurus*; 2022: maize x *M. javanica* and *P. brachyurus*; 2021: maize x *P. brachyurus*). The experimental units were pots with 0.90 cm³ of soil. Seeds were treated with 40 mL/60,000 seeds (500 g i.a./L) and they were deposited in the hole. Seven days after seeding, plants were inoculated with 2,000 eggs + J2 of *Meloidogyne* spp. or 500 *P. brachyurus*. After 60 and 75 days after inoculation to *Meloidogyne* spp. and *P. brachyurus* trials respectively, plants were evaluated for nematode control. In 2023, Tymirium reduced *M. incognita* and *P. brachyurus* reproduction in soybean by 95% and 91% respectively. In 2022, *M. javanica* and *P. brachyurus* reductions in maize were 94% and 100%, respectively; and in 2021, the control of *P. brachyurus* in maize was 81%. We can conclude that Tymirium Technology is efficient for nematode control.

HOW TO MAKE A NEMATODE PRODUCT COMPETITIVE TO INSECTICIDES IN PRICE AND EFFICACY? [COMO HACER COMPETITIVO CON INSECTICIDAS UN PRODUCTO A BASE DE UN NEMATODO ENTOMOPATOGENO EN PRECIO Y EFICACIA?].

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The target market was the control of the Western Corn Rootworm (*Diabrotica virgifera virgifera*) in maize. The Western Corn Rootworm (WCR) is an invasive pest accidentally introduced in 1992 into Serbia. Since then, it has dispersed over the Balkan region, Hungary, Poland, the Czech Republic, Slovenia and Slovakia, Germany, Austria, Switzerland and Italy. A control product (Dianem®) based on the nematode *Heterorhabditis bacteriophora* is registered as a plant protection product in Austria and Hungary. In Germany, it is recommended in the guidelines for integrated crop protection in maize (LIPS). Dianem® is the first microbial product in the market, which was genetically improved by breeding to adapt it to the specific requirements for the control of the WCR. In addition, the application technology was adapted to integrate it into common agricultural practice. Dianem® can substitute neonicotinoid seed treatment and application of granular pyrethroids. Since the phasing-out of neonicotinoids, less effective pyrethroids are in use. The efficacy of dianem® has surpassed the effect of the granular chemicals in several field trials during the past five years. However, because of the high application density, the nematode product could not compete with the synthetic chemicals. To solve this problem, we attempted to reduce the application density further. A breeding program was started aiming at increasing longevity/field persistence and the virulence of the nematodes. The phenotypic classification of these traits was accompanied by a comprehensive sequencing program, which provided a collection of molecular genetic markers (SNPs=single nucleotide polymorphisms) associated with the beneficial traits. We then crossed strains that were long-living

with highly virulent strains. The genetic markers allowed us to screen the progeny for individuals that carry both beneficial traits, longevity, and higher virulence. Such a strain was then tested in field trials and mass production. The adapted application technology and the genetically improved strain allow us to lower the application density to 1×10^9 nematodes/ha at equal control potential. Together with the application of economies of scale producing the worms in bioreactors of a total volume of 120,000 L, the product costs were further reduced. Today, the application costs are equal to the use of (less effective) synthetic soil insecticides.

TEACHING ENTOMOPATHOGENIC NEMATODE BIOTECHNOLOGY FOR APPLICATION IN BIOLOGICAL INSECT CONTROL [ENSEÑANZA DE LA BIOTECNOLOGÍA DE LOS NEMATODOS ENTOMOPATOGENOS PARA SU APLICACION EN EL CONTROL BIOLÓGICO DE INSECTOS].

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The International Master of Science in Agro- and Environmental Nematology (IMaNema) is a globally unique 2-year MSc program in English and brings together internationally renowned staff to train students in the broad field of agricultural and environmental aspects of Nematology. Included is information on entomopathogenic nematode (EPN) taxonomy, biology, and biotechnology. Since liquid culture mass production provides EPN at competitive costs, the market for these biological control agents is constantly increasing. Within the Master Course, students are introduced into EPN biotechnology, which covers practical

lessons on the production of monoxenic starter cultures and lessons on the biology of the symbiotic bacteria and the use of modern approaches using genetic markers for improve of beneficial traits. An example on how biotechnology supported the development of the EPN product dianem® is presented. Its target market is the Western Corn Rootworm (*Diabrotica virgifera virgifera*), an invasive pest accidentally introduced into Europe in 1992. Dianem® can substitute neonicotinode seed treatment and application of granular pyrethroides. However, due to high application density the nematode product was not compete with the synthetic chemicals. To solve this problem, biotechnology and improvement of application technology helped to lower the application density to 1×10^9 nematodes/ha at equal control potential. Together with the application of economies of scale producing the worms in industrial scale bioreactors and improvement of virulence and field persistence by marker-supported breeding the product costs were reduced to the level of chemical soil insecticides.

NEMATODES NEED A WATER FILM TO MOVE IN THE SOIL? NO; A FALSE ASSUMPTION [NEMATODOS NECESITAN UNA LAMINA DE AGUA PARA MOVERSE? NO; UNA ESTIMACION FALSA].

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Movement of nematodes in the soil, including entomopathogenic nematodes (EPNs) (*Steinernematidae*, *Heterorhabditidae*) depends on their biology, mobility, tolerance to environmental factors (soil moisture, temperature), the edaphic parameters and the soil water dynamics. All textbooks tell

us that nematodes need a water film to move in the soil. The talk will show that this was a wrong conclusion of experiments conducted in the 1960s. The free-living stage of EPNs is the 3rd juvenile stage, the so-called dauer larva (DL). Due to its diameter of 25-43 μm (depending on the species), it can only move through coarse soil pores (defined at $> 10 \mu\text{m}$ diameter). Considering that nematodes can only move when these pores are lined with water, movement would be impossible once these pores are dry. Since the coarse pores are empty at a water potential (pF) < 2.5 , infestations of insects by EPN would be impossible. However, results of field trials show that control was obtained at lower values. The talk will explain why the assumptions based on previous experiments were misinterpreted.

CAN ENTOMOPATHOGENIC NEMATODES CONTRIBUTE TO AGRO-ECOSYSTEM MANAGEMENT SYSTEMS WITHOUT INSECTICIDES? [¿PUEDEN LOS NEMATODOS ENTOMOPATÓGENOS APOYAR UN SISTEMA AGRO-ECOLÓGICO SIN INSECTICIDAS?].

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The major source of vegetable oil in Northern Europe is oilseed rape (OSR, *Brassica napus*). Worldwide, OSR is the second-largest source of protein meal and the third-largest source of vegetable oil. The crop is attacked by a wide range of insect pests. The most common are *Delia radicum* (L.), *Dasineura brassicae* (Winn.), *Psylliodes chrysocephala* (L.), *Brassicogethes aeneus* (Fab.), *Ceutorhynchus assimilis* (Payk.), *Ceutorhynchus pallidactylus* (Marsh.) and *Ceutorhynchus napi* (Gyll). Almost all these pests have developed resistance

against pyrethroid insecticides except one compound. The time will come when insecticides can no longer be used. In this case, farmers will depend on the natural antagonistic potential. The pests are all susceptible to entomopathogenic nematodes (EPN) and pupate in the soil, providing a biomass of $> 15 \text{ kg per ha and year}$, a paradise for *Steinernema* and *Heterorhabditis* spp. However, checking 11,000 soil samples of arable crop rotation, winter wheat, winter barley, and OSR, only 0.2% were positive for EPN. The talk will present results on the application of EPN in OSR and discuss models for future agro-ecosystem management without insecticides.

NEMATODE-TRAPPING FUNGI ISOLATED FROM SOIL IN TURKEY [HONGOS NEMATÓGAFOS AISLADOS DEL SUELO EN TURQUÍA].

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Root-knot nematodes (RKNs; *Meloidogyne* spp.) are one of the major pests of tomatoes, especially in greenhouse growing areas. Among the *Meloidogyne* spp., *M. incognita* is the world's most common and destructive plant-parasitic nematode. The primary control method for this pest is still based on synthetic nematicides, which are hazardous to human health and the environment. Using biocontrol organisms offers promising

alternatives to chemicals. There are many kinds of nematophagous (nematode-feeding) fungi which capture and kill nematodes in soil. Nematophagous fungi have been studied as a source of biological control of nematodes to reduce the significant economic damage caused by RKNs due to their association in the rhizosphere. Among the nematophagous fungi, nematode-trapping fungi are the most studied. The aim of the study was to determine and isolate nematode trapping fungus from tomato growing greenhouses. In this study, 223 soil samples were taken from tomato greenhouses in Antalya, Isparta and Burdur provinces in Turkey. The GPS coordinates of the locations where soil samples were collected, altitude, soil temperature, pH value, soil moisture, ambient light, and the presence of nematodes in the greenhouse were recorded. As a result of the study, 84 nematode-trapping fungi were isolated from the soil. Based on morphological characteristics, species of the nematode-trapping fungus *Arthrobotrys* spp. and *Drechslerella* spp. were identified in Antalya, Burdur, and Isparta greenhouse tomato cultivation areas. Further studies are underway, and determination of the activity of nematode trapping fungi against *M. incognita* in vitro and colonization studies on tomato roots have been started. This study was supported by a grant from the Scientific and Technological Research Council of Turkey (TUBITAK-TOVAG 221O399).

IN VITRO AND IN VIVO MOLECULAR RESPONSES OF *Meloidogyne incognita* AND TOMATO PLANTS DUE TO SILVER AND ZINC OXIDE NANOPARTICLES APPLICATION [RESPUESTAS MOLECULARES IN VITRO E IN VIVO DE PLANTAS DE TOMATE Y DE *Meloidogyne incognita* DEBIDO A LA APLICACIÓN DE

NANOPARTÍCULAS DE ÓXIDO DE ZINC Y PLATA].

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Meloidogyne incognita causes considerable losses in crop production worldwide. Many studies reported the toxicity of silver and zinc oxide nanoparticles against this nematode, however, at the molecular level, the mechanism of this toxicity is still unclear. In our study, the molecular response of *M. incognita* juveniles and tomato plants to silver and zinc nanoparticles were investigated *in vitro* and in pot experiments. For this purpose, AgNPs and ZnONPs were synthesized and characterized for their physicochemical properties. Then, second-stage juveniles (J2) of *M. incognita* were exposed to AgNPs and ZnONPs solutions for 24 h. Using Quantitative PCR, the expressions of six genes; neuropeptidergic gene (Ace-2), parasitism genes; (Xyl-1; msp-20; peptide 16D10), expansion-like proteins (MAP-1), and oxidative stress gene, glutathione S-transferases, (GSTS-1) were analyzed. In the pot experiment, we used infected tomato plants to measure the effect of NPs drench application on nematode infection and tomato plants molecular response. In the *in vitro* test, ZnONPs had LC50 and LC90 values of 63.56 and 208.5 ppm, respectively, while AgNPs were 11.78 and

28.59 ppm, respectively. *Meloidogyne incognita* J2 gene expression results showed down-regulation of parasitism, neuropeptidergic and expansion-like proteins genes with both of AgNPs and ZnONPs in a concentration-dependent manner. On the other hand, the oxidative stress response gene showed up-regulation. In pots, application of these NPs on tomato plants reduced nematode galls by about 74-78% in comparison to control. However, NPs also reduced plant fresh weights in the three tested concentrations by about 30% without any phytotoxic effects on plants. The study concluded that the AgNPs and ZnONPs have efficient nematocidal activity. Also, the molecular response of six genes due to NPs application was uncovered as nematode infection genes were negatively affected, however, oxidative stress gene expression was enhanced which finally caused infection failure. More studies are needed to estimate the suitable non phytotoxic concentration of silver and zinc NPs for nematode management. Tomato plants molecular response results are still under study.

INDUCTION OF SYSTEMIC RESISTANCE AND DEFENSE-RELATED ENZYMES IN TOMATO PLANTS USING SALICYLIC ACID AND ASCORBIC ACID AGAINST ROOT-KNOT NEMATODE *Meloidogyne incognita* [INDUCCIÓN DE RESISTENCIA SISTÉMICA Y ENZIMAS RELACIONADAS CON LA DEFENSA EN PLANTAS DE TOMATE UTILIZANDO ÁCIDO SALICÍLICO Y ÁCIDO ASCÓRBICO CONTRA EL NEMATODO AGALLADOR *Meloidogyne incognita*].

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The role of ascorbic acid and salicylic acid in the defense mechanism of tomato plants (GS as a susceptible, and 448 as a resistant cultivars) against root-knot nematode, *Meloidogyne incognita*, infection was studied under greenhouse conditions. The activities of the two enzymes (peroxidase and polyphenol oxidase) were taken as a parameter for inducing the resistance of the plant against *M. incognita*. The results indicated that the foliar spray of ascorbic acid and salicylic acid increased peroxidase activity during 1-5 days of the treatment application, in the resistant cultivar when compared to the susceptible one. Also, treatment with salicylic acid (24.3 U/mg protein) and with ascorbic acid (23 U/mg protein) one day day from nematode inoculation had an effect on resistant cultivar (448), while the activity of peroxidase enzyme with susceptible cultivar (GS) was (15.3 U/mg protein) with ascorbic acid, and (12.5 U/mg protein) with salicylic acid. There was no stability in the activity of peroxidase enzyme after 10 (4 U/mg protein) and 15 (1.56 U/mg protein) days regardless of cultivar, however, it was active (4.95 U/mg protein) after 10 days, and (3.93 U/mg protein) after 15 days from nematode inoculation with susceptible cultivar (GS). Meanwhile, data indicated that the treatment of ascorbic acid induced the polyphenol oxidase activity after 1 day (2 U/mg protein, and 5 days (1.23 U/mg protein 1) from nematode inoculation. As for salicylic acid it was 1.54 U/mg protein after 1 day, and 1.06 U/mg protein after 5 days with resistant cultivar (448). Meanwhile, it was 1.5, and 0.6 U/mg protein after 1 to 5 days from nematode inoculation respectively, with ascorbic

acid, 0.6 and 0.7 U/mg protein after 1 to 5 days from nematode inoculation.

ASSESSMENT OF *Actinomycetes* AND *Pseudomonas* SPECIES ON *Meloidogyne incognita* POPULATION AND GROWTH OF CARROT PLANTS IN DISPARATE SOILS [EVALUACIÓN DE ESPECIES DE *Actinomycetes* Y *Pseudomonas* EN POBLACIONES DE *Meloidogyne incognita* Y CRECIMIENTO DE PLANTAS DE ZANAHORIA EN SUELOS DISPARES].

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Synthetic nematicides play an important role in the limitation of *Meloidogyne incognita* on agricultural fields. However, the reliance on synthetic nematicides has made them a threat to the environment due to their toxic nature. Application of rhizobacteria could reduce excessive dependency on their use. In this research, an attempt was made to isolate and characterize growth-promoting bacterial strains through morphological and molecular methods. Sequencing of the 16S rRNA gene identified *Streptomyces pseudogriseolus* NRRL B-3288, *Actinomyces hongkongensis* H_KU8, *Actinomyces liubingyangii* VUL4_1, *Pseudomonas amygdali* AL1, *Pseudomonas aeruginosa* DSM 50071, and *Pseudomonas otitidis* MCC10330. The growth-promoting ability of the isolated organisms was evaluated in sandy-loam, silty-loam and clay-loam soils planted with carrots in a greenhouse. This was compared with carbofuran and an untreated control. Their potency on *M. incognita* was accessed simultaneously with the vegetative growth of carrot plants for 120

days. A probable degradation activity of the included organisms was also appraised. In the field, the organisms were assessed individually in sandy-loam soil. In the greenhouse, the organisms acted differently in disparate soils on their impact on *M. incognita* and vegetative growth of carrot plants. Significant ($p < 0.05$) increases in vegetative growth and yield of carrot plants was noticed with inclusion of *Actinomycetes* sp. in all soil classes. *Pseudomonas* sp. was not as effective as *Actinomycetes* sp. with regards to *M. incognita* management and increase in yield. Nonetheless, *Pseudomonas amygdali* in sandy-loam soil exhibited a remarkable action on *M. incognita* compared to carbofuran alone. In the field *Actinomycetes* sp. notably controlled *M. incognita* and resulted in a remarkable reduction of egg mass and root galls and an increase in yield. Evaluation of probable degradation of carbofuran with HPLC analysis revealed the presence of metabolites such as 3-hydroxy-carbofuran, 3-keto-carbofuran and carbofuran-phenol which implies that there was considerable degradation by the organisms. The growth-promoting attributes and nematocidal potential of *S. pseudogriseolus*, *A. hongkongensis*, *A. liubingyangii*, and *P. amygdali* have been established. These organisms are regarded as an excellent option in the management of *M. incognita* and they could be employed as part of the soil regimen in carrot production to reduce environmental contamination of synthetic nematicides.

ORCHID MYCORRHIZAL FUNGI, *Waitea circinata*, ON THE CONTROL OF *Meloidogyne enterolobii* [HONGO MICORRÍCICO DE ORQUÍDEAS *Waitea circinata* EM EL CONTROL DE *Meloidogyne enterolobii*].

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The plant-parasitic nematode, *Meloidogyne enterolobii* infects several crops including tomato, causing high yield losses. Mycorrhizal fungi are among the promising bioagents that can be used to nematode control. The objective of this study was to evaluate the effect of the orchid mycorrhizal fungus (OMF) *Waitea circinata* on *M. enterolobii* egg parasitism and hatching in vitro, and on the nematode control under greenhouse on tomato plants. The experiment was carried out in a completely randomized design, with six treatments (0, 5, 10, 15, 20 and 25 g of mycelial suspension/L) and seven replications. For in vitro assay, 4 mL of mycelial suspension + 1 mL of nematode suspension containing 200 eggs were transferred to Falcon tubes and maintained under constant stirring at 150 rpm at 28 °C. The evaluations were performed at 24, 48, 168 and 336 h after incubation by counting the number of parasitized eggs and hatched J2. For the greenhouse experiment, tomato seedlings of a susceptible cultivar were transplanted into pots filled with sterilized soil and sand (1:1). At transplanting 50 mL of each concentration of mycelial suspension were applied per plant in the soil and, 24 h after, 2000 eggs + J2 of *M. enterolobii* were inoculated. At 30 days after inoculation the plant height, root length, shoot and root fresh weight were recorded. Nematodes were extracted from roots, and population density (nematodes/g of root) and reproduction factor (RF) were determined. Egg parasitism rate increased as the OMF concentrations increased at all evaluating timings, with higher parasitism of 35.43%. The hatching rate decreased as

the OMF concentrations increased, with a lower hatching rate at the highest FMO concentration, varying between 87.86% (control at 336 h) and 1.29% (25 g/L at 24 h). *M. enterolobii* population density and RF decreased as the OMF mycelial suspension concentrations increased. Similar results were observed for plant height and shoot fresh weight. Root length and fresh weight were represented by polynomial regression increasing as the OMF increased up to the concentration of 15 g/L. *W. circinata* was effective in controlling *M. enterolobii* and improving tomato plant development being an efficient biocontrol agent.

CO-CULTURES OF PLANTS WITH PHYTOPARASITIC NEMATODES: A LAB TOOL FOR STUDIES ON SUSTAINABLE PEST MANAGEMENT [CO-CULTIVOS DE PLANTAS CON NEMÁTODOS FITOPARÁSITOS: UNA HERRAMIENTA DE LABORATORIO PARA ESTUDIOS DE MANEJO SOSTENIBLE DE PLAGAS].

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The diseases caused by plant-parasitic nematodes (PPNs) have serious impacts on agriculture and forestry. Current pest management strategies rely on the use of nematicides to control PPN populations in the field, however, many commercial

pesticides are being banned, due to environmental and human health concerns, and replacement formulations have been reported to show a lower efficacy. Research on sustainable pest management strategies is becoming very important since consumer pressure on low environmental impact agriculture is growing. Screening novel nematicides is mainly performed by using direct contact bioassays, which are unable to reflect phytotoxicity to the host or compound biotransformation and metabolization, and/or by testing *in vivo* using greenhouse or field assays, which can be extremely lengthy and unpractical. Plant-nematode co-cultures can be used as a biotechnological screening lab tool for assessing nematicidal activity and its effect on the host tissues, simultaneously, in an easily accessible system that simulates natural infection. *In vitro* co-cultures are refined screening systems, kept under controlled nutritional and environmental conditions, with defined and easily manipulated biological parameters. These innovative screening procedures have been devised based on *in vitro* cultures of transgenic roots with soil PPNs, and on *in vitro* pine shoot cultures with the pinewood nematode (PWN). By using natural nematicidal compounds, they were validated as being able to evaluate, concurrently, nematicidal activity and toxicity to the host. Ongoing research is now taking advantage of these testing systems for a faster *in vitro* functional validation technique to evaluate the effects of silenced or overexpressed parasitism regulator genes (effectors), with the aim of providing new PWN control targets and explore novel strategies for sustainable pest management in forestry.

EVOLUTION OF THE INCIDENCE OF *Aphelenchoides besseyi* IN BRAZIL [EVOLUCIÓN DE LA INCIDENCIA DEL NEMATODO DEL TALLO VERDE EN BRASIL].

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Confined to the warm and rainy regions, the incidence of the green stem nematode, *Aphelenchoides besseyi*, has rapidly increased and poses a threat to soybean and cotton cropping systems. The initial observation of this disease took place during the 2005-2006 crop season in the municipalities of Balsas and Riachão, MA, Brazil. Reports became more frequent and severe by 2014. By 2016, an estimated 3.3 million hectares in the states of Maranhão, Tocantins, Pará, and Mato Grosso were affected. Soybean yields experienced reductions of up to 100% during this period. In the 2018-2019 season, a single farm in Mato Grosso reported a 41% loss in soybean yield. Additionally, cotton production on the same farm suffered losses of 30% to 35%. In 2020, the nematode infestation expanded to Rondônia and Amapá states, in addition to the previously mentioned states, resulting in an estimated affected area of approximately 5 million hectares. In 2022, Paraguay reported suspicion of the pathogen in soybean, and Colombia confirmed the presence of the nematode within its territory. *Aphelenchoides besseyi* parasitizes the aerial parts of plants, particularly new and sugar-rich tissues, with inflorescences and young leaves serving as its primary feeding and reproduction sites. Damage to soybean floral racemes leads to pod formation failures, disrupting the nutrient source-sink relationship in the plant and promoting the

green stem and leaf retention effect. These symptoms are most noticeable during the reproductive stage. Affected plants exhibit thinning and curling of leaf blades, thickening of veins, and angular necrotic lesions. Stems may display grooves, and node thickening frequently occurs. Pods become deformed with thickened walls and reddish-brown necrotic lesion. Floral racemes exhibit necrosis and flower abortion, and in some cases, rosetting (second flowering) and excessive branching (emission of new shoots from affected nodes) may be observed. At the end of the crop cycle, plants retain green leaves, stems, and petioles, making harvesting challenging and reducing grain quality. Under adverse conditions, *A. besseyi* can enter a state of anhydrobiosis and survive for extended periods within plant residues or seeds of certain grasses, which can act as vehicles for nematode dissemination. The most effective control measures known so far are cultural management of crops, such as early desiccation before soybean sowing, early control of host weeds, and planting non-host crops in the soybean production system. For instance, corn following soybean has shown positive results for *A. besseyi* control. Sources of genetic resistance are not yet known. Chemical and biological control are feasible, and product efficacy is still under evaluation.

EFFICACY OF NOVEL TYMIRIUM® TECHNOLOGY IN PROTECTING GRAIN CROPS AGAINST KEY NEMATODE PESTS [EFICACIA SUPERIOR DE TYMIRIUM® TECHNOLOGY EN LA PROTECCIÓN DEL MAÍZ CONTRA PLAGAS DE NEMATODOS CLAVE].

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Infection and parasitism by economically important plant-parasitic nematode genera such as root-knot (*Meloidogyne*), lesion (*Pratylenchus*) and cyst nematodes (*Heterodera*) adversely impact global grain production. To mitigate yield and quality losses of grain crops, mostly grown in rotation in African cropping systems, is challenging due to the wide host and high pathogenicity levels of particularly root-knot and lesion nematodes, concomitant occurrence of nematode-microbe complexes, and adverse climatic conditions, amongst others. Addressing the need to develop a nematicide with superior action against key nematode pests of grain crops coupled with a favorable profile to the environment and non-target organisms, TYMIRIUM® technology has been evaluated during the past 4 years in major grain producing areas of the world and especially in African countries. This seed-applied product showed high efficacy, ranging between 72 to 94%, in reducing population densities of the key nematode pest species in maize (corn), soybean and wheat under both semi-controlled (tunnel or microplot) and natural occurring environmental conditions (field). In addition, the adverse effects of TYMIRIUM® technology on key fungal diseases were also recorded but research and evaluations are still in progress. Results about the efficacy of TYMIRIUM® technology as a nematicide, as well as added benefits as a fungicide, and how it can be used to sustainably produce grain crops by not impacting negatively on soil health will be shared.

**INCREASED PRODUCTIVITY
 OBSERVED IN BANANA APPLYING
 TYMIRIUM® TECHNOLOGY
 [MAYOR PRODUCTIVIDAD**

OBSERVADA EN BANANO APLICANDO LA TECNOLOGÍA TYMIRIUM®].

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Plant-parasitic nematodes and soil-borne like Panama disease are hard to eradicate once a field site has been infested. The management of nematodes and soil-borne diseases is very challenging and practices like crop rotation and cultural measures are difficult for growers to implement. Fusarium wilt of bananas, also known as Panama disease, is the most threatening disease towards banana production. Besides the disease there are also several plant parasitic nematode species that damage the root system like burrowing nematode (*Radopholus similis*), Spiral nematode (*Helicotylenchus multicinctus*) and Root knot nematode (*Meloidogyne* spp). Over the past three years, TYMIRIUM® technology, a new active substance with outstanding nematicidal and fungicidal efficacy, has been evaluated in lab and field studies against plant parasitic nematodes and Panama disease in bananas. Results show very good control. During the presentation we will cover the activity of TYMIRIUM® technology and the benefit of this new solution for growers.

IDENTIFICATION OF RESISTANCE TO *Meloidogyne enterolobii* ON SWEETPOTATO BREEDING LINES [IDENTIFICACIÓN DE RESISTENCIA A *Meloidogyne enterolobii* EN LÍNEAS DE MEJORAMIENTO DE CAMOTE].

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Meloidogyne enterolobii, commonly known as pacara earpod root-knot nematode, is a recently emerged plant-parasitic nematode currently distributed in Southeastern region of the United States as well as numerous countries worldwide with tropical climatic conditions. *M. enterolobii* is a more aggressive species because it induces more severe galling than other *Meloidogyne* species and it also causes disease on crop genotypes with root-knot nematode resistance genes. The ability of *M. enterolobii* to cause symptoms and reproduce on root-knot nematode-resistant sweetpotato cultivars represents a threat to the sweetpotato industry. In this research project, we aimed to identify the mechanisms of sweetpotato resistance against *M. enterolobii*. Therefore, the host status of 67 sweetpotato breeding lines to *M. enterolobii* parasitism was evaluated to identify potential sources of resistance. Also, roots of two breeding lines (L14-31 resistant and L18-100 susceptible) with different responses to *M. enterolobii* were stained with acid fuchsin to compare the development and reproduction of *M. enterolobii*. Sweetpotato vine cuttings were planted into sterile sand inoculated with approximately 3,000 eggs of *M. enterolobii* on the planting day. The cultivars Beauregard (susceptible) and Jewel (resistant) were included as controls. Results showed that breeding lines were either highly resistant or highly susceptible, with 19 sweetpotato lines showing high resistance to *M. enterolobii*. Regarding the nematode development, feeding site induction, vascularization of feeding site, gall formation, and nematode developing

into adults was observed on the susceptible control and breeding line only. In collaboration with the LSU AgCenter sweetpotato breeding program, selected breeding lines evaluated in this project are being used to incorporate the observed resistance to *M. enterolobii* into new commercially acceptable sweetpotato cultivars. Results from this project will directly benefit the stakeholders in Louisiana, and worldwide through the release of new root-knot nematode resistant sweetpotato cultivars.

SILVER NANOPARTICLES AS A PROSPECTIVE NEMATICIDE AGAINST *Meloidogyne incognita* IN SUGAR BEET FIELDS [NANOPARTÍCULAS DE PLATA COMO NEMATICIDA PROSPECTIVO CONTRA *Meloidogyne incognita* EN CAMPOS DE REMOLACHA AZUCARERA].

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Nematodes are common soilborne organisms that cause substantial economic injury to sugar beet (*Beta vulgaris*, subsp. *vulgaris*, var., Sahar) crops in the Nubaryia district, northern west of Egypt. A predominant plant-parasitic nematode invading sugar beet is root-knot nematode *Meloidogyne* spp. Chemical management

decisions for root-knot nematodes in sugar beet are imperfect (ecologically and economically), and there is a necessity for novel nematicidal resources to resolve this problem. This investigation evaluated the use of silver nanoparticles (AgNP) in laboratory, outdoor pots and field experiments as a potential nematicidal resource. For the preparation of AgNPs, solution A was used for the dissolution of AgNO₃ (0.75 g) in 100 mL of deionized water and solution B was used for the solubilization. When second-stage juveniles (J2) of *Meloidogyne incognita*, were exposed to AgNP in water at 5, to 100 ppm, >95% nematodes became inactive in 6 hr. When sugar beet and soil composite samples infested with *M. incognita* were treated with 150 mg/ml AgNP, J2 were reduced in soil samples by 92% and 82% after 4- and 2-d exposures, respectively, in the treated compared to the untreated soil samples. Field trials evaluating AgNP were conducted on a sugar beet field naturally infested with *M. incognita*. Biweekly application of 90.4 mg/m² of AgNP improved sugarbeet quality in one year and reduced gall formation in the roots in two years without phytotoxicity. The AgNP were conducted on a sugar beet field naturally infested with *M. incognita*. Biweekly application of 90.4 mg/m² of AgNP improved sugarbeet quality in one year and reduced gall formation in the roots in two years without phytotoxicity. The AgNP application did not significantly reduce the number of *M. incognita* J2 in plots during the growing season. The laboratory assays attested to the nematicidal effect of AgNP, and the field evaluation demonstrated its benefits for mitigating damage caused by root-knot nematode in sugar beet plantations.

LIPID OXIDATIVE STRESS OF *Heterorhabditis indica* AND *Steirnerinema feltiae*: THE EFFECT OF SOME

PHYSICAL AND CHEMICAL CONDITIONS ON THEIR INFECTIVITY AND SURVIVAL [ESTRÉS OXIDATIVO LIPÍDICO DE *Heterorhabditis indica* Y *Steirnernema feltiae*: EL EFECTO DE ALGUNAS CONDICIONES FÍSICAS Y QUÍMICAS SOBRE SU CAPACIDAD DE INFECCIÓN Y SUPERVIVENCIA].

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Entomopathogenic nematodes (EPNs) of the genera *Heterorhabditis* and *Steirnernema* represent an alternative for the biological control of insects. In many cases, the limited half-life of EPNs is still one of the most concerning issues in their commercialization. Lipid peroxidation (LPO) caused by reactive oxygen species (ROS) may be one of the most important causes of loss of infectivity and survival of EPNs when exposed to various physicochemical stress conditions (temperature, pH, hypoxia and osmotic pressure). Because LPO generates free radicals (FRs), it can trigger membrane peroxidation and lipid energy reserves of EPNs. However, in EPNs, there is no data on the role of LPO on their physiology, making strategies for conservation of formulated nematodes difficult. In this

sense, the influence of LPO on *S. feltiae* and *H. indica* under various conditions of physicochemical stress was studied. In both EPNs, the proposed stress conditions altered infectivity and survival over time, generating ROS associated with LPO with a variable tolerance depending on the species, type, and time of exposure to stress. A relationship was observed between the LPO induced by stress conditions and infectivity survival.

PIN NEMATODE SPECIES INFESTING GRAPEVINE SOILS IN PORTUGAL [ESPECIES DE NEMATODOS DEL ALFILER QUE INFESTAN VIÑEDOS EN PORTUGAL].

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Pin nematodes (*Paratylenchus* spp.) currently comprise 132 species of polyphagous plant ectoparasites with at least seven species that are plant pathogenic emphasizing the need for correct identification to establish an appropriate management strategy. Sequences of ribosomal and mitochondrial RNA genes are a powerful species-level diagnostic tool within the genus *Paratylenchus*. Since 2019, nematological surveys are conducted in the main grapevine-growing areas of Central and South Portugal. Thus, the main aim is to evaluate the biodiversity, prevalence, and distribution of *Paratylenchus* species from four major grapevine-growing areas of Central and South Portugal using an integrative approach. Contrasting morphological

hypotheses with molecular data provided rapid detection of eight species, specifically *P. goodeyi*, *P. hamatus*, *P. holdemi*, *P. pedrami*, *P. tenicaudatus*, *P. projectus*, *P. variabilis*, and *P. veruculatus*. *Paratylenchus pedrami* and *P. goodeyi* are the most frequently pin nematodes found Portuguese vineyards. This work was funded by National Funds through the Foundation for Science and Technology under the Project UIDB/05183/2020.

EVALUATION OF SOME RICE VARIETIES FOR GREENHOUSE AND FIELD RESISTANCE TO *Aphelenchoides besseyi* IN EGYPT AND SOME METHODS TO ITS CONTROL [EVALUACIÓN DE ALGUNAS VARIEDADES DE ARROZ PARA LA RESISTENCIA EN INVERNADERO Y CAMPO A *Aphelenchoides besseyi* EN EGIPTO Y ALGUNOS MÉTODOS PARA SU CONTROL].

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Aphelenchoides besseyi is an economically important pathogen of rice and has been reported from many countries. Recently, this nematode has been shown to be widely distributed in the rice fields of Egypt. The aim of this study was to analyze the frequency of occurrence and population densities of *A. besseyi* in cultivated-Egyptian rice. In addition, the assessment to 10 rice genotypes including promising lines and local varieties for resistance to *A. besseyi* under artificial inoculation (greenhouse) and natural field conditions was considered. Also, control methods

were also considered. Our results showed that the nematode was detected in 35.29% of a total of 102 seed samples representing nine different cultivars. Under artificial inoculation, the varieties differed in their response to *A. besseyi* infection. Based on average index of infection, GZ11190-3-8-2-3, GZ11190-3-13-1-1 and Giza 179 showed high resistance while, Giza 178 and GZ 183 were moderate resistance. Sakha 108, Sakha109, Sakha 106, Giza 177, and GZ10101-5-1-1-1 ranked as high susceptible. An increase was noticed in percentage of plants with white tip symptoms in the susceptible varieties Sakha 108 (35 to 53%) and Sakha 109 (32-55%). The susceptible varieties had lower values of growth parameters and yield component. Consequently, there were increase in the number of discolored grains and the quality of rice grains were negatively affected by white tip nematode infection. Sakha108 and Sakha109 had the highest yield losses due to nematode damage with 40% and 31.17%, respectively. There was a statistically positive correlation between number of *A. besseyi* per 100 seeds, percentage of plants with white tip symptoms and total yield losses. Application of some nematicides and chemicals compounds reduced percentage of plants with white tip symptoms and number of nematodes/100 seeds. They were more efficient in treating the nursery than in treating the plants after white tip nematode symptoms appeared. The best treatment was Vaydate 24% SL whether treated with a nursery or after symptoms appear and not significantly different with hot water treatment which was an effective control method to control *A. besseyi* to date. The results of our assessment of resistance will be particularly useful to rice breeders in Egypt.

EFFICACY OF CERTAIN CHEMICAL AND BIOLOGICAL CONTROL

MEASURES IN CONTROLLING *Ditylenchus dipsaci* ON PARSLEY IN SYRIA [EFICACIA DE CIERTAS MEDIDAS DE CONTROL QUÍMICO Y BIOLÓGICO PARA EL CONTROL DE *Ditylenchus dipsaci* SOBRE PEREJIL EN SYRIA].

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Parsley, *Petroselinum crispum*, is a very important vegetable crop all over the world. It is also the most important leafy vegetable crop in Syria where it is usually cultivated year-round. All the parsley cultivars cultivated in Syria are susceptible to *Ditylenchus dipsaci* which causes great economical losses to the crop. This research aimed to evaluate the potent of certain chemical nematicides (oxamyl and carbofuran), biocontrol agents (*Trichoderma harzianum* and *T. kanonjii*), and the bio-fertilizer (Echo Root) in controlling *D. dipsaci* on parsley in a greenhouse pot experiment. Results showed that the tested nematicides and biocontrol agents significantly ($P \leq 0.05$) suppressed the number of nematodes/100 cm³ soil. Treatment with oxamyl and *T. harzianum* were the most potent treatments in controlling *D. dipsaci* on parsley (19.0 and 18.75 nematodes/100 cm³ soil, respectively), compared to the nematode-infected plant (62.75 nematodes/100 cm³ soil). All the tested treatments significantly increased the growth of *D. dipsaci*-infected parsley plants with the "Echo Root" being the best in this respect.

BIOSYNTHESIZED METALLIC NANOSTRUCTURES AND POLYMERIC LOADED WITH MEDICINAL PLANT EXTRACTS FOR CONTROLLING ROOT KNOT NEMATODE [NANOESTRUCTURAS METÁLICAS Y POLÍMICAS BIOSINTETIZADAS CARGADAS CON EXTRACTOS DE PLANTAS MEDICINALES PARA EL CONTROL DEL NEMATODO DEL AGUJERO DE LA RAÍZ].

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Nematodes infecting plants are destructive parasites worldwide that cause crop damage with a wide host range, so lack of effective strategy to control root knot nematode is of concern. Bionano-nematicides (BNN) developed with the aid of certain medicinal plants can act as green efficient inhibitors against nematodes population in soil. BNN confer versatile advantages as they are safe organic compounds with no residual adverse effect, depict high ability to reach within roots to combat nematodes, ability to rapidly spread in irrigation water and stay in soil for a longer time leading to a direct death of nematodes after a few minutes. They also show a repellent effect around roots, and consequently prevent penetration. The current study involved the development of new series of biosynthesized metallic nanostructures and polymeric nanoparticles loaded with one of five different medicinal plant extracts

as new BNN for controlling root knot nematode with the best result attained from chitosan-based nanoparticles incorporating *Moringa oleifera* extract (CS-MO), with average particle size of 318 nm. The CS-MO nanoparticles were evaluated with approximately 100 *M. incognita* juveniles in 5 ml of water. The movement of the juveniles was very slow after 2 hours and 52% died after 24 hours which increased to 89% mortality after 48 hours. Hatching was reduced 2% after 48 hours compared with the hatching in water. The results revealed that the newly developed and investigated BNN could be recommended as commercialized cost-effective green nematicides after appropriate field assessment to manage root knot nematode.

MEASURES AND ACTION PLAN FOR IMPORTED POTTED ORNAMENTAL PLANTS IN THE NETHERLANDS. [HALLAZGOS, MEDIDAS Y PLAN DE ACCIÓN PARA LAS PLANTAS ORNAMENTALES DE MACETA IMPORTADAS A EN LOS PAÍSES BAJOS.]

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The tropical root-knot nematode (RKN) *Meloidogyne enterolobii* has been added to the list of EU quarantine pests in April 2022, as it can infest many important agricultural crops as pepper, tomato, cucumber, potato, as well as many woody

and herbaceous crops. Furthermore, *M. enterolobii* reproduces on RKN resistant tomato and pepper cultivars, which increases the risk of serious damage. This species is an emerging threat due to its global distribution. It is known to be present in several (sub)tropical countries in North, Central and South America, Africa, and Asia. However, this species was also detected on roses originating from China, suggesting that it can also survive more temperate conditions. Recent reports of *M. enterolobii* in Portugal and the ongoing outbreak in greenhouses in Switzerland demonstrate that this tropical root-knot nematode has the potential to enter and establish in (the warmer parts of) Europe and in greenhouses throughout Europe. This emphasizes the importance of assessing the distribution of *M. enterolobii* by conducting reliable surveys and performing (import) inspections to prevent introduction and further spread of this highly damaging species. Analysis of the samples obtained should consider the challenges in identifying this species due to similarities with other RKN. Since April 2022, several lots infested with *M. enterolobii* have been intercepted at import inspections in the Netherlands: 23x *Ficus microcarpa*, 5x *Zelkova*, 2x *Portulacaria*, 1x *Gardenia*, and 1x *Sageretia*, all originating from China and 1x *Portulacaria* from Indonesia. During an export certification inspection in 2023 *M. enterolobii* was found on *Ficus microcarpa* in the Netherlands. Affected plants showed root galls, all plants in the greenhouse of the same lot were destroyed. Tracing was conducted by the National Plant Protection Organization. The lot originated from a plant grower who had imported the plants from China. As measures, all plants for planting within the same watering system were destroyed, and the production site and water system had to be cleaned and disinfected. As a result of these findings import inspections were intensified for

high-risk hostplants as *Amaranthus*, *Caladium*, *Callistemon*, *Chlorophytum*, *Colocasia*, *Fraxinus*, *Ficus*, *Gardenia*, *Hibiscus*, *Ligustrum*, *Philodendron*, *Portulacaria*, *Sageretia*, *Synchonium*, *Xanthosoma* and *Zelkova* originating from China, Costa Rica, Indonesia, Sri Lanka, Surinam, Thailand and USA based on previous findings. Furthermore, a survey was conducted at all growers in the Netherlands with *Ficus microcarpa*. *M. enterolobii* was found in three out of 33 companies inspected. Besides *Ficus microcarpa* and *Zelkova*, *M. enterolobii* was also detected on *Sageretia* and *Syzygium*.

EFFECT OF LAND-USE CHANGE ALONG ALTITUDINAL GRADIENTS ON NEMATODE COMMUNITIES IN THE MOUNTAIN ECOSYSTEM OF INDIAN (KASHMIR AND EASTERN) HIMALAYA [EFECTO DEL CAMBIO DE USO DE LA TIERRA A LO LARGO DE LOS GRADIENTES ALTITUDINALES EN LAS COMUNIDADES DE NEMATODOS DEL ECOSISTEMA MONTAÑOSO DEL HIMALAYA INDIO (CACHEMIRA Y ESTE)].

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Understanding the role of land use type and elevation on soil nematodes is essential, assuming that they are among the key soil quality indicators in each landscape. We investigated the effects of the conversion of forests into agriculture, industries, and landfills; on the diversity of nematode communities at different elevation ranges in two zones of Himalayan region, i.e., Kashmir Himalaya (900 m to 3500 m) and

Eastern Himalaya (150 m to 1500 m). The research fills a critical knowledge gap by resolving multidirectional influences between local conditions, land use practices, and nematode communities. Fifty-five nematode taxa were obtained in Kashmir Himalaya range at four different elevations and fifty-three nematode taxa were obtained from Eastern Himalaya range at two elevations. The different trophic groups obtained were: 18 bacterivores, 9 herbivores, 12 fungivores, 6 omnivores and 10 predators. Forty-one out of total nematode genera, showed specificity towards altitudinal variation and the community structure also varied among land use classes (Forest, Agricultural fields, Industrial area, and landfills). It was found that elevation significantly affects the nematode trophic groups, diversity, and abundance. Fungivores and bacterivore nematodes were more abundant and diverse in agricultural fields but fungivores were sensitive towards elevation and decreased in all land use classes with the increasing elevation. Herbivores and omnivores decreased in agricultural fields and increased in forests at all elevations indicating higher sensitivity to disturbances. The abundance of predatory nematode communities in industrial areas and landfills differed from communities in agricultural fields, with differences being more pronounced at higher elevations. Nematode richness and evenness index indicated a relatively low biodiversity of soil nematodes at higher altitudes. Across land use types, nematode abundance in agricultural fields was greater, and generally, bacterivores were the most dominant nematode trophic group. This study also underlined that several nematode taxa were significantly correlated with edaphic and climatic/geographic properties. Among the four land use types in Kashmir and eastern Himalayas, landfills had the greatest impact on nematode community structure and the soil environment,

especially in relatively sensitive higher altitudes. Results indicate that unique environmental and edaphic characteristics in Himalayan regions drive substantially different soil nematode community structure and soil conditions. As anthropogenic pressures on these ecosystems increase, it is critical to understand how different land use types influence nematode communities, at a gradient of elevation.

NEW APPROACHES FOR EXTRACTING AND MASS REARING OF ENTOMOPATHOGENIC NEMATODES *IN VIVO* [NUEVOS ENFOQUES PARA LA EXTRACCIÓN Y CRÍA MASIVA DE NEMATODOS ENTOMOPATÓGENOS *IN VIVO*].

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The dual purpose of spongy traps for extracting and storage of entomopathogenic nematodes (EPNs) was validated in this investigation. The spongy traps proved to be the most efficient method for recovering infective juveniles (IJs) from the insect cadavers (*Galleria mellonella*) compared with the traditional white traps. Also, the spongy trap kept the viability of IJs for a prolonged time (12 weeks). Based on these results, duplications of insect cadavers in spongy traps will be rather encouraging for nematode mass production. A linked study was continued for the detection of an artificial diet for *G. mellonella* larvae. This step is necessary for the mass production of EPNs *in vivo*. The recommended artificial media is divided into two parts: the first part is supplemented with old beeswax used for feeding the first and second instars of insect larvae. The second part is

supplemented with paraffin oil used for feeding the other instars of insect larvae. The present results demonstrated that the insect larvae could live and develop on this artificial diet. Moreover, both *Heterorhabditis bacteriophora* (Hb) and *Steinernema carocapcae* (Sc) have proven to propagate perfectly in insects fed on artificial media. Total death of all treated insects by Sc or Hb occurred (mortality = 100%). The pathogenicity and reproduction of Hb nematodes produced from insect larvae fed on an artificial diet gave initial population (Pi), final population (Pf), Rate of reproduction (Rr), and Efficiency of conversion (Ec) values superior to those fed on beeswax checks at 100 IJs/insect larva. Similarly, the pathogenicity and reproduction of Sc nematodes produced from insect larvae fed on an artificial diet were equivalent to or superior to those produced from insects fed on beeswax in all inoculum levels. These new methods require minimal expertise and capital investments for extracting, storage, and mass production of beneficial biocontrol agents such as EPNs.

EVALUATING NOVEL STRATEGIES FOR CONTROLLING ROOT-KNOT NEMATODE INFECTING TOMATO PLANTS USING TWO BIOAGENTS, GARLIC EXTRACT, COMMERCIAL AND SYNTHESIS PRODUCTS [EVALUACIÓN DE NUEVAS ESTRATEGIAS PARA CONTROLAR EL NEMATODO AGALLADOR QUE INFECTA LAS PLANTAS DE TOMATE UTILIZANDO DOS BIOAGENTES, EXTRACTO DE AJO, PRODUCTOS COMERCIALES Y SINTÉTICOS].

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Root-knot nematodes are considered one of the most harmful pathogens that cause serious damage to plant hosts. The application of different bioproducts has attracted increasing attention as an effective and safe method compared with chemical nematicides for their hazards to humans and the environment. Our work focusses on evaluating the nematicidal potential of two culture filtrates of *Bacillus subtilis* and *Trichoderma* spp., extracts of garlic cloves, two commercial products; Hawasan and Stop Power, and two new synthesis products; Nematunistic and Masternema compared with the nematicide Vydate® L 24% for controlling *Meloidogyne incognita* infecting tomato plants cv. Dussehra, under laboratory and greenhouse conditions. Results indicated that culture filtrates of *B. subtilis*, *Trichoderma*, and garlic cloves extract showed significant effects on egg-hatch and J2 mortality percentages after 2 and 4 days of exposure. Results reached 38-70.1 % inhibition for egg-hatch and 41.6-65.4 % J2 mortality compared with the treatment of Vydate L 24%, which resulted in 77.2-89.6%. Moreover, treatments with both culture filtrates of used bioagents, garlic extract, and their mixtures caused significant reductions in numbers of root-knot nematode root galls, egg masses/plant, and J2/ 250 cc soil. The highest reduction results of 88.1-95.8 % were achieved with the mixture followed by that of "garlic extract plus *B. subtilis* or *Trichoderma*" treatments which showed reductions of 75.4- 81.1% compared with a reduction of 97.7- 98.6% obtained with the nematicide, Vydate L 24%. All of the treatments resulted in significant increases in root and shoot lengths and fresh and dry weights of treated tomato plants with 35.4-67.9 % increase. Under greenhouse

conditions, significant reductions in numbers of nematode root galls, egg masses/plant, and J2/250 cc soil were obtained by using three Egyptian isolates of the antagonistic bacterium, *Pasteuria penetrans* applied alone or in the mixture of the 3 isolates, that's by testing two doses of 4×10^7 and 8×10^7 spores/kg soil. Treatment with the mixture of all *P. penetrans* isolates showed 88.9-94.6 % reduction compared to 99.4-99.5 % that was obtained with Vydate L 24% application. As well, growth parameters of treated tomato plants were improved with a 62.5-69.8 % increase. Additionally, laboratory data using the two commercial bioproducts; HawaSan, Stop Power, and the new synthesis bioproduct; Nematunistic compared with the nematicide, Vydate L 24% showed significant egg-hatch inhibitions and increasing J2 mortality by 25-72.9% after 2 and 4 days of exposure. Furthermore, greenhouse experimental data using the two commercial bioproducts; HawaSan, Stop Power, and the two new syntheses; Nematunistic and Masternema compared with the nematicide, Vydate L 24% showed significant reductions in numbers of nematode root galls, egg masses/plant and J2/250 cc soil by 35.2-74.9% compared with that obtained with Vydate L 24% with 96.7-97.8%. As well, the growth parameters of treated plants were improved with a 30.9-65.4% increase compared with treatment of Vydate L 24% that reached 72.2%. These optimizing results of using the tested biocontrol agents, garlic extract, their combinations, *P. penetrans* isolates and the tested bioproducts could achieve root-knot nematode safe management on tomato and other plants grown in the root-knot nematode-infected fields.

**FUNGAL ENDOPHYTES SUPPRESS
Radopholus similis INFECTION OF**

BANANA (*Musa* spp.) THROUGH ENHANCED EXPRESSION OF DEFENCE-RELATED GENES [LOS ENDÓFITOS FÚNGICOS SUPRIMEN LA INFECCIÓN POR *Radopholus similis* DEL BANANO (*Musa* spp.) MEDIANTE LA EXPRESIÓN MEJORADA DE GENES RELACIONADOS CON LA DEFENSA].

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Radopholus similis, the root-burrowing nematode, is reputedly the most damaging nematode parasite of banana and responsible for major yield losses. In this study, 13 fungal isolates were endophytically assessed for their efficacy in the management of *R. similis* infection of tissue culture-derived East African Highland banana (cv. Ng'ombe). All isolates successfully colonised the banana roots, with isolates from *Fusarium*, *Hypocrea* and *Trichoderma* producing the highest ($\geq 49.1\%$) and *Beauveria* isolates the lowest ($\leq 14.4\%$) colonisation. The fungal isolates *H. lixii* (ICIZE 697) and *T. asperellum* (ICIZE 700) were the most effective in reducing *R. similis* densities ($\geq 81\%$) relative to the non-inoculated control. However, the combined inoculation of ICIZE 700 and ICIZE 697, led to greater suppression of *R. similis* ($\geq 21\%$) relative to individual inoculation.

Suppression of *R. similis* following inoculation of banana roots with ICIZE 700 and/or ICIZE 697 was associated with the significant upregulation of the cell signaling gene calmodulin Ca²⁺, the defence-related gene PR-1 and the cell wall strengthening gene β -1,3-glucan synthase. This study demonstrates the potential for nematode management in bananas with fungal endophytes, especially when using the combined isolates ICIZE 700 and ICIZE 697.

ELUCIDATING THE ROLE OF MIGPSY PEPTIDES IN INTERACTION BETWEEN PLANTS AND ROOT-KNOT NEMATODE [ELUCIDACIÓN DEL PAPEL DE LOS PÉPTIDOS MIGPSY EN LA INTERACCIÓN ENTRE LAS PLANTAS Y EL NEMATODO AGALLADOR].

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Plant-parasitic nematodes pose a severe threat to global food production. These parasites invade plant roots and establish permanent feeding sites, which serve as their sole source of nutrients. To manipulate host responses, they secrete effectors such as phytohormones or peptides that hijack the host's cellular machinery. Plants produce a family of peptides called Plant Peptide Containing Sulfated Tyrosine (PSY) that promote root growth via cell expansion and

proliferation. Intriguingly, the bacterial pathogen *Xanthomonas oryzae* pv. *oryzae* also produce a PSY-like peptide called RaxX (required for activation of XA21 mediated immunity X), which contributes to bacterial virulence. Our previous research has identified a group of secreted peptides called MigPSYs in root-knot nematodes (*Meloidogyne* spp.) that resemble plant PSY peptides and stimulate root growth in *Arabidopsis*. We found that MigPSY transcript levels are highest during the early stages of infection in rice and tomato plants. Furthermore, down-regulating expression of MigPSY results in reduced root galling and egg production, suggesting that the MigPSYs serve as nematode virulence factors. To gain a better understanding of the roles of MigPSYs, we plan to characterize the mechanisms underlying their function and host perception in plants. This research is expected to provide valuable insights into the mechanism of nematode infection and may lead to development of new methods for controlling plant-parasitic nematodes.

CHITOSAN METABOLISM: A WAY TO MODULATE NEMATOPHAGOUS FUNGI PATHOGENICITY DURING PLANT PARASITIC NEMATODES-PLANT INTERACTION [METABOLISMO DEL QUITOSANO: UNA FORMA DE MODULAR LA PATOGENICIDAD DE LOS HONGOS NEMATÓFAGOS DURANTE LA INTERACCIÓN PLANTA-NEMATODO PARÁSITO DE PLANTAS].

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Nematophagous fungi have been employed in biological control to protect crops of interest because of their ability to manage nematodes sustainably. *Pochonia chlamydosporia*, a worldwide fungal parasite of nematode eggs and females is responsible for natural suppression of soils to plant parasitic nematodes. This fungus is also a true endophyte in both mono and dicot crop plants. *Pochonia chlamydosporia* can modulate plant local and systemic defenses. Extracellular depolymerases of nematophagous fungi reflect their parasitic, endophytic, and saprophytic traits. Cell wall degrading enzymes allow fungi to colonize plant tissue. *Pochonia chlamydosporia* presents fewer cellulases, xylanases and pectinases than mycoparasite and nematode-trapping fungi. *Pochonia chlamydosporia* genome includes genes encoding enzymes to infect hosts with external barriers based on chitin/protein. The nematode eggshell is composed of a protein matrix embedding chitin microfibrils. *P. chlamydosporia* a highly expanded family of hydrolases related with chitin modification. Chitosan is a highly deacetylated form of chitin with antimicrobial activity. Entomopathogenic and nematophagous fungi are resistant to chitosan. Genomes of most isolates of *P. chlamydosporia* from worldwide origin show genes encoding putative chitin deacetylases and chitosanases. Most of these isolates display high parasitism to nematode eggs and degrade chitosan. However, we found no correlation between egg-parasitism and chitosanolytic activity. Chitin perception is a key component of the Plant Immune System (PTI). Chitin shielding/deacetylation in fungi is a way to circumvent plant defenses. Plant chitinases show less affinity for chitosan than chitin. Besides, chitosan is a less efficient plant defense elicitor than chitin. We propose that chitosan metabolism protects endophytic biocontrol fungi such as *P. chlamydosporia* from plant defenses in the

rhizosphere and allows them to parasitize efficiently endoparasitic nematodes embedded in root tissues.

POPULATION DENSITY AND REPRODUCTION FACTOR OF ROOT-KNOT NEMATODE, *Meloidogyne javanica* INFECTING SUGARBEET AS AFFECTED BY WATER DEFICIT UNDER DRIP IRRIGATION IN SANDY SOIL [DENSIDAD DE POBLACIÓN Y FACTOR DE REPRODUCCIÓN DEL NEMATODO AGUARDADOR DE LA RAÍZ, *Meloidogyne javanica*, QUE INFECTA A LA REMOLACHA AZUCARERA AFECTADA POR EL DÉFICIT DE AGUA BAJO RIEGO POR GOTE EN SUELO ARENOSO].

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A field experiment was conducted at West Nubaryia region, Egypt (30° 54' 54" N latitude and 29° 57' 53"E longitude) during the two successive seasons of 2021/22 and 2022/23 to evaluate the effect of three deficit irrigation rates i.e.60, 80 and 100% of the full irrigation water requirement (IWR) on the final population (Pf) and reproduction factor (Rf) of the root-knot nematode, *M. javanica* and productivity of sugarbeet (*Beta vulgaris*) cv. Merador grown in sandy soil under drip irrigation system. The results showed that the deficit irrigation rates of 60 and 80 % from IWR decreased significantly ($p \leq 0.05$) Pf and RF of *M. javanica* on sugarbeet, compared to full irrigation rate (100% of IWR). Also, the highest values for roots and gross sugar yields (tons/fed*) of sugarbeet and water use efficiency were achieved under deficit irrigation rate of 80% from IWR, while

the deficit irrigation rate of 60% from IWR recorded the lowest values. Our findings indicated that the deficit irrigation rate of 80% from IWR significantly reduced the damage caused by *M. javanica* to sugarbeet, and recorded a significant increase in sugarbeet productivity, compared to a full irrigation rate (100% from IWR). In summary, the application of deficit irrigation rate of 80% of IWR as an item in an integrated control program might provide an effective control of *M. javanica* on sugarbeet in sandy soil under drip irrigation system. *1 feddan = 0.42 hectare.

EFFICACY OF NATURALLY ORGANIC COMPOUNDS EXTRACTED FROM SOME MEDICINAL AND ORNAMENTAL PLANTS FOR CONTROLLING ROOT-KNOT NEMATODES INFECTING TOMATO PLANTS [LA EVALUACIÓN DE LA EFICACIA DE LOS COMPUESTOS ORGÁNICOS NATURALES EXTRAÍDOS DE ALGUNAS PLANTAS MEDICINALES Y ORNAMENTALES PARA EL CONTROL DEL NEMATODO AGALLADOR QUE INFECTA LAS PLANTAS DE TOMATE].

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Root-knot nematodes are considered one of the most serious plant pathogens that can be controlled successfully with nematicides despite their threats to humans and the environment. The efficacy of hexane extract of seven ornamental and medicinal plants, asparagus, coleus,

demsisa, garlic, moringa, rosemary, and wormwood, to inhibit egg-hatch of *Meloidogyne incognita* and increase second-stage juvenile (J2) mortality % were studied under laboratory conditions. Results of 2 and 4 days of exposure to different tested extracts showed significant inhibitions of egg-hatch reached 79.7% and increased J2 mortality by 83%. Intercropping of the seven tested plants with tomato plants cv., Dussehra infected with *M. incognita* resulted in significant reductions in numbers of nematode root galls, egg masses/plant and J2/250 cc soil. Results reached 81.3% decreases of nematode parameters compared with a reduction reached 97.4% with that obtained by Vydate L 24% applied treatment. The highest decrease percentage was achieved with garlic intercropping treatment with a 72.9 - 81.3% reduction in nematode parameters. As well, intercropping with the tested plant treatments resulted in 75% increases in all growth parameters of the infected tomato plants. In addition, tomato plants infected with *M. incognita* and treated with two doses of 50 and 100 g/kg soil of dried plant materials of the seven tested plants showed 40.6 - 94.3% reductions in numbers of nematode root galls, egg masses/plant, and J2/250 cc soil compared with that obtained by Vydate L24% application which reached 98.9% reductions. The highest reduction percentage was achieved with dried garlic materials, which showed 88.8 - 94.3% reduction followed by that obtained with dried materials of wormwood and demsisa which showed 66.9 - 70.6% reductions. All treatments increased the growth parameters of the infected tomato plants by 41 - 69.8%. Furthermore, the application of three doses of 25, 50, and 100 µl/ml, of the two commercial bioproducts; HawaSan, Stop Power and the new synthesis bioproduct Orgafamy (a mixture of all the tested plants extracts), inhibited

root-knot nematode egg-hatch and increased J2 mortality percentages after 2 and 4 days of exposure. The highest inhibition % of egg-hatch and increasing J2 mortality % was achieved by Orgafamy application treatment with 68.3 and 76.6 % inhibition of egg-hatch and 72.5 and 81.2 % increase of J2 mortality compared with 84.2 and 92.4% which were obtained with Vydate L 24% application treatment after 2 and 4 days of exposure, respectively. The new synthesis bioproduct, Orgafamy, is considered a promising candidate among applicable bioproducts because of its strong toxicity to root-knot nematodes. Further assessments of its potential in greenhouse and field practice should be encouraged.

JUSTIFICATION OF BIOCHEMICAL AND MOLECULAR MARKERS ASSOCIATED WITH RESISTANCE TO ROOT-KNOT NEMATODE (*Meloidogyne incognita*) IN SOME GRAPE CULTIVARS [JUSTIFICACIÓN DE MARCADORES BIOQUÍMICOS Y MOLECULARES ASOCIADOS A LA RESISTENCIA AL NEMATODO AGALLADOR (*Meloidogyne incognita*) EN ALGUNOS CULTIVARES DE VID].

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The lack of an effective evaluation method for root-knot nematode resistance in grape cultivars is one of the reasons for limited success in conventional resistance breeding. Emerging molecular-genetic

methods can be used as new approaches to the classification of different resistant genotypes. This study was carried out to reveal some highlights of the differences between contrasting tolerant grape cultivars regarding genetic expression and molecular characterization under root-knot nematode stress. Five grape cultivars were included to study molecular and genetic variations, including three susceptible cultivars (Flame seedless, Thompson seedless, and Superior) and two tolerant cultivars (Harmony and Freedom). SDS PAGE (sodium dodecyl sulphate polyacrylamide gel electrophoresis) analysis revealed differences in band patterns in diseased plants when compared with their respective healthy plants. Moreover, RAPD (random amplification of polymorphic DNA) markers produced a total of 34 bands (DNA fragments) among cultivars tested with an average of 6.8 bands per primer. ISJ9 primer showed a specific PCR (Polymerase chain reaction) product of 189 bp in the Freedom cultivar. This primer may be useful and beneficial to the genotype that recognizes tolerance QTL (Quantitative Trait Loci) marker alleles to use in marker-assisted selection in future research. However, the findings might be valuable and helpful to identify the genetic and molecular characterizations of different grape cultivars regarding root-knot nematode resistance.

UTILIZING REAL-TIME PCR TO EVALUATE THE MOVEMENT AND PERSISTENCE OF *Purpureocillium lilacinum* IN SOIL [IMPLEMENTACION DE PCR EN TIEMPO REAL PARA EVALUAR LA PERSISTENCIA Y MOVIMIENTO DE *Purpureocillium lilacinum* EN EL SUELO].

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Purpureocillium lilacinum (= *Paecilomyces lilacinum*) has been used as a biological control agent (BCA) which mainly parasitizes eggs and females of several plant-parasitic nematodes such as root-knot (*Meloidogyne* spp.) and cyst (*Heterodera* spp.) nematodes, *Tylenchulus semipenetrans*, *Rotylenchulus reniformis* and *Radopholus similis*. Among the various strains available, PL251 is the most commercially used as MeloCon[®] and a new liquid formulation has just become available recently. The efficacy of this BCA is often attributed to its movement and persistence in soil. However, PL251 has been reported to have low persistence, particularly in sandy soils. First, we tested the movement of fungal spores in the soil profile following a drench application of PL251 at 2x10⁶ spores/ g of soil. Soil samples were taken weekly for four weeks at 3, 6, and 9 cm depth and then cultured in PDA to count the fungal colonies. A higher number of spores was found in the top layer (3 cm) and in the first sampling date, and spore density decreased over time. In another (ongoing) experiment, we are evaluating different quantification methods of *P. lilacinum* from soil. Traditionally, spore quantification and persistence involve isolating the fungus through soil serial dilutions, which is time-consuming. This method also shows difficulties when working with non-sterilized soil and has a limit of detection at 10² viable spores per gram of soil. To overcome these challenges, we wanted to evaluate whether real-time PCR could be a more precise and efficient way to detect spores. This methodology quantifies the

number of spores based on the DNA present in the soil. A series of experiments was set up comparing real-time PCR and soil serial dilution as a detection method of *P. lilacinum* spores by inoculating soil with *P. lilacinum* PL251 spores from either the commercial liquid formulation (Melocon[®] LC) or from a pure culture on potato dextrose agar (PDA). The soil is kept at 25 °C for four weeks in a growth room and the spore presence is evaluated at 1, 10, 20 and 30 days after application. Each treatment has five replicates in a completely randomized design (CRD) and the experiment is repeated three times. This study may provide insights into the persistence of *P. lilacinum* strains in soil by the real-time PCR as a rapid and more reliable method than the laborious soil serial dilution method. The findings will contribute to enhancing the understanding and application of *P. lilacinum* as a promising biocontrol agent for nematode management in agricultural systems.

PENETRATION AND DEVELOPMENT OF *Meloidogyne graminis* ON BERMUDAGRASS COMPARED TO TOMATO [PENETRACIÓN Y DESARROLLO DE *Meloidogyne graminis* EN CÉSPED BERMUDA COMPARADO CON TOMATE].

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Meloidogyne graminis parasitizes a wide range of grasses in the United States and elsewhere. The optimum temperature for the nematode's penetration and development on grasses is reported as 28 °C. Although the host range of *M. graminis* appears to be restricted to grasses, the nematode's ability to infect

certain other plant species, namely tomato, is unknown. Our objectives were to determine the developmental cycle of *M. graminis* on bermudagrass at 25 °C and 28 °C and whether it penetrated and developed in tomato roots. The experiment was conducted in environmentally controlled chambers with artificial light. Four-week-old 'Rutgers' tomato seedlings and sprigged 'Tifway' bermudagrass (*Cynodon dactylon* × *C. transvaalensis*) were transferred to 470 cm³ styrofoam cups containing pasteurized sand, fertilized with 50 mL solution of Miracle-Gro (20-20-20 + micronutrients), and maintained in the greenhouse for 7 days. After this period, the plants were inoculated with 250 freshly hatched second-stage juveniles (J2) of *M. graminis*/ plant and placed in the chambers. The penetration and development were determined by sequential sampling two plants of each temperature treatment starting 24 h and 48 h after inoculation and then at 2-day intervals for 20 days. The roots were stained and observed for the presence of J2 under a binocular microscope. On bermudagrass, the highest J2 number penetrating roots was at 48 h after inoculation at 28 °C and 96 h at 25 °C. Some immature females and males were observed 10 DAI (days after inoculation) at 28 °C and 12 DAI at 25 °C. Adults, egg laying females, and males (50:50) were observed 14 DAI at 28 °C and 16 DAI at 25 °C. Numerous J2 were observed 20 DAI at 28 °C indicating a second generation. On tomato, only one J2 was observed inside roots 24 h and 48 h after inoculation both at 25 °C and 28 °C. These results suggest that tomato is not a host for *M. graminis*.

TRANSCRIPTOMIC ANALYSIS OF *Bursaphelenchus xylophilus* IN RESPONSE TO 3-OCTANOL [ANÁLISIS TRANSCRIPTÓMICO DE

***Bursaphelenchus xylophilus* EN RESPUESTA A 3-OCTANOL].**

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The pinewood nematode (PWN), *Bursaphelenchus xylophilus*, is one of the most damaging plant parasites, causing economic and ecological losses in the coniferous forestry systems. The spread of PWN, the causal agent of pine wilt disease (PWD), has a direct impact on the wood industry, and an indirect effect on the restrictions in the circulation of wood products from affected areas worldwide. The increasing consciousness of environmental protection is a necessity for the development of sustainable methods to control the PWN. The use of natural compounds produced by plants may provide a viable alternative for nematode control. In this study, we evaluated the transcriptomic profile of PWN in response to the plant compound 3-octanol (C8H18O) to better understand the differentially expressed genes and the metabolic pathways involved. Previous studies have shown an efficient nematicidal effect of this metabolite against PWN. Nematode transcriptomic analysis revealed an up-regulation in the expression of cytochrome P450s, UDP-glucuronosyl/UDP-glucosyltransferase and nuclear hormone receptors genes involved in the xenobiotic's biodegradation metabolic pathway. The transcriptomic analysis unveiled a down-regulation effect in the expression of collagen coding genes, which may indicate the modification of the nematode's cuticle as a reaction to the direct contact to the nematicide. This research will help to understand the mode of action of this

nematicide function at a molecular level providing new targets for nematode control.

EFFICIENCY OF NEMAT® (*Purpureocillium lilacinum*) IN THE CONTROL OF *Meloidogyne javanica* IN SOYBEAN [EFICIENCIA DE NEMAT® (*Purpureocillium lilacinum*) EN EL CONTROL DE *Meloidogyne javanica* EN SOJA].

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Root-knot nematodes are widely distributed in Brazil and negatively affect soybean (*Glycine max*) productivity. Biological control has become one of the main nematode control strategies in the country. Thus, the objective of this work was to evaluate the efficiency of the commercial product Nemat® (*Purpureocillium lilacinum*) in the control of *Meloidogyne javanica*, comparing it to other microorganisms. The experiment was conducted in the 2022 harvest, in a greenhouse, in a completely randomized design, with 11 treatments and six replications. The treatments were: control, Nemat® (*P. lilacinum*), *Bacillus subtilis* + *B. licheniformis* + *P. lilacinum*, *B. firmus*, *B. subtilis*, *B. methylotrophicus*, *B. amyloliquefaciens*, *B. subtilis* + *B. licheniformis*, *Trichoderma harzianum*, *Pochonia chlamydosporia* and the chemical abamectin. The treatments were applied via seed treatment in soybean or in the planting furrow, at the doses suggested by the manufacturers. After soybean emergence, 2,000 eggs + J2 (second-stage juveniles) of *M. javanica* were inoculated and 60 days after inoculation the total number of nematodes

and nematodes per gram of root was evaluated. All treatments reduced the total number of nematodes when compared to the control. However, Nemat® and abamectin differed statistically from the other treatments, showing a reduction of 95.7 and 98.5%, respectively. The reduction of the same parameter for the other treatments varied from 83.6 to 90.4%. For the number of nematodes per gram of root, it was observed that all treatments reduced this variable. Nemat® and abamectin showed control percentages of 99%, and the other treatments reduced an average of 98% of the nematode population. Thus, it is concluded that Nemat® was efficient in controlling *M. javanica* in soybean, standing out from the other biological treatments studied, having similar efficacy to abamectin.

REPRODUCTIVE POTENTIAL OF ENTOMOPATHOGENIC NEMATODE ISOLATES ON GALLERIA MELLONELLA [POTENCIAL REPRODUCTIVO DE AISLAMIENTOS DE NEMATODOS ENTOMOPATOGENOS EN GALLERIA MELLONELLA].

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Georgia is an agricultural country, and about 95% of the population is based on agriculture. Therefore, all efforts are being made to control insect pests through biological enemies, such as entomopathogenic nematodes (EPN), to increase the availability of quality

agricultural products for the growing population. Accurate knowledge of the reproduction and recovery of entomopathogenic nematodes is considered an important process to determine the timing and dosage of EPN for their subsequent use. Reproduction and recycling of EPN strains in the insect host play an important role in the persistence, infectivity, and overall effectiveness of pest control by EPN in the soil. Observational data on the reproduction of entomopathogenic nematodes showed that inoculation in an insect pest with entomopathogenic nematodes was able to infect and multiply by all tested EPN species in the body of the insect host, i.e., *Galleria mellonella*. The highest reproduction of *Steinernema carpocapsae* nematodes 2,708 was recorded on the fourth instar larvae of the insect *G. mellonella* at 100 IJs/100 µl. EPN *Heterorhabditis bacteriophora* gave us 2,384 reproductive potential on the larvae of the insect *G. mellonella* of the fourth age, while the entomopathogenic nematode *Steinernema germanica* revealed low reproductive potential. From this, we can conclude that the entomopathogenic nematode *S. carpocapsae* is characterized by a higher reproductive potential on fourth instar *G. mellonella* larvae than other nematodes (*H. bacteriophora* and *S. germanica*).

PLANT-PARASITIC NEMATODE DISEASES IN INTENSIVE STRAWBERRY CROPS OF SOUTHERN SPAIN [ENFERMEDADES CAUSADAS POR NEMATODOS EN CULTIVOS INTENSIVOS DE FRESA EN EL SUR DE ESPAÑA].

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Spain is the fourth largest strawberry producer in the world, producing approximately 350,000 tons per year on 6,500 ha, with an approximate annual commercial value of €400 million. Soilborne pathogens such as *Macrophomina phaseolina*, *Fusarium oxysporum f. fragariae*, and *Meloidogyne hapla* are widespread and frequently co-occur in strawberry crops in Spain representing a major constraint to achieving strawberry premium quality and economically sustainable yields. Plant-parasitic nematodes (PPN) were found in 63% of strawberry fields, resulting in average yield losses of 5-10%. *Meloidogyne hapla*, *Pratylenchus penetrans* and *Hemicycliophora* spp. are the main species found in the area, with *M. hapla* the most prevalent species (71% of the fields). Strawberry is a poor host for *M. hapla* in southern Spain area with a tolerance limit of 0.2 J2/g of soil, and low population increases in cropping cycles of 7–8 months. Strawberry cultivars show a range of susceptibility and tolerance to *M. hapla*, but no resistance was found. Comparative nematicidal efficacies and cost-benefit analyses were conducted on a variety of nematicidal products and techniques for managing PPN. The range of PPN soil densities (P0) that nematode control methods were able to manage while maintaining profitability in strawberry intensive crops was dependent on nematicidal efficacy, treatment costs, and crop revenue. Using agrochemical fumigants and biosolarization, soil nematode populations were reduced by over 75%. Other agrochemical nematicides showed efficacies ranging from 51% to 64%, whereas botanicals reduced nematode populations by 41% to 48%. Fumigants and biosolarization were

profitable and effective in reducing high nematode soil densities (greater than 300 J2/100 cm³ of soil). Profitability ranges for less effective nematicidal treatments varied from 30 to 250 J2/100 cm³ of soil. Interactions between soil pathogenic fungi and nematodes were analyzed in pot experiments on strawberry plants. There was an increase in disease symptoms in joint inoculations of PPN and soil pathogenic fungi, suggesting an additive interaction between them in the strawberry SBP caused diseases. A screening of bacterial strains isolated from strawberry rhizospheres was conducted for plant growth promotion and biocontrol potential on *M. phaseolina* and *M. hapla*. *Pseudomonas aeruginosa* AC17 showed the greatest potential as biocontrol agent candidate to be included in integrated disease management programs to control the two most prevalent soilborne pathogens of strawberry in Spain *M. phaseolina* and *M. hapla*. Financial support: IFAPA PP.AVA.AVA201601.10 and FEDER funds from European Union.

ENDOPHYTIC BACTERIA AS BIOCONTROL AGENTS AGAINST ROOT-KNOT NEMATODES *Meloidogyne incognita* ON EGGPLANT [BACTERIAS ENDOFÍTICAS COMO AGENTES DEBIOCONTROL CONTRA NEMATODOS DEL NUDO DE LA RAÍZ *Meloidogyne incognita* EN BERENJENA].

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Endophytic bacteria have the capability of colonizing internal host tissues, and this makes them a valuable tool to improve crop performance and protection from many pathogenic organisms. A total of 31 bacterial endophytes isolates were obtained from tomato, pepper and eggplant from leaf, stem, and root of the plant. Ten bacterial isolates provided in vitro activity against *Meloidogyne incognita*, with strain FB2-20 exhibiting the strongest performance in the assay and significantly reducing the number of eggplant root galls, egg masses and juveniles in a pot study. Strain FB2-20 significantly increased the eggplant root and shoot fresh weight compared to that of controls. The strain FB2-20, identified as *Pseudomonas chlororaphis*, has potential to be an environmentally safe and effective bio-fertilizer for improving growth of nematode infected eggplant.

EVALUATION OF SOIL MOISTURE REGIME AND POTASSIUM FERTILIZATION EFFECTS IN CONTROL OF ROOT-KNOT NEMATODE, *Meloidogyne incognita* ON TOMATO CROP [EVALUACIÓN DEL RÉGIMEN DE HUMEDAD DEL SUELO Y LOS EFECTOS DE LA FERTILIZACIÓN CON POTASIO EN EL CONTROL DE LA INFECCIÓN POR EL NEMATODO AGALLADOR *Meloidogyne incognita* EN EL CULTIVO DE TOMATE].

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Influence of soil moisture regime and K-fertilization rates and their interactions were studied on root-knot nematode (*Meloidogyne incognita*) in tomato under greenhouse conditions. Five levels of soil moisture, i.e. 20, 40, 60 and 80% of field capacity (FC) compared with 100 % FC as a control treatment, while K-fertilization was 0.18 and 240 Kg/ha as potassium sulfate. The two main parameters considered were plant response (plant growth and yield) and penetration rate, reproduction factor (Rf) and final population density (Pf). Soil moisture regime levels of 80, 60, 40 and 20% FC resulted in a decrease in all studied tomato crop growth attributes. Such effects were clearer at 40 and 2 % FC. Potassium fertilization with all studied application rates resulted in higher fresh weight at all soil moisture regime level treatments. Application of 240 kg/ha of K-fertilization under 80 and 60% FC resulted in similar fresh fruit weights of tomato (551.33 and 540.23 g/plant) compared to (561.10 g/plant) at 100% FC, which were not different from the control. All studied *M. incognita* infection parameters were significantly reduced due to soil moisture decreasing levels. The lower soil moisture levels to 40 and 20% FC caused the relatively higher reduction RF. Penetration rate values were reduced due to decreasing soil moisture regime levels than that of control. Application of K-fertilization at all studied rates resulted in comparable reduction in penetration rate values under all studied soil moisture regime level treatments. The highest rate of K-fertilization (240 kg/ha) resulted in penetration rates lower than that of control treatment. Under soil moisture regime studied levels, RF values of *M. incognita* were significantly reduced ($P \leq 0.05$) The percentage reduction values of RF were 42.9, 46.9, 85.0 and 88.9 % lower than that of control treatment, respectively.

Addition of high K-fertilization (240 kg/Fed) resulted in percentage values of 54.5, 54.5, 85.3, and 89.1% under 80, 60, 40 and 20% FC, soil moisture regime, respectively. By linking obtained results 80 and 60% FC soil moisture regime levels combined with 240 Kg/ha K-fertilization can be a beneficial tool in tomato crop cultivation under limiting water conditions as well as to reduce *M. incognita* infection with insignificant reduction in all tomato growth attributes compare to that of 100% soil moisture regime control treatment.

IMPACT OF TWO *Bacillus* STRAINS AND TWO *Pseudomonas* SPECIES AS BIOCONTROL AGENTS IN CONTROLLING *Meloidogyne incognita* INFECTING TOMATO PLANTS [IMPACTO DE DOS CEPAS DE *Bacillus* Y DOS ESPECIES DE *Pseudomonas* COMO AGENTES DE BIOCONTROL DE *Meloidogyne incognita* EN PLANTAS DE TOMATE].

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Root-knot nematodes *Meloidogyne* spp. are considered one of the most economically important plant-parasitic nematodes, which cause severe yield and quality losses annually in most economic crops. Exploring certain antagonistic bacterial species e.g., *Bacillus* sp. and *Pseudomonas* spp. which can act as biocontrol agents against *M. incognita*, as well as increasing plant growth parameters is important. The present research was designed to study the efficacy of the two *Bacillus* (in: *firmicutes*) strains (AB-11 and SA-16) with the

following accession numbers (MK509792 and MK509796), one *B. thuringiensis* strain (JA-9) with accession number MK509790, one isolate of *Pseudomonas fluorescens* and one strain (AB-20) of *P. chlororaphis* with accession number MK509799 (isolated from tomato root and soil samples collected from several localities in Abu-Arish, Sabia, and Damed governorates, Jazan province, southwest Saudi Arabia) on root-knot nematode, *Meloidogyne incognita*, infecting tomato plants cv. Super Strain-B during 2020-2021. Under laboratory conditions, treatment with the nematicide, Vydate L® 24% resulted in the highest significant effect reaching 97.8% egg-hatch inhibition or second-stage juvenile (J2) mortality, followed by treatments with the high dose (8×10⁷ cfu/well) of strain (JA-9) of *B. thuringiensis*, *P. fluorescence* and strain (AB-20) of *P. chlororaphis*, which resulted in 62.2-80.4% egg-hatch inhibition or J2 mortality. Meanwhile, the lowest inhibitions of 20-40.4% were gained from applying the two strains (AB-11 and SA-16) of *Bacillus* sp. Under greenhouse and field conditions the efficacy of applying the two bacterial species *Bacillus* and *Pseudomonas* against *M. incognita* infected tomato plants was tested through two microplot experiments during in 2020-2021. Under greenhouse condition, treatments in 2020 with the two doses of strain (JA- 9) of *B. thuringiensis*, *P. florecences* and strain (AB-20) of *P. chlororaphis* resulted in 50.1-80.0 % decrease in number of nematode root galls, egg-masses/root system and number of eggs/kg soil, followed by treatments with the two strains (AB-11 and SA-16) of *Bacillus* sp. which showed 30-48.6% reduction. Meanwhile, all treatments in 2021 resulted in a 49.2-89.5% reduction in all nematode parameters. Meanwhile, all treatments resulted in a significant increase of 22.1-72.0% in root and shoot dry weights. Under field conditions, application of all bacterial strains resulted in a 38.5-64.1% reduction in

2020 and 67.2-87.9 % in 2021 in the number of nematode root galls, egg-masses/root system, and the number of eggs/kg soil. Treatments with all bacterial strains showed a significant increase (27.8-62.0%) in root and shoot dry weights in both years. Treatment with Vydate L 24% resulted in the highest reduction of 98.3% in all nematode parameters in greenhouse and field experiment. This study revealed that the tested strains of *Bacillus* spp. and *Pseudomonas* spp. showed the potential for controlling root-knot nematodes in sustainable agriculture.

EFFICACY OF TYMIRIUM® 450SC AS SOIL APPLICATION AGAINST PLANT PARASITIC NEMATODES ON TOBACCO, CITRUS, VEGETABLES AND POTATO IN AFRICA AND THE MIDDLE EAST [FITOTOXICIDAD Y EFICACIA DE TYMIRIUM® 450SC COMO APLICACIÓN EN EL SUELO CONTRA NEMATODOS PARÁSITOS DE LAS PLANTAS EN TABACO, CÍTRICOS, VERDURAS, POTATO Y EN ÁFRICA Y ORIENTE MEDIO].

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Africa will contribute more to global population growth than any other region. There is no doubt about the need to increase agricultural efficiency and productivity. To achieve this, cropping systems must become more intensified while improving water-use efficiency, managing elevated pest and disease threats, and boosting the quality and use of external inputs. Emphasized especially is the need to address the nematode problem to assist alleviating world hunger. Food crops are infected by plant-parasitic nematodes that cause root necrosis and

death due to damaging the root system and weakening plant anchorage. Infected and damaged root systems contribute towards crop yield loss mainly due to their inability to effectively translocate water and nutrients to the aerial plant parts. Now, Syngenta innovated the newest and latest nematicide technology VANIVA® 450SC, a soluble concentrate, soil-applied nematicide that provides protection of crop plants from all major plant-parasitic nematodes. It targets all root-damaging nematodes through contact and feeding activity, and potentially also nematodes that infect and damage above-ground plant parts through systemic feeding activity.

THE ARTIFICIAL SELECTION PROCESS USING AN ODOR CUE INCREASES THE EFFICACY OF THE ENTOMOPATHOGEN NEMATODE *Steinernema australe* AGAINST *Aegorhinus superciliosus* (COLEOPTERA: CURCULIONIDAE) IN BERRY ORCHARDS [EL PROCESO DE SELECCIÓN ARTIFICIAL USANDO UN OLOR COMO SEÑAL AUMENTA LA EFICACIA DEL NEMÁTODO ENTOMOPATÓGENO *Steinernema australe* CONTRA *Aegorhinus superciliosus* (COLEOPTERA: CURCULIONIDAE) EN HUERTOS DE BERRIE].

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The entomopathogenic nematode (EPN) *Steinernema australe* was first isolated in

Chile and identified as a good alternative for controlling *Aegorhinus superciliosus* (Coleoptera: Curculionidae) larvae. This weevil is native to the south of Chile and some regions in Argentina, causing berry orchards to decline and die. The major problem is caused by the larva, which spends between nine to eleven months below ground and feeds inside the root-making galleries. This study seeks to increase *S. australe*'s efficacy through an artificial odor stimulus selection process. We selected *S. australe* infective juveniles (IJs) that follow the stimulus and reach the larva at 30 cm deep faster. Larvae infected with selected IJs and IJs from the original stock were compared under laboratory, greenhouse, and field conditions. Insect mortality and EPN penetration were analyzed using ANOVA with the number of dead larvae and IJs that penetrated the larvae as response variables. Results showed a 20% increase in the efficacy of selected IJs compared with IJs from the original stock. The most remarkable effect of the selection process on *S. australe* was the increase in the proportion of IJs that reached the larva faster, vertically down in the soil, during the first four days post-application. Moreover, larvae treated with selected IJs showed a mix of nematode stages emerging from the cadaver. A potential trade-off on nematodes' recycling in the soil is proposed. This is the first report focusing on the effect of artificial selection to increase the efficacy of *S. australe* in the field.

PEST AND PESTICIDE MOVEMENT: CAUSES FOR NEMATODE MANAGEMENT INCONSISTENCIES IN SANDY SOILS [MOVIMIENTO DE PLAGAS Y PESTICIDAS: CAUSAS DE LAS INCONSISTENCIAS EN EL MANEJO DE NEMATODOS EN SUELOS ARENOSOS].

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Problems continue with crop and pest control response variability for some of the soil fumigants and other nonfumigants applied pre and post plant via shank and drip irrigation delivery system. Most Florida small fruit and vegetable soils are classified as fine sands with low water and nutrient holding capacity and high hydraulic conductivity. These features allow water too easily, and in some cases the chemical in them, to rapidly percolate through soil. The lack of nematicide product performance in Florida sandy soils suggests that drip application fails to provide adequate distribution of these chemical products in sandy soils. From previous drip fumigation research, the average depth, width, and cross-sectional bed area wetted by drip irrigation water was determined to increase as a hyperbolic function of total water volume applied. Based on this previous work, chemical injection schedules and irrigation run times should not be exceeded to contain the wetting front principally within the future rooting zone of the plant. Other studies in Florida have clearly shown that most soil fumigants, once injected to soil are incapable of diffusing very deeply into soil, particularly through a highly resistant soil traffic pan, into soil horizons far below that of the strawberry plant rooting zone where nematodes often reside. To address the depth distribution of nematodes in Florida, a vertical management zone approach is now being used to inject fumigants at multiple intervals to manage nematodes at depths of 40 cm or more. The substantial yield increases using the vertical management zone approach strongly suggests that nematode damage potential to

a given crop occurs from migrating individuals from soil depths after and below which fumigants distribute. Drip application delivery of chemical and biological products is also extensively used for post plant soil borne nematodes and disease control. Consistent delivery of an effective dosage of any chemical material throughout the target soil profile is considered necessary to achieve acceptable pest control. More recent studies are showing how sodium bromide can be suitably used as a soil tracer to characterize lateral spread and downward percolation rates of water-soluble compounds. Patterns of drip irrigation solute movement of the tracer is being used to infer nonfumigant nematicide radial movement and solute percolation in soil. There is sufficient data from this work to suggest that effective use of the post plant applied biological nematicides will require multiple applications, synchronized with host and nematode biology, to maintain efficacious concentrations in soil and or on plant foliage. This presentation will attempt to clarify recent findings of pest and chemical movement, considering a variety of physical, chemical, and biological factors, and how it impacts future strategies to manage nematodes.

SOME NEMATOPHAGOUS FUNGI IN EGYPT [ALGUNOS HONGOS NEMATÓFAGOS EN EGIPTO].

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Nematophagous fungi can be fungal egg-parasites, nematode-trapping fungi that capture nematodes using modified hyphal traps, or endoparasitic that parasitize the nematode by means of small conidia or zoospores. Nematode-trapping fungi, facultative fungi that form trapping structure to trap nematodes, include six types of

traps. Traps come in many forms: adhesive hyphae, networks, knobs, rings, constricting rings and non-constricting rings. Soils with heavy organic manure application are rich in the antagonistic fungi. Occurrence of nematode-trapping fungi in Egypt was studied by collecting soil samples from fruit orchards, field crop and vegetables during two consecutive years. Seven species of nematode-trapping fungi *Arthrobotrys conoides*, *A. dactyloides*, *A. oligospora*, *Dactylaria brochopaga*, *D. Thaumasia* var. *longa*, *Dactylella gephyropaga* and *Stylopaga hadra* were isolated from the root-knot nematode-positive samples. The fungus which egg-parasites (*Verticillium chlamydosporium*) and endoparasitic fungi (*Harposporium anguillulae*, *Catenaria anguillulae*, *Cephalosporium balanoides*, and *Haptoglossa heterospora*) were isolated from the root-knot nematode-positive samples.

***Trichoderma harzianum* TRANSCRIPTOME IN RESPONSE TO THE NEMATODE *Pratylenchus brachyurus* [TRANSCRIPTOMA DE *Trichoderma harzianum* EN RESPUESTA AL NEMATODO *Pratylenchus brachyurus*].**

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The root-lesion nematode *Pratylenchus brachyurus* causes extensive damage in several crops of economic importance.

Fungi of *Trichoderma* genus have been highlighted as biopesticide agents in the control of several plant diseases. Although it is already widely used in agriculture, there are few studies, especially at the molecular level, that evaluate *T. harzianum* in the control of *P. brachyurus*. The aim of the present study was to investigate how interaction with the nematode *P. brachyurus* influences gene expression of *T. harzianum*, by using RNA-Seq analysis. Of the 13,932 predicted genes in the *T. harzianum* genome, 2,922 (21%) were differentially expressed in the presence of *P. brachyurus*, in relation to the absence of the nematode. Among the differentially expressed genes, we found genes encoding Carbohydrate Active EnZymes (CAZy), MEROPS peptidases, and proteins related to secondary metabolite synthesis. 118 pathways were identified as related to the biosynthesis of secondary metabolites. The analysis identified 136 metabolic pathways related to these differentially expressed genes, among which we highlight: aminobenzoate degradation, xenobiotic metabolism by cytochrome P450, and sesquiterpenoid and triterpenoid biosynthesis. Our results contribute to a better understanding of the response of *T. harzianum* to *P. brachyurus*, the potential for biocontrol by this fungus.

USING FLAVONOIDS OF PHYSIC NUT AS CONTROL AGENT FOR ROOT-KNOT NEMATODE *Meloidogyne incognita* ON OKRA [USO DE FLAVONOIDES DE *Jatropha curcas* COMO AGENTE DE CONTROL PARA EL NEMATODO AGALLADOR *Meloidogyne incognita* EN OKRA].

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The biocidal efficacy of a plant based nematicide is largely dependent on their phytochemical constituents and medicinal values. In vitro and screen house experiments were conducted to investigate the biocidal efficacy of flavonoids of Physic nut (*Jatropha curcas*) plant parts on *M. incognita* on okra (*Abelmoschus esculentus*). Efficacy of flavonoids was evaluated against nematode juveniles (J2) after 24, 48 and 72 hours of incubation at 0, 5 and 10 ml in in vitro conditions. Flavonoids evaluated against *M. incognita* J2 under in vitro conditions revealed that nematode mortality was highest (93 %) after 72 h incubation period at 10 ml rate of application and differed significantly ($P = 0.05$) with nematode mortality (80 %) obtained at 5 ml. Under screen house conditions, flavonoids at 0 (control), 1, 2, 3, 4, and 5 ml were applied to potted okra plants inoculated with 1,200 *M. incognita* J2. The experiment was a 3x6 factorial arranged in completely randomized design with five replications. Results showed that flavonoids applied at 5 ml /pot significantly ($P = 0.05$) reduced galls on roots and increased plant growth parameters after application of seed and leaf flavonoids compared to the untreated control in 2019 and 2020. Seed and leaf flavonoids also increased okra pod weight by 75% and 71% in both years over the control. These findings elucidated the potential of *J. curcas* flavonoids as a possible alternative for the control of root-knot nematodes on okra. The present study suggests that the *J. curcas* based phytochemical, flavonoids possess strong nematicidal effects and can be used effectively in an integrated disease management program against root-knot nematodes.

***Trichoderma harzianum*
TRANSCRIPTOME IN RESPONSE TO
THE NEMATODE *Pratylenchus*
brachyurus [TRANSCRIPTOMA DE
Trichoderma harzianum EN
RESPUESTA AL NEMATODO
Pratylenchus brachyurus].**

Oliveira, C. M.¹, L. H. Oshiquiri², N. O. Almeida³, A. S. Steindorf⁴, **M. R. Rocha³**, R. C. Georg¹, and C. J. Ulhoa¹. ¹Federal University of Goiás, Institute of Biological Sciences, Goiânia, Brazil, ²University of São Paulo, Ribeirão Preto Medical School, Ribeirão Preto, Brazil, ³Federal University of Goiás, Faculty of Agronomy and Food Engineering, Goiânia, Brazil, ⁴U. S. Department of Energy Joint Genome Institute, Berkeley, CA, USA. camillam.08@gmail.com.

The root-lesion nematode *Pratylenchus brachyurus* causes extensive damage in several crops of economic importance. Fungi of *Trichoderma* genus have been highlighted as biopesticide agents in the control of several plant diseases. Although it is already widely used in agriculture, there are few studies, especially at the molecular level, that evaluate *T. harzianum* in the control of *P. brachyurus*. The aim of the present study was to investigate how interaction with the nematode *P. brachyurus* influences gene expression of *T. harzianum*, by using RNA-Seq analysis. Of the 13,932 predicted genes in the *T. harzianum* genome, 2,922 (21%) were differentially expressed in the presence of *P. brachyurus*, in relation to the absence of the nematode. Among the differentially expressed genes, we found genes encoding Carbohydrate Active EnZymes (CAZy), MEROPS peptidases, and proteins related to secondary metabolite synthesis. 118 pathways were identified as related to the biosynthesis of secondary metabolites.

The analysis identified 136 metabolic pathways related to these differentially expressed genes, among which we highlight: aminobenzoate degradation, xenobiotic metabolism by cytochrome P450, and sesquiterpenoid and triterpenoid biosynthesis. Our results contribute to a better understanding of the response of *T. harzianum* to *P. brachyurus*, the potential for biocontrol by this fungus.

***Steinernema australe* DISPLAYS
CHEMOTAXIS TOWARDS
VOLATILES IDENTIFIED FROM
BLUEBERRY ROOTS [*Steinernema*
australe PRESENTA QUIMIOTAXIS
HACIA VOLÁTILES
IDENTIFICADOS A PARTIR DE
RAÍCES DE ARÁNDANOS].**

Palma-Millanao, R. A.¹, R. E. Ceballos², **A. J. Monje¹**, J. A. Urzúa², J. P. Alveal², and P. D. Navarro(1). ¹Agricultural Research Institute, Laboratory of Insects Science, Carillanca, Chile, ²Agricultural Research Institute, Laboratory of Insects Chemical Ecology, Chillán, Chile. patricia.nararro@inia.cl

Steinernema australe (Panagrolaimomorpha: Steinernematidae) is an entomopathogenic nematode isolated in Chile, which has shown promising characteristics for controlling larvae of the weevil *Aegorhinus superciliosus* (Coleoptera: Curculionidae) one of the most damaging blueberry pests in this country. Recently, chemical volatile compounds were isolated and characterized from *Vaccinium corymbosum* damaged and non-damaged roots by this weevil (unpublished data). The capability of these compounds to elicit chemotaxis upon *S. australe* was determined, establishing their potential role as attractants to find their host (*A. superciliosus* larvae). To reach this aim, we used a two-sided olfactometer to

perform bioassays that measured the preference of infective juveniles (IJs) towards eight compounds in five concentrations each: 1,000, 100, 10, 1, and 0.1 µg/mL. Double-distilled hexane was used as a control. The olfactometer consisted of two plastic Petri dishes on an external 90 mm plate. The internal components were divided into halves representing treatment and control, separated by the decision area. Three hundred (±50) IJs of *S. australe* were suspended in one milliliter of distilled water and inoculated over the decision area. Olfactometers were randomly oriented and kept in a dark room at 14 (± 2 °C) for 15 hours. Results showed that in dose-response tests, *S. australe* was attracted to all five tested concentrations of methyl salicylate, 1-nonine, α-terpineol, and 2-carene; and by 100 µg/mL of 10-undecyn-ol; 0.1 and 100 µg/ mL of linalool; 100 µg/mL of limonene, whereas eucalyptol elicited no attraction or repellency. These results suggest that some volatiles released from roots damaged by *V. corymbosum* may attract *S. australe*, which may have implications for the biocontrol of subterranean pests.

ACTIVE PLANT NEMATOLOGISTS: A PROJECT DEDICATED TO PROMOTING PLANT NEMATOLOGY [ACTIVE PLANT NEMATOLOGISTS: UN PROYECTO DEDICADO A PROMOVER LA NEMATOLOGÍA VEGETAL].

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Active Plant Nematologists (APN) is an international scientific community, dedicated to promoting Plant Nematology, by fostering collaborations between professionals and enthusiasts. The group was founded during the coronavirus pandemic of 2020, to tackle the cancellation of physical conferences and meetings. We are committed to creating a safe space for all Nematologists worldwide, regardless of current position, location, or background, and raising awareness to crop protection and the crucial role of nematodes in soil health. APN's primary platform started with a workspace on SLACK, currently with 564 registered members around the globe, and a plethora of channels covering the most various topics in Nematology, from student and professional opportunities to nematode taxonomy and phylogenetics, and much more. APN is now present on other social media platforms, and has co-organized two successful virtual seminars, with the sponsorship of ADAMA US, the second of which had well over 500 registered participants from many countries! Two parallel student contests were held during the event: a 5-mi thesis competition and a poster competition. More recently, APN has teamed up with the Young Nematologists Network, from the European Society of Nematologists, to organize the second edition of the Virtual Nematology Conference. The group will organize

further activities to engage a broader audience and explore alternative ways to improve communication in Nematology.

PURPEST: CHEMICAL PROFILE OF THE PINWOOD NEMATODE FOR RAPID DETECTION [PURPEST: PERFIL QUÍMICO DEL NEMATODO DE LA MADERA DEL PINO PARA UN DIAGNÓSTICO RÁPIDO].

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The pinewood nematode (PWN), *Bursaphelenchus xylophilus*, is a quarantine pest and the causal agent of pine wilt disease (PWD), a major phytosanitary concern that is ravaging native pine trees in Asia and Europe, having also been detected in Mexico. Management of PWD involves strict regulations and heavy contingency plans, resulting in the felling, removal, and destruction of infected trees, having serious economic and ecological impacts. Regular monitoring of the PWN and its insect vector is the most common strategy to prevent outbreaks of PWD, but introduction and dissemination can eventually occur. Current screening of suspected wood material requires highly trained personnel and can be time consuming. Rapid detection is therefore of utmost importance in preventing the establishment of the nematode. The PURPEST project aims to investigate the volatile organic compound (VOC) signature of *B. xylophilus* using gas chromatography–

mass spectrometry. This information will be utilized to optimize sensor components and develop a prototype sensor system. This technology will then be validated in the field and at import control sites and will enhance pest management strategies by enabling early diagnosis of PWD and improving inspection rates for pine stands and woody material imports. The non-invasive, reliable, and high throughput methodology employed by PURPEST will help prevent the spread of PWD to new forestry areas. PURPEST is co-funded by the EU through grant agreement 101060634.

TRANSITIONING TO SUSTAINABLE FOOD PRODUCTION: WHAT CAN NEMATODES TELL US ABOUT SOIL ECOSYSTEM HEALTH? [TRANSICIÓN HACIA LA PRODUCCIÓN DE ALIMENTOS SUSTENTABLES: ¿QUÉ NOS PUEDEN DECIR LOS NEMATODOS SOBRE LA SALUD DEL ECOSISTEMA DEL SUELO?].

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Understanding soil ecosystems is crucial for sustainable food production, with nematodes playing a pivotal role in ecosystem functioning and serving as bioindicators of soil health. In this case study, Nematode-Based Indices (NBIs) were used to assess soil ecosystem status across diverse agricultural and natural systems in South Africa, including Regenerative Agriculture (RA) research trials, Conservation Agriculture (CA) farmlands, and undisturbed grasslands. Nematode communities were quantified,

and NBIs calculated using the NINJA online tool, with descriptive and inferential statistics employed to explore and interpret the data. We observed no significant differences in soil ecosystem status among the treatments in research trials, possibly due to the recent implementation. This finding emphasizes that soil ecosystems may require substantial time to recover from physical and chemical degradation. However, established CA farmlands demonstrated significantly improved soil ecosystem health compared to conventional agriculture systems. Further analysis revealed a negative correlation between food web structure and inorganic nitrogen, underscoring the need for reduced fertilizer usage. Also, grassland habitats exhibited significant seasonal variations in soil ecosystem status, emphasizing the importance of acknowledging natural ecosystem dynamics. This study affirms the potential for recovery of soil ecosystems following the implementation of more sustainable food production systems and supports the use of NBIs in the ecological assessment of agricultural systems. However, the specific land use and environmental context should be considered for accurate interpretation when utilizing these biological parameters.

ISOLATION OF FUNGI ASSOCIATED WITH ROOT-KNOT NEMATODES, AND SCREENING FOR THEIR ANTAGONISTIC ACTIVITIES AGAINST *Meloidogyne javanica* [AISLAMIENTO DE HONGOS ASOCIADOS A NEMATODOS AGALLADORES Y ESTUDIO DE SU ACTIVIDAD ANTAGÓNICA CONTRA *Meloidogyne javanica*].

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Root-knot nematodes (RKN) caused more than 50% from total crop losses caused by plant-parasitic nematodes (PPN-21.3%). RKN infected eggplants at Riyadh region, KSA was identified morphologically and by molecular technique. Biological control is considered an eco-friendly measure to control PPN alternatives to nematicides. Sixty-five antagonistic fungal isolates were isolated from egg mass, females, and juveniles (J2s) of RKN and screened for their abilities to control *Meloidogyne javanica* in both direct parasitism and culture filtrate (50&75%) *in vitro*. Their ability to infect eggplant under laboratory conditions were investigated as well. Results showed that *M. javanica* was the predominant species that infected eggplants. Overall, the 65 antagonistic fungal isolates have different effects on J2s mortality and egg hatch of *M. javanica*. In parasitism tests, isolates TF24 and TE6 were inhibited egg hatching while FF3 exhibited high mortality of J2s (90.91%) compared to the control treatment. Culture filtrate of antagonistic fungi at 75% was more effective than 50% at all. Twenty-one antagonistic fungal isolates were selected and identified by molecular techniques using ITS-4 and ITS-5 primers. Data revealed that seven isolates were *Fusarium solani*, three isolates were *F. oxysporum*, two isolates were *Trichoderma harzianum*, and two isolates were *Plectosphaerella cucumerina*. *F. incarnatum*, *F. inflexum*, *F. equiseti*, *T. polysporum*, *T. asperellum*, *Ceraceosorus*

guamensis and *Cladosporium limoniforme* were identified individually. In a pathogenicity test, *T. harzianum* found as a promising antagonistic fungus that has no effect on seed germination. Thus, antagonistic fungus, *T. harzianum* can be used alternatively to nematicides and has a positive impact on seed germination and growth.

CANDIDATE EDAPHIC DRIVERS OF LOCAL ABUNDANCE PATTERNS OF AN INSECT HERBIVORE [CONDUCTORES EDÁFICOS CANDIDATOS DE PATRONES DE ABUNDANCIA LOCAL DE UN INSECTO HERBÍVORO].

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The citrus root weevil (CRW) *Diaprepes abbreviatus* is a devastating pest of citrus orchards in the Caribbean Basin and North America. Root herbivory by the larvae debilitates and eventually kills trees. In Florida, weevil abundance varies by ecoregion, and there is evidence that regionally adapted entomopathogenic nematodes (EPNs) contribute to the weevil spatial pattern on the peninsula. Weevils also typically persist at higher, more damaging levels at specific locations within orchards for unknown reasons. We hypothesize that soil properties driving soil food webs contribute to these local patterns. Since July 2022, an ongoing survey has monitored tree condition and DRW adults (both in the tree canopy and as they emerge from the soil) at 94 sites arranged in a grid pattern in a 2.45 ha orchard block. Soil physico-chemical properties were characterized from soil samples taken in May 2023. DNA was extracted from soil

organisms obtained from 250 cm³ subsamples using sucrose centrifugation. The extracted DNA was then subjected to qPCR, utilizing species-specific primers-probes and a metabarcoding approach where three gene regions (ITS2 rDNA, 16S rDNA, and COI mtDNA) were sequenced using the Illumina NovaSeq platform. The weevils trapped in the tree canopies during 12 months were significantly aggregated, as measured by Spatial Analysis by Distance Indices (SADIE Ia index), and occurred primarily in a location that confirmed the grower's previous observations. The weevil pattern was strongly associated (SADIE Xindex) with the pattern of tree death during spring 2023 and dissociated with that of elevation. The EPNs *Steinernema diaprepesi* traits, longevity, and higher virulence. Such a strain was then tested in field trials and mass production. The adapted application technology and the genetically improved strain allow us to lower the application density to 1 x 10⁹ nematodes/ha at equal control potential. Together with the application of economies of scale producing the worms in bioreactors of a total volume of 120,000 L, the product costs were further reduced. Today, the application costs are equal to the use of (less effective) synthetic soil insecticides.

STING NEMATODE IPM IN CITRUS ORCHARDS WITH HUANGLONGBING [MIP DE *Belonolaimus longicaudatus* EN HUERTOS DE CITRICOS CON HUANGLONGBING].

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Citrus production in Florida has declined more than 85% since 2005 due to the introduction of the disease huanglongbing

(HLB). The phloem-limited bacteria cause trees to shed half their fibrous roots before symptoms appear above-ground. Widespread replanting of orchards due to HLB has focused grower awareness of *Belonolaimus longicaudatus* (sting nematode) because nematode damage to roots causes tree decline soon after trees are planted. Research was initiated to 1) compare the efficacy of six nematicides for sting nematode management, 2) evaluate perennial peanut ground cover between rows for nematode reduction and, 3) determine whether trees debilitated by HLB can respond profitably to management of the nematode. Fifteen-month-old Valencia trees on Kuharske rootstock exhibiting HLB symptoms were treated with recommended rates of six nematicides (oxamyl, aldicarb, fluensulfone, fluopyram, fluazaindolizine, and an experimental compound) for three years. The trial design was a randomized complete block with eight, four-tree replicates. Plots in 16 rows of trees were plumbed to receive treatments from a central location via buried lines leading to the appropriate microsprinklers. Trees were treated in spring and autumn by rotating pairs of chemicals. The numbers of nematodes and mass density of fibrous roots were measured during summer and winter seasons. The 3-year average reduction in sting nematode population density compared to untreated plots was greatest for oxamyl (48%) and ranged between 6%-37% for the pairs of other products. Compared to untreated controls, oxamyl was the only product to increase the fibrous root mass density (2.27-fold, $P = 0.001$) and trunk growth (36%, $P = 0.02$). Perennial peanut as a ground cover between tree rows reduced the numbers of sting nematodes by an average of 67% compared to middles with native plants, and by 94% during the periods of peak density. None of the treatments increased fruit yield; however, the nematicide

effects on the 3-year, cumulative numbers of sting nematodes were highly predictive. Multiple regression of fruit yield against the trunk girth prior to initiating treatments ($P = 0.001$), combined with the cumulative sting nematode populations during the trial ($P = 0.01$) explained 31% of the fruit yield in 2022. The harvested fruit from trees in the trial averaged just 3544 kg/ha in 2022, well below a level needed to profit from nematode management. Consequently, an ongoing study is evaluating 1) new rootstocks for tolerance and/or resistance to the sting nematode, and 2) young tree responses to sting nematode management while utilizing fabric-mesh tree covers shown recently to prevent the transmission of the huanglongbing causal agent.

PLANT-PARASITIC NEMATODES IN AL-QASSIM AGRICULTURE, SAUDI ARABIA [NEMATODOS PARÁSITOS DE PLANTAS EN LA AGRICULTURA DE AL-QASSIM, ARABIA SAUDITA].

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Al-Qassim region is considered one of the major agricultural areas in the Kingdom of Saudi Arabia, it ranks second in terms of cultivated area after the Riyadh region. Recent statistics indicated that agricultural products exceeded 1.2 million tons, on an area of 94,923 hectares. Al-Qassim region is a major producer of fresh dates, vegetables, ornamentals, and citrus. The warm climate and porous sandy soils throughout the region favor numerous nematodes, often resulting in extensive crop damage. The most important plant-parasitic nematodes associated with crop

production in Al-Qassim are the root-knot nematodes. *Meloidogyne incognita* and *M. javanica* limit vegetable, fig, and grape production. Other nematode species that can be highly damaging include the cereal cyst nematodes *Heterodera avenae* on wheat, the citrus nematode *Tylenchulus semipenetrans* on citrus. Lesion nematodes *Pratylenchus* spp. are important on several field crops such as wheat and alfalfa. Other nematodes found were reniform, lance, stubby root, dagger, needle, and spiral nematodes. Nematode control relies on the use of fumigant and non-fumigant nematicides. Also, crop rotation in combination with fallowing and soil solarization is common practice for nematode population reduction. Some biological nematicides products and natural enemies of nematodes are available, but their use has not resulted in consistent control of nematodes in Al-Qassim region. The development of resistant plant varieties and other environmentally sound and economically sustainable control measures is critical for future nematode management programs. Efforts must continue to prevent and manage nematode infestation, and actions should be implemented to make farmers and agriculturalists aware of the importance of nematodes and practices to manage them.

DISTRIBUTION AND EDUCATIONAL PROGRAMS DESIGNED TO REDUCE THE IMPACT OF ANIMAL-PARASITIC NEMATODES; RAT LUNGWORM *Angiostrongylus cantonensis*. RACCOON ROUNDWORM, *Baylisascaris procyonis*, AND HEARTWORM, *Dirofilaria immitis* IN NEW ORLEANS, LOUISIANA, UNITED STATES [DISTRIBUCIÓN Y PROGRAMAS

EDUCATIVOS DISEÑADOS PARA REDUCIR EL IMPACTO DE LOS NEMATODOS PARÁSITOS DE ANIMALES; GUSANO PULMOINAR DE LA RATA *Angiostrongylus cantonensis*. ASCÁRIDO DEL MAPACHE, *Baylisascaris procyonis*, Y EL GUSANO DEL CORAZÓN, *Dirofilaria immitis* EN NUEVA ORLEANS, LOUISIANA, ESTADOS UNIDOS].

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Urban and suburban environments often provide the harborage, abundant food and water sources needed to support robust populations of mosquitos, commensal rodents, and urban wildlife such as raccoons. Water-holding containers, bird feeders, community gardens and abandoned properties on or near residential properties provide ideal conditions for mosquitoes and urban wildlife and increase their interaction with people and pets. Nearly 8% of dogs tested in Louisiana were positive for heartworm. Until recently, little information was known about prevalence of animal-parasitic nematodes in rodents and raccoons from metropolitan New Orleans. The aim of these studies was to estimate the prevalence of *Baylisascaris procyonis*, the raccoon roundworm, and *Angiostrongylus cantonensis*, rat lungworm, in the animal hosts in New Orleans. Both *A. cantonensis* and *B. procyonis* are considered emerging zoonotic diseases in the United States. In separate studies, Norway rats, *Rattus norvegicus*, roof rats, *Rattus rattus*, and raccoons, *Procyon lotor*, were trapped throughout metropolitan New Orleans. Institutional Animal Care and Use

Committee protocols were followed for trapping and animal handling. Necropsies were performed to identify *B. procyoni* and *A. cantonensis*. Tissue and/or fecal samples were examined for nematode presence. In rodents (n = 696), an average of 38% prevalence of *A. cantonensis* was observed. Differences in infection rates varied by host species and trap location. Similar infection rates of *B. procyonis* were observed in raccoons. Twenty-four of 65 raccoons (36.9%) had *B. procyonis* in their intestines and 31.7% of the fecal samples were positive with eggs. These studies indicate the importance of educating the public and veterinary and health care professionals about potential health risks and providing resources to prevent exposure and disease.

NEW HOST RECORDS OF ROOT-KNOT NEMATODES (*Meloidogyne* spp.) INFECTING VEGETABLE AND FRUIT CROPS IN FLORIDA, USA [NUEVO REPORTE DE NEMATODO AGALLADOR (*Meloidogyne* spp.) EN FRUTALES Y VEGETALES DE FLORIDA, ESTADOS UNIDOS].

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Root-knot nematodes (RKN) are a widely distributed and a polyphagous plant-parasitic nematode genera. In 2003, the host range already encompassed more than 3000 plant species. In Florida, several *Meloidogyne* spp. have been found infecting ornamental, horticultural and agronomic crops, turfgrass and weed plants. RKN are very widespread in most of the state, but information on which species of *Meloidogyne* is present,

especially in agricultural fields, is lacking. Therefore, we conducted a RKN survey between September 2019 and January 2023, focused on South and Central Florida. Soil and root samples were collected in commercial vegetable and fruit farms, research farms, horticultural gardens, Asian vegetable farms, and natural landscapes in 12 counties. *Meloidogyne* species identifications were performed using molecular methods, including DNA sequencing and phylogenetic analysis. RKN were detected in 247 out of 304 (81.3%) root samples collected. Five RKN (*M. arenaria*, *M. enterolobii*, *M. hapla*, *M. incognita* and *M. javanica*) were identified. *M. incognita* and *M. enterolobii* were the most prevalent species, each present in 76 (25.0%) of the samples. *M. javanica* was identified in 50 (16.4%) samples, followed by *M. arenaria* in 25 (8.2%) samples and *M. hapla* in 16 (5.3%) samples. Mixed populations of *M. enterolobii* and *M. incognita* were identified in 4 (1.3%) samples. Fifty-six crops belonging to 22 different families were sampled during the surveillance. New host records include: a worldwide host record, *Solanum capsicoides* (*M. enterolobii*); new continental USA host records, *Vigna unguiculata* (*M. enterolobii*), *Opuntia cochenillifera* (mixed species – *M. enterolobii* and *M. incognita*). Additionally, new state host records found were, *Cannabis sativa*, *Colocasia esculenta*, and *Lilium* sp. (*M. arenaria*), *Phaseolus vulgaris* (*M. enterolobii*), *Cucumis melo* (*M. hapla*), and *Lavandula angustifolia* and *Helianthus annuus* (*M. incognita*). The new hosts records reported in this study confirmed the RKN broad host range reported in previous studies. In addition, the new host findings and the mixed species that were found in some crops implies a more precise management when it comes to alternative strategies such as

cover crops, crop rotation and biological control.

NEMATODE MANAGEMENT WITH ORCHID MYCORRHIZAL FUNGI, *Waitea circinata* [MANEJO DE NEMATODOS CON EL HONGO MICORRIZICO ORQUIDOIDE, *Waitea circinata*].

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The fungi *Waitea circinata* isolate En07 was isolated from an orchid (*Epidendrum nocturnum*), native in the Cerrados region. This orchid mycorrhizal fungi (OMF) has been proved efficient in controlling fungi diseases in rice and nematodes in other crops. We evaluated the efficiency of *W. circinata* controlling *Meloidogyne javanica* and *M. enterolobii* in tomato plants, and *Heterodera glycines* in soybean plants. We also evaluated the effect of the OMF on the plant development. Concentrations of 5, 10, 15, 20 and 25 mg of *W. circinata* mycelia suspension/L were tested in vitro and under greenhouse conditions for *M. javanica*, *M. enterolobii* and *H. glycines*. Same concentrations were tested in a field experiment for *H. glycines* x soybean. In vitro trials showed an increase in J2 mortality as the OMF concentrations increased for *M. javanica* and *H. glycines*. Also, OMF parasitized eggs and reduced hatch of the three nematode species tested. Under greenhouse, *M. javanica* and *M. enterolobii* reproduction factor and population density reduced as the OMF concentration increased. *H. glycines* females and cysts were lower at concentration around 15 mg/L. Eggs/female and eggs/cyst reduced with

the increase in OMF concentrations. Tomato and soybean plants presented higher fresh root weight, root length and plant height at concentration of 15 mg/L when inoculated with *M. javanica* and *H. glycines*, respectively. Tomato inoculated with *M. enterolobii* had an increase in fresh shoot weight and plant height as the OMF concentrations increased.

A SURVEY OF PLANT-PARASITIC NEMATODES ASSOCIATED WITH HEMP IN OREGON AND WASHINGTON, U.S.A. [NEMATODOS FITOPARÁSITOS ASOCIADOS A CÁÑAMO EN OREGON Y WASHINGTON, US].

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In 2022, hemp (*Cannabis sativa*) production in the US, including oil, bud, seed, and fiber, was valued at \$238.4 million USD. Since hemp is a new crop, there is a lack of information about biotic factors that affect its production, including plant-parasitic nematodes (PPN). The objectives of the study were to 1) conduct a survey of PPN associated with hemp in Oregon and Washington, and 2) assess the host status of hemp to two species of *Meloidogyne* and *Pratylenchus*. A total of 63 soil samples (23 from Washington and 40 from Oregon) were collected between 2021 and 2022. For each sample, nematodes were extracted from 250 g of

soil using the decant sieve method. In 2022, 27 root samples (13 from Washington and 14 from Oregon) were also collected and nematodes were extracted by intermittent mist. Seven different PPN were found in soil samples with *Pratylenchus* spp. being the most frequently encountered (present in 59% of soil samples). Only *Pratylenchus* spp. and *Meloidogyne* spp. were found in root samples and *Pratylenchus* spp. occurred most frequent with its presence detected in 93% of the root samples. *Meloidogyne hapla*, *Pratylenchus crenatus*, *P. fallax*, *P. neglectus*, and *P. penetrans* were identified from root samples using DNA-based methods. To achieve the second objective, individual hemp seedlings (5-weeks- old) were transplanted into pots containing 2.1 kg of steam-pasteurized 1:1 sand:loam soil mix and then inoculated with *M. hapla*, *M. chitwoodi*, and *P. neglectus*. The initial population density for each *Meloidogyne* species was 4,000 eggs and 2,000 mixed-stage nematodes for *P. neglectus* in each pot. Each nematode/plant combination was replicated five times and non-inoculated plants were included in the experiment. The experiment was conducted twice. Plants were harvested 60 days after inoculation. *Meloidogyne* spp. were extracted from roots using the hypochlorite method and *P. neglectus* was extracted from roots by intermittent mist. The Baermann funnel method was used to extract nematodes from soil. There was no impact of PPN on plant growth when compared to non- inoculated controls. The reproduction factor (RF) was calculated by dividing the final population density by the initial population density. Results from both experiments were combined since there was no statistical difference between experiments ($P > 0.05$). In general, hemp was a poor host for all evaluated PPN: *M. chitwoodi* (RF = 0.007), *M. hapla* (RF = 0.60), and *P. neglectus* (RF

= 0.90). Our results show that hemp is a poor host for *M. chitwoodi*, *M. hapla*, and *P. neglectus* which should be considered within the crop rotation system in the Pacific Northwest. Additional research should be carried out to assess the host suitability of hemp to these PPN under field conditions.

A COMPARATIVE ANALYSIS OF VINEYARD MANAGEMENT EFFECTS ON NATIVE ENTOMOPATHOGENIC NEMATODES AND THE SOIL NEMATODE COMMUNITY [ANÁLISIS COMPARATIVO DE LOS EFECTOS DE LA GESTIÓN DE VIÑEDOS SOBRE LOS NEMATODOS ENTOMOPATÓGENOS NATIVOS Y LA COMUNIDAD DE NEMATODOS DEL SUELO].

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Vineyards and their associated socio-economic activities are of global importance. However, intensive management and erosion-prone nature make vineyard agroecosystems vulnerable. Conventional viticulture practices, including tillage and agrochemical applications, lead to the loss of soil biodiversity and the reduction of beneficial soil organisms such as entomopathogenic nematodes (EPNs). In the autumn of 2019, we collected composite soil samples from

80 vineyards across the Doca Rioja region (Northern Spain), categorized them based on pest (integrated vs. organic) and soil management (tillage vs. cover cropping). Using sucrose-gradient centrifugation and species-specific primers/probe qPCR sets, we identified the occurrence and abundance of ten EPN species. We also estimated EPN activity using the insect bait method. Our results revealed the positive effects of organic viticulture on native EPNs, particularly on the abundance and activity of the predominant steinernematid species *S. feltiae*. However, the impact on EPNs was similar between tilling and cover cropping despite variations in several abiotic factors. Subsequently, we selected an optimal subset of DNA samples from 57 vineyards out of the total 80 studied for investigating the structure of nematode communities using high-throughput sequencing. To conduct metataxonomic analysis, we employed specific primers and followed the Illumina amplicon protocol. The resulting data underwent comprehensive bioinformatics analysis using Qiime2 and the SILVA v138.1 database, allowing us to explore biodiversity measures and identify taxa that exhibited differential abundances. Over 80 taxonomic groups (genus/family) were successfully identified and utilized for calculating nematode-based indices via the NINJA platform. As observed for EPNs, no significant differences were found between cover cropping and tilling practices but for pest management. Thus, organic viticulture positively enhanced the α -biodiversity of soil nematodes. Additionally, nematode-based indices revealed increased environmental disturbance, a higher occurrence of plant-parasitic nematodes with negative implications for crop health, and a decline in the soil food web structure in vineyards practicing integrated pest management. In summary, the conclusions from both analyses underline the parallel beneficial impact of organic vineyard

management on EPNs and the soil nematode community. Moreover, these findings highlight the significance of minimizing the usage of synthetic agrochemicals in crop management but also emphasize the potential value of specific EPN species as bioindicators of soil health in agroecosystems.

RESPONSE OF TOMATO CULTIVARS TO THE RICE ROOT-KNOT NEMATODE *Meloidogyne graminicola* [RESPUESTA DE CULTIVARES DE TOMATE AL ATAQUE DEL NEMATODO AGALLADOR DEL ARROZ *Meloidogyne graminicola*].

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Tomato (*Solanum lycopersicum* L.) is an important and versatile vegetable crop of great nutritional relevance. Worldwide production, in 2021, was about 189 million tons, more than half coming from Asia (approx. 63%), followed by the Americas and Europe. The European Union holds 9.5% of the world production with Italy reporting the highest production (approx. 37.1%). Portugal is the 3rd largest European producer with approximately 1.7 million tons, corresponding to 9.7% of the

EU total. Plant-parasitic nematodes (PPN) are highly damaging pests as they cause serious losses worldwide. A considerable part of this damage is caused by root-knot nematodes (RKN), *Meloidogyne* spp., one of the most devastating pests of economically important crops. *Meloidogyne graminicola* (*Mg*) is the most serious PPN of tropical rice production. It was reported for the 1st time in Europe in 2016 in Italy. In addition to rice, *Mg* has a wide range of hosts, including cereals, grasses, and some horticultural crops among which is tomato. However, contradiction among authors regarding wheat and tomato as important hosts has been found, so, the response of four commercial cultivars (Ox-Heart, Rio-Grande, Marmande, Tiny-Tim) traditionally used in Portugal was evaluated. The experiment was carried out in a quarantine greenhouse. Tomato seeds were germinated at 27°C and sown in individual pots (500 cm³) with substrate and sand (1:2), daily watered and fertilized once a week. Plants of *Echinochloa crus-galli* were included as positive control. Each plant was inoculated with 200 second stage juveniles (J2) (initial population density, Pi) three weeks after planting. After 30 days, plants were harvested, root systems washed, the number of galls quantified, and *Mg* gall index (GI) determined. Eggs and juveniles were extracted from roots and soil to find out the final population density (Pf) and the reproduction factor ($Rf = Pf/Pi$) calculated. *Mg* host suitability was assessed based on GI and Rf. Results show that all the tomato cultivars were susceptible to *Mg* ($4.8 \leq IG \leq 5$ and $39.8 \leq Rf \leq 53.3$). To confirm the infection was caused by *Mg*, biochemical and molecular identification was performed. The *Mg* isolate displayed an esterase phenotype corresponding to VS1. The molecular analysis using *Mg* specific primers presented a band of the expectable size. It can be concluded that the infection was caused by *Mg* and that this species may

also constitute a potential threat to tomato production.

BIOCONTROL-BASED STRATEGIES FOR IMPROVING SOIL HEALTH AND MANAGING PLANT-PARASITIC NEMATODES IN COFFEE PRODUCTION [ESTRATEGIAS BASADAS EN BIOCONTROL PARA MEJORAR LA SALUD DEL SUELO Y MANEJAR NEMATODOS PARÁSITOS DE PLANTAS EN LA PRODUCCIÓN DE CAFÉ].

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Despite the global demand for coffee, Kenya is facing a decline in production due to various factors, including plant-parasitic nematodes. This study focused on evaluating the effectiveness of two biocontrol agents, *Trichoderma asperellum* and *Purpureocillium lilacinum*, applied through drenching, in controlling nematodes and their impact on the soil nematode community in established coffee trees in Kenya. Seven field trials were conducted over two years, targeting Arabica coffee trees heavily infested with *Meloidogyne hapla*, which was reported for the first time on coffee in Kenya. After 12 months, treated trees showed a significant decrease in *M. hapla* populations in the roots, while soil nematode densities were similar across treatments. *T. asperellum* treatment improved soil health conditions

and increased microbial community diversity, as indicated by nematode based indices. Conversely, *P. lilacinum* application resulted in higher abundances of fungivorous nematodes, particularly *Aphelenchus* spp., suggesting its suitability as a food source for these nematodes. Principal component analysis (PCA) revealed differences in nematode assemblages between treatments and temporal effects on associated genera. For example, *Aphelenchus* spp. shifted from weak associations to a strong association with *P. lilacinum*, and *Mesorhabditis*, a c-p 1 group nematode, initially associated with *T. asperellum* but later showed a strong association with *P. lilacinum*. However, the stressed and depleted soil conditions in the trials might have caused a delay in the impact of the treatments and the detection of differences, as indicated by the functional metabolic footprint. A longer study would provide better insights into treatment benefits. Nevertheless, this study highlights the potential of biologically based approaches for sustainable nematode management in established coffee plantations, aligning with environmentally and climate-smart practices.

RESISTANCE OF SOME POTATO AND TOMATO HYBRIDS TO *Globodera rostochiensis* IN EGYPT [RESISTENCIA DE ALGUNOS HÍBRIDOS DE PAPA Y TOMATE A *Globodera rostochiensis* EN EGIPTO].

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In Egypt, potato (*Solanum tuberosum* L.) and tomato (*Lycopersicon esculentum* Mill.) are among the most important

economic vegetable crops and are commonly grown in the Nile Valley and Nile Delta at most times of the year. A recent nematode survey showed the presence of the golden cyst nematode *Globodera rostochiensis* in high frequency of occurrence in several potato fields in Wadi El-Natron and El-Nubaria region in El-Behera governorate in Northern Egypt. Resistance to *G. rostochiensis* in three potato and four tomato hybrids was evaluated in separate greenhouse experiments with five replicates in clay pots (25-cm-diameter). The tested plants were inoculated with an initial density (Pi) of 20 crushed nematode cysts/pot, about 5,000 eggs/pot of *G. rostochiensis* approximately 15 days after plant emergence. Nematode cysts were extracted and counted to determine final population (Pf) 55 days after nematode inoculation, and rate of reproduction of *G. rostochiensis* ($Rf = Pf/Pi$) was determined. The tested plant hybrids were rated on a scale of 0-5 according to the nematode Rf, $Rf = 0$ were considered resistant, $Rf = 0.1-0.5$ moderately resistant, $Rf = 0.6-1.0$ moderately susceptible $Rf = 1.1-5.0$ susceptible, and $Rf > 5.0$ highly susceptible. The results showed the tested potato hybrids Spunta, Hermes, and Bern, were highly susceptible, while the tested tomato hybrids 023 F1, LX 025, T- 186, and Dorra103 F1 were susceptible to *G. rostochiensis*. More research is needed to further test more potato and tomato cultivars and hybrids for resistance to *G. rostochiensis*. It is likely that the use of most resistant potato and tomato cultivars and hybrids could be used in managing *G. rostochiensis*.

THE NEWCOMER: CURRENT SITUATION OF *Aphelenchoides fragariae* IN CHILE [EL RECIÉN LLEGADO: SITUACIÓN ACTUAL DE *Aphelenchoides fragariae* EN CHILE].

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The strawberry nematode (*Aphelenchoides fragariae*) was detected for the first time in Chile in 2022 in the metropolitan region by the Agricultural and Livestock Service (SAG). Since then, it has spread to other regions of the country, including the Valparaíso, metropolitan region, O'Higgins, Maule, Ñuble, Biobío, La Araucanía, and Los Lagos (about 56.6% of the Chilean territory). Due to this, the Government of Chile has taken a series of measures to control the spread of the nematode, which include: 1) the creation of regional tables to coordinate the response to the nematode, 2) the issuance of press releases to inform producers about the pest and, 3) the implementation of quarantine measures to prevent its spreading. The current situation of *A. fragariae* in Chile is worrying since the nematode has rapidly spread and has caused significant damage to strawberry production. The SAG authorized the use of 12 chemical products and one biological (neem oil) for the control of *A. fragariae* within the framework of the established emergency measures. However, it is necessary to implement integrated management programs in the short and medium term. For this reason, the Government of Chile is also working on the development of new techniques to control *A. fragariae*. These techniques include the use of biocontrol agents, the development of new varieties of resistant strawberries, diversification of the offer through new nurseries, among others. According to official data in 2021, strawberry production reached 155,000 tons, of which 90% was produced by small strawberry producers

(less than 10 hectares). Because of this, the problem has escalated from a purely agricultural perspective to a social and political one, which is why the situation needs a comprehensive model for its management.

DEVELOPMENT OF A FORMULATION PROTOCOL FOR A SOUTH AFRICAN ENTOMOPATHOGENIC NEMATODE ISOLATE FOR BIOLOGICAL CONTROL AGAINST THE FALSE CODLING MOTH (*Thaumatotibia leucotreta*) [DESARROLLO DE UN PROTOCOLO DE FORMULACIÓN PARA UN NEMATODO ENTOMOPATÓGENO AISLADO DE SUDÁFRICA PARA EL CONTROL BIOLÓGICO DE LA POLILLA FALSA DE LA MANZANA (*Thaumatotibia leucotreta*)].

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The false codling moth (FCM) *Thaumatotibia leucotreta* is a polyphagous, quarantine pest of Southern African causing major economic losses. To control this pest, we are investigating the application of entomopathogenic nematodes. Entomopathogenic nematodes (EPNs) are successful biological control agents of a variety of soil-borne pests. Key to their commercial success is the development of a formulation protocol that possesses prolonged shelf life without negatively affecting their pathogenicity and application methods. Exponential growth has occurred in the use of EPNs as a biocontrol agent for insect pests in recent years. However, the cost implications pertaining to the production, formulation, and storage of

EPNs play an important role in establishing their high market value. Although significant progress has been made and multiple formulation techniques exist, prolonged shelf life is still a limiting factor in most countries, including South Africa. Recent studies have largely focused on how to develop and improve high-quality EPN formulations, with extended storage periods. This study assessed the shelf life and pathogenicity of different formulation techniques for *Steinernema yirgalamense* a South African EPN isolate and the addition of anti-microbial products to the formulation to further increase the survival of infective juveniles. *Steinernema yirgalamense* has displayed successful control of multiple South African agricultural insect pests including the false codling moth. However, a suitable formulation has not been developed for South African industries. The EPNs for this study were obtained from in vitro liquid mass produced EPNs and different formulations were further investigated to fulfil their role as an effective biological control agent for application in orchards to reduce FCM invasions.

**TAKING IT TO THE FIELD:
ORGANIC MANAGEMENT OF
Meloidogyne incognita IN
SWEETPOTATO USING WINTER
COVER CROPS AND BIOLOGICAL
CONTROL [LLEVÁNDOLO AL
CAMPO: MANEJO ORGÁNICO DE
Meloidogyne incognita EN CAMOTE
USANDO CULTIVOS DE
COBERTURA DE INVIERNO Y
CONTROL BIOLÓGICO].**

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Interest in organic production is growing, but there is a need to develop effective organic nematode management practices for sweetpotatoes. To address this, field trials were established in Alabama, (fine sandy loam soil) and North Carolina, (sandy clay loam soil), USA to determine the efficacy of selected winter cover crops and biological control products in the suppression of *Meloidogyne incognita* and insect pests. Winter cover crops were arranged in a randomized complete block design with five replications and were planted in October. Winter covers were terminated in May and sweetpotatoes planted. Three species of entomopathogenic nematodes (*Steinernema feltiae*, *Steinernema carpocapsae*, and *Heterorhabditis bacteriophora*), the insect pathogen *Beauveria bassiana*, and the biological product Majestene were applied as a three way mix to half of each sweetpotato plot to determine their combined ability to suppress *M. incognita* and insect populations. Ultimately, a winter cover crop mix of crimson clover, daikon radish, elbon rye, and wheat was associated with high marketable yields (over 2,000 lb/A increase over fallow), low insect damage, and low *M. incognita* populations. The combined biological products numerically increased marketable yields in both locations and significantly reduced internal *M. incognita* damage in Alabama. In Alabama, crimson clover and field peas were associated with high *M. incognita* populations at sweetpotato planting of 97 to 368 J2s per 100 cm³ soil, respectively. All other cover crops supported from 1-78 J2s per 100 cm³ soil at sweetpotato planting. Total *M. incognita* populations through the season across 4 sampling dates increased on crimson clover and field peas to 454 and 863 J2s per 100 cm³ soil, respectively. The lowest population of 345 J2s per 100 cm³ soil was observed following daikon radish. North Carolina populations were lower at sweetpotato

planting ranging from 28 to 72 J2s per 100 cm³ soil for fallow and crimson clover. Total *M. incognita* populations across the season of 4 sampling dates were significantly lower following elbon rye, wheat, and the cover crop mix compared with crimson clover. All cover crops in North Carolina increased numbers of free-living nematodes compared with the fallow. Bacterivores were most numerous followed by fungivores and predators. In the greenhouse, *M. incognita* populations/gram of root were highest on field peas at 5,430 eggs/gram of root and lowest on elbon rye at 48 eggs/gram root after 56 days. Subsequently, summer cover crops were tested in the greenhouse with velvet beans supporting the lowest *M. incognita* population at 18 eggs/gram root, followed by sunn hemp, and pepper sudangrass. The cover crop mix supported the highest organic sweetpotato yield, was associated with lower *M. incognita* populations, and high CO₂ respiration. Overall, the biological control products significantly reduced internal *M. incognita* damage in Alabama and numerically increased yields across both locations.

TOXIC EFFECTS OF THE TRAP CROP *Solanum sisymbriifolium* ON *Globodera pallida* [EFECTOS TÓXICOS DEL CULTIVO *Solanum sisymbriifolium* SOBRE *Globodera pallida*].

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New methods for controlling *Globodera pallida* are essential for the success of the eradication program in the United States. *Solanum sisymbriifolium* induces hatch but limits reproduction of *Globodera pallida*, and can be used as a trap crop for management of potato cyst nematodes.

However, because *S. sisymbriifolium* has little economic value as a crop and seeds are largely unavailable, it has not been widely adopted for use by producers. There is evidence that this plant kills the nematode through production of toxins although this is poorly understood. Our research indicates that pure solanaceous glycoalkaloids may be toxic to *G. pallida*, and reduce hatch, infection, and reproduction of *G. pallida* by 87%, 94%, and 99% respectively. Plant material extracted with hexane or butanol are highly effective in reducing hatch and viability of *G. pallida*, whereas *S. sisymbriifolium* extracts made with dichloromethane or ethyl acetate had no impact on hatch and viability of *G. pallida*. Liquid-liquid extraction of *S. sisymbriifolium* leaf and stem tissue by hexane and 1-butanol reduced hatch by 49.5%, and 68.3% respectively, and reduced viability by 28.5%, and 33.4% respectively compared to the potato root diffusate control. There are many different chemicals that could be responsible for this toxic effect. In hexane this includes sterols, flavonoids, and non-polar lipids. In butanol this includes steroidal glycoalkaloids, glycosides, and anthocyanins. A mass spectrometry analysis of the extracts found that the highest concentration of the glycoalkaloid solamargine is found in the stem and leaf tissue when extracted with butanol. To identify which compounds are responsible for the toxic nematode effects, further fractionation of *S. sisymbriifolium* extracts will be conducted and evaluated for nematode control. The discovery of novel chemistries for nematicide development would be a valuable achievement for producers, or anyone dealing with nematode infestations. This and other management tools for *G. pallida* will be discussed.

EFFICACY OF THE COMBINED APPLICATION OF ENTOMOPATHOGENIC FUNGI AND NEMATODES AS BIOCONTROL AGENTS AGAINST *Spodoptera litura* [EFICACIA DE LA APLICACIÓN COMBINADA DE HONGOS ENTOMOPATÓGENOS Y NEMATODOS COMO AGENTES DE BIOCONTROL CONTRA *Spodoptera litura*].

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The use of entomopathogens against agricultural pests reduces the need for toxic synthetic chemical insecticides. Co-cultivation of entomopathogens is a novel method that is emerging recently in demand for more highly effective and sustainable agricultural practices. This study aimed to evaluate the individual and combined pathogenicity of locally occurring entomopathogenic fungi (EPF) and entomopathogenic nematodes (EPNs) as biocontrol agents against the tobacco cutworm *Spodoptera litura*. A total of 32 local EPF from various agricultural areas in Bukidnon were isolated and identified using ITS1/ITS4 and the TEF region. From this collection, the five most virulent EPF isolates against *Zophobas morio* larvae, namely *Penicillium crustosum* CBB.11, *Talaromyces muroii* BNNS1C.3,

Penicillium solitum SVS.28, *Diaporthe salsuginosa* BPS1.5, and *Trichoderma virens* PPVS3A.22 were examined in a bioassay along with the available globally used EPFs *Metarhizium anisopliae* and *Beauveria bassiana*, on the different developmental stages of *S. litura* (e.g. larvae 1-2, 4-5; 2 and 5 day old pupae). *Metarhizium anisopliae* obtained 100% mortality against L4-5 on day 6, while *B. bassiana* induced 100% mortality on L1-2 on day 3. The larval (2-day-old pupae) mortality rate for *T. virens* were 72.50%, 80%, and 76.66% on day 9, and *D. salsuginosa* had a pupal (5-day-old pupae) mortality rate of 92.50%, 100%, and 96.66% (day 7), post-treatment of 1.6×10^7 , 4.3×10^8 , 3×10^9 conidia/ml, respectively. To further investigate the combinatorial effects of these two different entomopathogens, three EPNs *Oschieus* sp., *Oschieus columbiana*, and *Oschieus carolinensis* were selected with *M. anisopliae* against the third instar larvae (L3) of *S. litura*. Co-cultivation of *M. anisopliae* + *O. carolinensis* induced the highest larval mortality rate on day 2 with 97.5% post-treatment of *M. anisopliae* suspension containing 3×10^9 conidia/ml and 500 IJs/ml of *O. carolinensis* in comparison to the larval % mortality of *Oschieus* sp. 75%, *O. columbiana*, 85%, *O. carolinensis* 90%, *M. anisopliae* 87.5%, *M. anisopliae* + *Oschieus* sp. 92.5%, and *M. anisopliae* + *O. columbiana* 85%. Further studies are recommended for co-cultivation of EPF and EPN against all developmental stages of *S. litura* to determine its consistency against this pest and further to assess its efficacy in greenhouse and field conditions to validate the laboratory results.

IMPACT OF PLANT EXTRACTS ON THE INFECTION OF *Meloidogyne incognita* TO TOMATO PLANT GROWN IN THREE NATURAL SOIL TEXTURES [IMPACTO DE LOS

EXTRACTOS DE PLANTAS EN LA INFECCIÓN DE *Meloidogyne incognita* A TOMATES CULTIVADOS EN TRES TEXTURAS NATURALES DEL SUELO].

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The influence of three soil textures (sandy, loamy, and clayey) combined with four leaf plant extracts (dill, castor, mint, and neem) in comparison with krenkel 24% L for controlling *Meloidogyne incognita* infection and development on tomato was investigated under greenhouse conditions at 22 ± 3 °C. All tested plant extracts improved tomato plant growth and reduced nematode criteria in all soil types. Moreover, dill leaf extract significantly surpassed all other applications at increasing plant length, total plant fresh, and shoot dry weights with increase percentage values of 26.4%, 15.8% and 21.3%, respectively in sandy soil, 75.7%, 68.9% and 72.2 % in loamy soil and 71.8%, 54.1% and 70.3% in clay soil, compared to nematode alone. Dill extract also resulted in the highest reduction percentage of nematode densities in soil and root with value of 83.9%, 84.1% and 79.1% for sandy, loamy, and clayey soils, respectively. Krenkel as a nematicide at the recommended dose ranked first among the tested extracts in suppressing nematode population with values of 86.4%, 87.9% and 85.4% for sandy, loamy and clay soil textures, compared to nematode alone, respectively. Reproduction factor of the nematode under the stress of the tested extracts dill, castor, neem, and mint aqueous leaf extracts or krenkel were adversely affected according to soil types. Such rates ranged between 0.68 or 0.46 or 0.30 to 1.74 or 1.41 or 1.08 for sandy or loamy or clay soil textures, vs 4.21 or 2.90

or 1.44 for the same soil types, respectively.

INNOVATIVE TECHNOLOGIES FOR THE MASS PRODUCTION AND FIELD APPLICATIONS OF ENTOMOPATHOGENIC NEMATODES TO MANAGE THE RED PALM WEEVIL (PALM AIDS) IN THE EGYPTIAN BAHARIYA OASIS [TECNOLOGÍAS INNOVADORAS PARA LA PRODUCCIÓN EN MASA Y APLICACIONES DE CAMPO DE NEMATODOS ENTOMOPATÓGENOS PARA EL MANEJO DEL PICUDO ROJO DE LAS PALMERAS EN EL OASIS EGIPCIO DE BAHARIYA].

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Entomopathogenic nematodes control their insect host by inserting their symbiotic bacteria into the hemocoel of the insect host, causing septicemia and killing the host. The principal goal of this work was to discover that the Red Palm Weevil (RPW) is sensitive to infection with entomopathogenic nematodes (EPN). Furthermore, a plant-derived product of "natural essential oils mix" was applied to safely kill all stages of the red palm weevil and maintain a clean environment at the same time. Our biological products will stabilize the antagonistic potential of the environment and thus contribute to the further development of sustainable agriculture practices. It will better protect farmers and their animals, particularly in developing areas such as "Bahariya Oasis". Such areas are often severely polluted by non-protected and random applications of dangerous chemical insecticides. We applied our beneficial EPN in the seasons of 2018-2019 and 2019-2020 during the

winter when activities of different stages of RPW are at their lowest level. In the winter, the life cycle of RPW is the longest, and healthy palm trees are less exposed to the infection of this devastating insect pest. In winter, nematodes are also not exposed to high temperatures, usually lethal during the summertime.

PREVALENCE, MORPHO-TAXOMETRIC IDENTIFICATION AND PATHOGENICITY OF *Hemicriconemoides rosae* ON INDIAN VEGETABLE CROPS [PREVALENCIA, IDENTIFICACIÓN MORFOTAXOMÉTRICA Y PATOGENICIDAD DE *Hemicriconemoides rosae* EN CULTIVOS DE HORTALIZAS DE LA INDIA].

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Nematodes belonging to Genus *Hemicriconemoides*, commonly known as sheathoid nematodes, damaged many fruits, vegetables, and cash crops worldwide. A survey has been conducted in the agricultural fields of Bulandshahr district to find out the plant parasitic nematode load. A total of 85 soil samples were collected from mustard fields of Bulandshahr district of Uttar Pradesh and processed for the presence of plant parasitic nematodes and they were isolated by “Cobb sieving method”. Among all the collected soil samples, one soil sample was to be positive for the genus *Hemicriconemoides* and docketed as HCN. The earliest identification based on morphology revealed the species to be *Hemicriconemoides rosae* which was recovered from the mustard field for the

first time. The morphology was found to be more consistent with rose population as compared to sugarcane population of the *H. rosae*. Further, the *H. rosae* identified using both molecular and phylogenetic analysis. In addition, correlation analysis of the *H. rosae* based on morphometric parameters was done. The results revealed the importance of body length and its relation with other morphometric parameters and they were found significant. Besides this, the “Manian index a” showed the highest correlation with the body length in adult females. In all the studied ratios, ‘a’ is very important for the evaluation of the females of a specific species of genus *Hemicriconemoides*. The data from the principal component analysis (PCA) revealed the high intraspecific and interspecific variations between the species of genus *Hemicriconemoides*. However, less intraspecific variations were present between the rose population and mustard population of *H. rosae*. The study revealed the new host i.e., mustard crops, for *H. rosae* showing dissimilarity in morphology with the sugarcane population.

INTERACTION BETWEEN *Mesocriconema xenoplax* AND *Ilyonectria macrodidyma* ON *Vitis* spp. GENOTYPES [INTERACCIÓN ENTRE *Mesocriconema xenoplax* E *Ilyonectria macrodidyma* EN GENOTIPOS DE *Vitis* spp.].

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Plant-parasitic nematodes and fungi that cause trunk diseases have been found associated with grapevine decline disease

(GDD) in southern Brazil on other important world wine regions around the world. However, the interaction between these agents in the development of GDD is still unclear. Considering the importance of these pathogens to the vine crop, the present study aimed to study the interaction between the ring nematode (*Mesocriconema xenoplax*) and the causal agent of the black foot (*Ilyonectria macrodidyma*) on the predisposition of *Vitis* spp. genotypes to GDD. The study was carried out at greenhouse conditions (completely randomized design with six replications of a pot containing sterilized soil and one plant) using four genotypes (Paulsen 1103, R99, VR043-43 and Bordô). The soil of each pot was infested with 1,000 individuals of *M. xenoplax* and, after 30 days, the plants were inoculated with 10 mL of a spore suspension (2.5×10^6 spores/mL) of *I. macrodidyma* through small holes at the base of each plant. The plants were submitted to different combinations with *M. xenoplax* (+Mx and -Mx) and *I. macrodidyma* (+Im and -Im). After 184 days, nematode reproduction, plant growth parameters and vascular symptoms were assessed. Paulsen 1103 and R99 showed reductions in root (RFW) and shoot (SFW) fresh weight in the interaction (+Mx+Im). Analyzing the isolated effect of each pathogen (+Mx-Im and -Mx+Im), the greatest negative effects were observed in the interaction between the pathogens. Bordô showed reductions in SFW in both interaction and isolated effect, on the other hand, reductions in RFW were observed only in the interaction and in the isolated effect of the nematode. VR043-43 genotype was resistant to *I. macrodidyma* and immune to *M. xenoplax*. The other genotypes showed different levels of susceptibility to *M. xenoplax* ($82.9 > \text{FR} > 2.5$), highlighting the high susceptibility of Bordô. Vascular symptoms were higher in +Mx+Im than in the isolated effect of *I.*

macrodidyma for Paulsen 1103, R99 and Bordô, suggesting synergism between the pathogens. In addition, the population of *M. xenoplax* was significantly higher in the presence of *I. macrodidyma*. The interaction between *M. xenoplax* and *I. macrodidyma* potentiates damage and is an important factor in the development of GDD.

AGRONOMIC EFFICIENCY OF VIGGA® ON THE CONTROL OF *Pratylenchus brachyurus* IN SOYBEAN. [EFICIENCIA AGRONÓMICA DE VIGGA® EN EL CONTROL DE *Pratylenchus brachyurus* EN SOJA].

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Every year, Brazil has reported increased losses because of the damage induced by *Pratylenchus brachyurus* in many different crops. The largest yield losses have occurred in soybean. The national market for nematicides has been offering intelligent solutions to producers, with alternatives that cause less impact on the environment. In this context, the Vigga® product stands out for its innovation in the nematicides market, as it is a phytochemical product, derived from garlic extract, with potential ovicidal and nematicidal effects. Thus, the objective was to evaluate the efficiency of the Vigga® product on the control of *P. brachyurus* in soybean. The experiment was conducted in a greenhouse, in a completely randomized design, with eight replications per treatment. Each experimental unit consisted of one plant, sown in a pot containing 1 L of autoclaved

substrate (soil: sand, 1:2). Soybean seeds were submitted to the treatments: Vigga® at a dose of 2 mL kg⁻¹ of seed; Vigga® at a dose of 4 mL/kg of seed; Vigga® + Primer CoMo Bio33 + Biomex Plus at doses of 2 mL, 1 mL and 2 mL/kg of seeds, respectively; Vigga® + Primer CoMo Bio33 + Biomex Plus at doses of 4 mL, 1 mL and 2 mL/kg of seeds, respectively; Presence® (*Bacillus subtilis* + *Bacillus licheniformis*) at a dose of 1g/kg of seed; Control without treatment. The plants were inoculated at four days after germination with 2 mL of suspension containing 500 *P. brachyurus* and 70 days after inoculation, the nematode reproduction was evaluated. All treatments promoted nematode control. The reductions in the total number of nematodes ranged from 65.6% to 74.9% in relation to the untreated control and the Vigga® treatments did not differ from each other or from the standard biologic in the market. For nematodes per gram of root, such reductions were 72.2% to 84.2% for Presence® and Vigga® + Primer CoMo Bio33 + Biomex Plus treatments, respectively. There was no difference for plant height and root fresh mass. However, there was an increase in the fresh and dry mass of the aerial part of the soybean submitted to the Vigga® + Primer CoMo Bio33 + Biomex Plus treatments, regardless of the dose of Vigga® applied in this combination. It is concluded that the phytochemical product Vigga® was efficient in controlling *P. brachyurus*.

IMPACT OF FIVE SPECIES OF NEMATOPHAGOUS FUNGI ON *Meloidogyne incognita* IN PIQUILLO PEPPER (*Capsicum annuum*) UNDER CONTROLLED CONDITIONS IN LA LIBERTAD, PERU [IMPACTO DE CINCO ESPECIES DE HONGOS NEMATÓFAGOS SOBRE *Meloidogyne incognita* EN PIMIENTO DEL

PIQUILLO (*Capsicum annuum*) BAJO CONDICIONES CONTROLADAS].

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Meloidogyne incognita is one of the main phytosanitary problems in the Piquillo crop peppers in the Peruvian coast. In the present work, the impact of strains of *Purpureocillium lilacinum*, *Pochonia chlamydosporia*, *Trichoderma harzianum* and *T. virens*, on the development of *Meloidogyne incognita* in Piquillo Pepper plants, was evaluated under controlled conditions. To compare this impact, a chemical treatment (oxamyl), an absolute control and a control inoculated with nematodes were included. The results, based on the degree of root nodulation, showed that all the nematophagous were effective. However, the nematicidal potential of the chemical treatment was higher. Most of the fungi generated a significant reduction of *M. incognita* eggs and juveniles per 5 g. root, with respect to the control inoculated with this nematode. All the nematophagous promoted root development, plant height and number of fruits per plant, being this effect, in some cases, greater than that observed in plants treated with oxamyl.

INTERFERENCE OF *M. javanica* IN NODULATION CHARACTERISTICS IN SOYBEAN [INTERFERENCIA DE *Meloidogyne javanica* EN CARACTERÍSTICAS DE NODULACIÓN EN SOJA].

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Studies report that *Meloidogyne javanica* can affect the symbiosis between soybean and rhizobium (*Bradyrhizobium* spp.), interfering with the productivity and nitrogen fixation capacity of the symbiotic bacteria. Thus, the objective was to evaluate the effect of different application times of *Bradyrhizobium japonicum* + *B. elkanii* on the *M. javanica* reproduction in soybean. The experiment was conducted in a greenhouse, in a completely randomized design, with eight replications per treatment. Each experimental unit consisted of one plant, sown in a pot containing 500 mL of autoclaved substrate (soil: sand, 1:2). The treatments consisted of four application times: *M. javanica* + *B. japonicum* + *B. elkanii* simultaneously; *M. javanica* 15 days before *B. japonicum* + *B. elkanii*; *M. javanica* 15 days after *B. japonicum* + *B. elkanii* and the control with only *M. javanica* at sowing. Plants were inoculated with 2,000 eggs + second-stage juveniles of *M. javanica*, and root nematode reproduction and nodulation characteristics were evaluated at 64 days after inoculation. Inoculation of *M. javanica* 15 days after application of *B. japonicum* + *B. elkanii* resulted in an increase in total number of nematodes, nematodes per gram of root and reproduction factor. Regarding the nodulation of soybean plants, the number of active nodules in plants treated with *B. japonicum* + *B. elkanii* showed lower values when inoculated with *M. javanica* after 15 days, when compared to the control. The number of inactive nodules was higher in all plants treated with *B. japonicum* + *B. elkanii* and *M. javanica*, and the time of nematode inoculation did not influence this parameter. No differences were observed in the fresh and

dry weight of active nodules, nor in the fresh weight of inactive nodules. However, the dry weight of inactive nodules was higher in the presence of *M. javanica*, at different times of application, compared to the control. It is concluded that *M. javanica*, regardless of the time of inoculation, influenced the nodulation characteristics of soybean.

GIANT AFRICAN LAND SNAIL *Lissachatina fulica* ERADICATION PROGRAMS IN FLORIDA, USA, AND THE DETECTION OF THE RAT LUNGWORM *Angiostrongylus cantonensis* [PROGRAMAS DE ERRADICACIÓN DEL CARACOL GIGANTE AFRICANO *Lissachatina fulica* EN FLORIDA, EE. UU. Y LA DETECCIÓN DEL GUSANO PULMONAR DE LA RATA *Angiostrongylus cantonensis*].

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The giant African land snail (GALS) (*Lissachatina fulica*) is listed as one of the top 100 worst invasive species in the world. This snail feeds on over 500 different hosts and can cause devastating consequences if introduced. In addition, GALS is an intermediate host of the rat lungworm (*Angiostrongylus cantonensis*) that can cause meningitis in humans. An adult GALS can grow to a diameter of 76 cm and a length of 200 cm or more, making it one of the largest of all land snails. Breeding begins at about 6-8 months and with each mating, one snail can produce 100 to 500 viable eggs. GALS can reproduce several more times without mating again. GALS are hermaphroditic

and can generate clutches of eggs every 2 to 3 months without mating. The state of Florida has conducted multiple eradication programs of the giant African land snail dating back to 1966, when it was first reported in the state. Currently, the Florida Department of Agriculture and Consumer Services has declared a quarantine in three Florida counties where eradication of GALS is taking place. These include Pasco, Lee, and Broward Counties. Eradication programs consist of survey and control with specialized teams including canines trained to alert on GALS, outreach, data collection and decommission of quarantine zones. The confirmation of rat lungworm in GALS populations is very important information to adopt protective measures for the health of the people in the affected areas and the safety of FDACS/DPI inspectors collecting snails as part of the eradication program.

USING THE GENOTYPE AND PHENOTYPE OF LITERATURE-DESCRIBED NEMATOCIDAL STRAINS TO DEVELOP MICROBIALLY-BASED NEMATOCIDES WITH MULTI-SITE MODE OF ACTION [UTILIZANDO EL GENOTIPO Y EL FENOTIPO DE BACTERIAS NEMATOCIDAS DESCRITAS EN LA LITERATURA PARA DESARROLLAR NEMATOCIDAS MICROBIANOS CON MODO DE ACCIÓN MULTI-SITIO].

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Crop protection products are necessary for combating devastating yield losses caused by numerous plant pests. Many of these products have high activity at first, but experience decreases in efficacy due to

the development of resistance over long term, repeated use. Selection pressure from overuse of products allows for the eventual development of resistance, especially when products employ a single-site mode of action (MOA). Newer nematicidal products with single-site MOAs are susceptible to the development of resistance as well. Microbially-based plant protection products have the potential to deliver numerous nematicidal compounds with multiple MOAs, making them an attractive, more durable, alternative to newer single-site MOA synthetic nematicides. AgBiome maintains a large bacterial collection with over 100,000 isolates with fully sequenced genomes. We conducted a thorough literature search focusing on microbes that have described nematicidal activity. Using proprietary bioinformatic tools, we curated an internal representative set of bacteria based on literature-described nematicidal strains, proteins, and metabolites. We screened this set through various assays to understand their nematicidal activity, and compared our results to what was described in literature. Additionally, we want to understand the breadth of literature-described MOAs within each strain. Using information learned from our literature review, we conducted a thorough examination of each strain's genome within our representative set, listing the presence of any known nematicidal MOAs. Combining bioassay activity with our genomic analysis, we can advance our development of microbially-based nematicides, offering an alternative to single-site MOA products, and ultimately deliver sustainable nematode management tools to growers.

RECOMBINASE POLYMERASE AMPLIFICATION ASSAY FOR RAPID DETECTION OF THE PLANT-PARASITIC NEMATODES [ENSAYO DE AMPLIFICACIÓN DE

POLIMERASA DE RECOMBINASA PARA LA DETECCIÓN RÁPIDA DE LOS NEMATODOS PARÁSITOS DE PLANTAS].

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Rapid diagnosis tools for detection of plant parasitic nematodes play an important role in disease control and eradication programs. Recombinase polymerase amplification (RPA) assays have been developed that target the different genes of several plant parasitic nematode species: *Aphelenchoides fragariae*, *Meloidogyne arenaria*, *M. hapla*, *M. incognita*, *M. javanica*, *M. enterolobii* and *Rotylenchulus reniformis*. RPA assays using TwistAmp® Basic, TwistAmp® exo kits, and TwistAmp® nfo kits (TwistDx, UK) allow for the detection of nematode species directly from plant tissues and crude nematode extracts of all life stages without a DNA extraction step. The study included three steps: i) testing and selection of RPA specific primer combinations; ii) validation of sensitivity and specificity for RPA assays using real-time fluorescence detection (real-time RPA) and lateral flow dipsticks (LF-RPA); and iii) practical evaluation of RPA assays with field samples. The results of the -RPA assays with a series of crude nematode extracts show reliable detection of 0.1 nematode specimen and within 15 min for real-time RPA and 30 min for LF-RPA. RPA assays provide affordable, simple, fast, and sensitive detection of nematodes. Application of the LF-RPA assay has great potential for application and implementation of nematode diagnostics in the lab, field or in areas with a minimal laboratory infrastructure.

EFFECT OF ENTOMOPATHOGENIC NEMATODES, *Heterorhabditis bacteriophora* ON *Galleria mellonella* IN BEEHIVES OF *Apis mellifera* [EFECTO DE LOS NEMATODOS ENTOMOPATÓGENOS, *Heterorhabditis bacteriophora* EN *Galleria mellonella* EN PANALES DE ABEJA *Apis mellifera*].

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Wax worms cause economic damage in storage wax, and chemicals used in insect control cause harmful effects on stored bee honey inside combs. The present work was carried out to investigate the effect of entomopathogenic nematodes (EPNs) on the wax worm *Galleria mellonella* in natural beehives. Seven different inoculum levels of *Heterorhabditis bacteriophora* (Hb) (100, 500, 1,000, 2,000, 3,000, 4,000, and 5,000 infective juveniles (IJs)/ml) were investigated on *G. mellonella* larvae, and larvae and adults of honeybees *Apis mellifera*, inside the beehives for one and two times. The highest mortality percentage was 90% and 100% when 5000 IJs/ml were used once and twice, respectively. On the other hand, the EPNs did not affect the larvae or adults of honeybees. The initial population (Pi), final population (Pf) and reproduction rate (Rr) were affected by the increase of EPN inoculum levels and duplication of treatment. The Pi was 648.00 and 766.67/insect cadaver at 5,000 IJs applied once or twice. The highest Pf was 61083.33 and 246166.7 when 2,000 IJs were used one and two times, respectively. The highest concentrations of EPNs caused 100% mortality for *G. mellonella*, and there was no side effect on larvae or adults of honeybees.

IMPACT OF CHEMICAL AND ENGINEERED SILVER NANOPARTICLES ON SOME PLANT PARASITIC NEMATODES, AND ON DNA DAMAGE IN LABORATORY AND UNDER SCREEN HOUSE CONDITIONS [IMPACTO DE LAS NANOPARTÍCULAS DE PLATA EN ALGUNOS NEMATODOS PARÁSITOS DE LAS PLANTAS Y EN EL DAÑO AL ADN EN CONDICIONES DE LABORATORIO Y BAJO MALLA].

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Nanotechnology is a fast-growing technology for management of nematodes and other pathogens. This technology is suitable to avoid the hazardous effects of chemical nematicides on human health and non-target organisms. In the laboratory, *Meloidogyne incognita* second-stage juveniles (J2) were exposed to chemically prepared silver nanoparticles (AgNPs) at concentrations of 20, 40, 200, 500, and 1500 ppm/ml. and exposure time up to three days after treatments. Engineered nanoparticles (AgENPs) synthesized using plant extracts of *Curcuma comosa* (N1), *Cycas circinalis* (N2), *Chitosan* (N3), and *Crotalaria juncea* (N4) were also tested for their lethal effects on *M. incognita*, *Pratylenchus penetrans*, and *Tylenchulus semipenetrans* at concentrations of 2.5, 5.0, 10.0, 20.0, and 40 ppm and exposure time up to five days after treatments.

Results in laboratory experiments showed that AgNPs at 200 ppm caused 52% mortality by the third day, while 500 ppm caused 51% mortality after one day, and 64% and 82% after the second and the final day, respectively. The most effective concentration was 1500 ppm which caused 89%, 93%, and 96.5% mortality, respectively, after the three days. *Meloidogyne incognita* was more affected by AgENP, than *P. penetrans* and *T. semipenetrans* in all the treatments. N1 was the most effective preparation against nematode juveniles, followed by N3, N4, and N2. These effects were increased proportionally with the nano concentration and the exposure time. N3 recorded the highest reduction in egg hatchability. Some morphological changes were recorded by microscopic images in the treated juveniles and eggs. The greatest DNA damage for nematode juveniles was detected with N1, followed by N4, N3, and N2. In the screen-house, all concentrations of AgNPs inhibited *M. incognita* gall development, egg formation, hatch rate, and final population, with the highest concentrations of 200 ppm, 500 ppm, and 1500 ppm having the most significant effect. Damage to DNA also increased proportionally with the concentration. Silver residue in tomato fruits after application was relatively very low. This research emphasized the positive efficacy of AgNPs against plant-parasitic nematodes *in vitro* and nanoparticles prepared with *Curcuma comosa*, and Chitosan was greater and safer than chemical silver nanoparticles. These findings contribute to the development of environmentally friendly strategies for nematode control in agricultural systems.

REKLEMEL ACTIVE: A POTENTIAL NOVEL TOOL TO MANAGE NEMATODES IN EGYPT [REKLEMEL ACTIVE: UNA NUEVA

HERRAMIENTA POTENCIAL PARA MANEJAR NEMATODOS EN EGIPTO].

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Currently nematodes are considered as one of the key limiting factors for crop production in Egypt. Root-knot nematodes *Meloidogyne* spp. are the most prevalent species in Egyptian soils and cause severe damage to important economic crops such as potatoes and tomatoes, crop losses may reach 50 - 100%, especially in combination with fungal infections like wilting disease, this makes nematode control an indispensable necessity. With Reklemel active Corteva has recently started to launch a novel soil applied nematicide (formulated as Salibro 500 SC) in various countries around the world and a development project is ongoing for the Egyptian market. Salibro™, which contains the novel active ingredient fluazaindolizine, has been shown to control various species of root-knot nematodes, to reduce root damage and consequently increase yield. Efficacy field studies on this new nematicide have been conducted in Egypt over several seasons and have shown promising results. During our talk we will share insight on optimal rates, timings of applications as well as efficacy data from recent trials in fruiting and root vegetables.

REKLEMEL ACTIVE: A NOVEL TOOL FOR INTEGRATED NEMATODE MANAGEMENT – KEY LEARNINGS FROM A GLOBAL NEMATICIDE DEVELOPMENT PROJECT [REKLEMEL ACTIVE: UNA NUEVA HERRAMIENTA PARA

EL MANEJO INTEGRADO DE NEMATODOS – ENSEÑANZAS CLAVE DEL PROYECTO GLOBAL DE DESARROLLO DE UN NEMATICIDA].

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Reklemel active (fluazaindolizine) is a proprietary novel soil applied nematicide that has been developed by Corteva Agriscience and is currently under commercialization in various geographies including several countries in Africa. The development of this chemistry was started more than 10 years ago and during its global development, more than 3,500 field studies have been initiated to test it under different edaphic and climatic conditions in numerous crop-nematode combinations. During our talk, we will present both, key biological attributes (e.g. mode- of-action, spectrum, effective concentration ranges, soil health compatibility) of this novel chemistry as well as some novel learnings regarding its soil behavior (e.g. soil movement, microbial adaptation, OM impact) that were made throughout this development process.

UNKNOTTING THE MICROBIAL ROLE IN THE LIFE CYCLE AND SURVIVAL OF ROOT-KNOT NEMATODES [DESANUDANDO EL PAPEL MICROBIANO EN EL CICLO DE VIDA Y LA SUPERVIVENCIA DE LOS NEMATODOS AGALLADORES].

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The type of interactions between plant-parasitic nematodes and microbes determines the survival and infectivity of nematodes. Plants may recruit beneficial microbiomes to fight against the nematode attack. However, depending on the plant host and soil type, microbiomes may also facilitate nematode survival and parasitism. We used different *in vitro* and greenhouse approaches to characterize the microbiome that associate with nematodes in soil and roots and to study the effects of the microbiome on nematode survival and parasitism. Using amplicon sequencing, we showed that the composition of bacteria attaching to the second-stage juveniles (J2s) of *Meloidogyne hapla* is more diverse in nematode suppressive soils compared to nematode conducive soils. In addition, we found that active and non-motile J2s differ in the composition of attached bacteria when incubated with soil suspensions, which may be correlated with the presence of potential nematode-protective taxa on active J2s, including *Algoriphagus*, *Pedobacter* and *Bdellovibrio*. To unravel the importance of the microbiome in nematode parasitism on different plant hosts, we infested nine different plant species with *M. incognita* J2s. We collected galls, females and egg masses after nematode reproduction and used amplicon sequencing to characterize whether there are taxa with a similar function associated with nematodes collected from good and poor hosts. We propose that some of these taxa may facilitate nematode parasitism and protect the J2s against the antagonists in soil upon hatching. Altogether, our work represents a holistic overview of nematode-microbe associations that should be explored and considered in order to improve sustainable nematode control.

INVESTIGATION OF EFFECT OF FOLIAR APPLICATION OF SOME CHEMICALS TO *Meloidogyne incognita* ON TOMATO [INVESTIGACIÓN DEL EFECTO DE LA APLICACIÓN FOLIAR DE ALGUNOS QUÍMICOS EN *Meloidogyne incognita* EN TOMATE].

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Root-knot nematodes (RKNs) are a major threat to global food security and *Meloidogyne incognita* is one of the most important RKN species of tomato plantations in tropical and climatic zones. Chemical nematicides and soil fumigants have been used for many years in the management of RKNs in vegetable growing areas. Nematicides have caused a significant reduction of nematode populations in the soil. Most of the nematicides are used as soil applications. However, there are limited studies about the foliar application of systemic pesticides/nematicides. This study aimed to evaluate the foliar application of some chemicals to *M. incognita* on tomatoes under the controlled conditions. In this study, the effects of IRAC MoA Group 5: Spinosyns [Spinosad], Group 6: Avermectins [Abamectin; Emamectin benzoate; Milbemectin], Group 23: Tetrone and Tetramic Acid Derivatives

[Spirotetramat], and FRAC MoA C2:7 Group: Pyridinylmethyl benzamides [Fluopyram] to *Meloidogyne incognita* S6 isolate on tomato were investigated. Susceptible tomato plant leaves grown in 250 cc pots containing sandy soil were sprayed with pesticides/nematicides one time, 24 hours before inoculation with 1000 J2s of *M. incognita* S6 isolate per plant. Application of chemicals was done according to recommended application doses on the products. The study was conducted on a randomized complete block design with five replicates and the experiment was performed twice in the plant growth room ($25 \pm 1^\circ\text{C}$). Eight weeks after inoculation plant roots were evaluated based on parameters; root fresh weight, the number of egg masses, number of galls, and root galling index (0-5 scale) per root. Results show that differences in root fresh weight, the number of egg masses, number of galls and root galling index (0-5 scale) were found among chemical treatments when compared to the control ($p < 0.05$). However, there was no significant reduction in root galling index except fluopyram application. Foliar application of these chemicals did not significantly affect *M. incognita* S6 on tomatoes.

INTEGRATED NEMATODE MANAGEMENT IN COTTON: A LOUISIANA PERSPECTIVE [MANEJO INTEGRADO DE NEMATODOS EN ALGODÓN: UNA PERSPECTIVA DE LOUISIANA].

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The reniform nematode (*Rotylenchulus reniformis*) is the primary nematode pest of cotton in the Southeastern United States, including Louisiana. New cotton cultivars

with resistance to this nematode have recently become available. Using a series of field experiments, the aim of this study was to evaluate the utility of new nematode-resistant cotton cultivars and determine if supplemental nematicide application improves nematode suppression and lint yield. For both experiments and growing seasons, replicate field trials were established in St. Joseph, Louisiana and Winnsboro, Louisiana. In 2022, the first experiment evaluated four new resistant cotton cultivars (Deltapine 2141NR, Phytogen PHY332, Phytogen PHY411, and Phytogen PHY443) in comparison to a susceptible cultivar (Deltapine 1646). Plots planted with Phytogen PHY411 had consistently fewer reniform nematodes in soil than Deltapine 1646 at both locations throughout the growing season; however, yield did not differ among cultivars. The second experiment in 2022 was multifactorial and included two cultivars (Deltapine 2141NR (resistant) and Deltapine 1646 (susceptible)), as well as four supplemental nematicide treatments: (1) untreated, (2) BIORST seed coat (a.i. heat-killed *Burkholderia rinojenses*), (3) Velum in-furrow (a.i. fluopyram), or (4) BIORST seed coat + Velum in-furrow). In both locations, plots planted with Deltapine 2141NR had fewer reniform nematodes in soil throughout the growing season; however, at the Winnsboro field, yield was reduced relative to that of Deltapine 1646. In both locations in-furrow application of Velum reduced mid-season reniform nematode soil population densities regardless of cotton variety, but this suppression was not observed by the harvest sampling date and no yield differences were observed among treatments. In 2023, the first experiment evaluated the same four new resistant cotton cultivars as above in comparison to Deltapine 1646; however, an additional

susceptible cultivar was also included (Phytogen PHY340). The second experiment conducted in 2023 evaluated the same two cotton cultivars as in 2022 (Deltapine 2141NR and Deltapine 1646), as well as four supplemental nematicide treatments; however, the BIOST seed coat treatments were substituted for COPeO seed coat applied nematicide (a.i. fluopyram). Plant establishment, canopy coverage, and mid-season reniform nematode soil population densities for the 2023 growing season will be presented and discussed in relation to the 2022 results.

OPPORTUNITIES FOR EDUCATION AND TRAINING IN NEMATOLOGY IN THE UNITED STATES [OPORTUNIDADES DE EDUCACIÓN Y CAPACITACIÓN EN NEMATOLOGÍA EN LOS ESTADOS UNIDOS].

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Nathan A. Cobb (1859 – 1932) laid the foundation for nematology research in the United States through his pioneering work in nematode taxonomy and technical innovation in the laboratory. Since his time, nematology in the United States has expanded exponentially, with public university, government, and private industry-based research laboratories now established across the country. As a result, opportunities for education and training in nematology in the United States are vast and provide students with a solid framework for a successful career in this discipline. This presentation will overview: (1) current institutions in the United States offering programs or coursework in nematology, (2) advanced training opportunities in nematology, (3) internship

opportunities for international students, and (4) careers in nematology in the United States. The targeted audience for this presentation is international nematology students and faculty abroad interested in internship opportunities in the United States for their students.

THE IRAC INTERNATIONAL MODE OF ACTION CLASSIFICATION SCHEME FOR NEMATICIDES [EL ESQUEMA INTERNACIONAL DE CLASIFICACIÓN DEL MODO DE ACCIÓN PARA NEMATICIDAS DEL IRAC].

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The IRAC Nematode Working Group is the most recently established IRAC International working group. The initial aim of the working group was to develop a similar international MoA classification scheme for nematicides, as for the insecticides (and indeed fungicides FRAC and herbicides HRAC). Several documents have been created (see the IRAC website - <https://www.irc-online.org/teams/nematodes/>) and continue to be updated. The “Nematicide MoA Classification scheme” incorporates a wide

range of active ingredients, organisms, conventional chemical nematicides, fumigants and agents of biological origin that have demonstrated nematicidal activity. The classification follows the same principles as other schemes, and the group names start with the letter N to denote “nematicide/nematode control agent”. The proposed groupings include, Carbamates (Group N-1A), Organophosphates (Group N-1B), Avermectins (abamectin, Group N-2), Pyridinylmethyl benzamides and Phenethyl pyridineamides (fluopyram, cyclobutrifluram, Group N-3), Tetramic acids (spirotetramat, Group N-4), a group of novel compounds (Group N-UN) with unknown MoA’s, including products such as fluazaindolizine, fluensulfone and furfural and fumigants (Group N-UNX). The various biologicals for nematode control have been divided into three groups: Bacteria (Group N-UNB), Fungi (Group N-UNF), and botanical/animal Extracts (Group N-UNE). As with other MoA Classification schemes, when new information is submitted to the Working Group, the group evaluates it and considers updating the nematicide MoA Classification scheme accordingly. The overall aim is to encourage companies/suppliers and regulators around the world to use this classification code and associated icon on nematicide product labels to inform the user/grower as to what type of nematicide they are using. This poster shows the current classification scheme, which is also available by open access on the IRAC website - <https://www.irac-online.org/teams/nematodes/>.

ASCAROSIDE PHEROMONES AS KEY SIGNALS IN COMMUNICATION AND FORAGING BEHAVIOR OF ENTOMOPATHOGENIC NEMATODE INFECTIVE JUVENILES [LAS FEROMONAS ASCARÓSIDAS COMO SEÑALES

CLAVE EN LA COMUNICACIÓN Y EL COMPORTAMIENTO DE BÚSQUEDA DE LOS JUVENILES INFECTIVOS DE NEMATODOS ENTOMOPATÓGENOS].

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Combinations of entomopathogenic nematode (EPN) species are sometimes more effective in managing insect pests than individual species. Previous studies have shown that a greater number of *Diaprepes* root weevil larvae were killed when two EPN species were used together compared to the same number of individual species. This increase in efficacy is likely due to the enhanced dispersal of either one of the EPN species. Moreover, nematodes secrete exometabolites that contain important chemical signals, including ascaroside pheromones, which influence developmental and socialization behaviors. Therefore, we hypothesized that these chemicals also play a crucial role in the communication and foraging behavior among EPN species. In this study, we stimulated *Steinernema carpocapsae* using exometabolites from two species of Heterorhabditid nematodes and five species of Steinernematid nematodes. The results showed that the host-seeking efficiency of *S. carpocapsae* increased five-fold and three-fold when stimulated with exometabolites from *S. riobrave* and *H. bacteriophora*, respectively. Exometabolites from *S. riobrave* also significantly improved the dispersal ability of *S. carpocapsae* by 20%. Similarly, the exometabolites from *H. bacteriophora* increased the jumping behavior of *S.*

carpocapsae by 20%. Additionally, targeted metabolomics analysis revealed differential metabolite contents, such as ascr#9, ascr#11, ascr#12, ascr#14, ascr#16, and ascr#18, in the exometabolites of *S. riobrave* and *H. bacteriophora* when compared to *S. carpocapsae*. Based on these findings, biological assays were conducted to verify the effects of different concentration gradients of single ascaroside pheromones on the foraging behavior of *S. carpocapsae*. The results suggest that different EPN species can communicate through ascr#9 and ascr#11, which in turn affects their dispersal efficiency and foraging ability.

DEVELOPMENT AND VALIDATION OF A HIGH-THROUGHPUT SEQUENCING TEST FOR MITOGENOME AND rDNA ASSEMBLY AND ANNOTATION, AND ITS USE IN SUPPORT OF NEMATODE IDENTIFICATION OF REGULATORY CONCERN [DESARROLLO Y VALIDACIÓN DE UNA PRUEBA DE SECUENCIACIÓN DE HIGH-THROUGHPUT PARA ENSAMBLAJE Y ANOTACIÓN DE MITOGENOMA Y ADNR, Y SU USO EN APOYO DE LA IDENTIFICACIÓN DE NEMATODOS DE INTERÉS REGULATORIO].

van de Vossenbergh, B. T. L. H., T. L. van Kempen, A. A. L. A. M. van Duijnhoven, T. Warbroek, L. P. van der Gouw, D. A. S. de Oliveira, E. Y. J. van Heese, and G. Karssen. Dutch National Plant Protection Organization, National Reference Centre, Wageningen, The Netherlands.

Nematoda is a diverse phylum, and representatives are found in most habitats, including in and on animals and plants. Nematodes are regarded as the most abundant group in terms of individuals in

marine and terrestrial sediments. Plant-parasitic nematodes are globally responsible for an annual yield loss of \$125 billion. Reliable species identification is essential to take appropriate phytosanitary measures. The introduction of validated Sanger sequencing of 18S, 28S, and *cox1* barcode loci represented a powerful tool in support of nematode identification. However, technical challenges associated with PCR and Sanger sequencing and the need for additional loci for identification hamper the efficient use of sequence data. To overcome these challenges, we developed an automated bioinformatic pipeline for the assembly and annotation of mitochondrial genomes and ribosomal DNAs, and we defined and validated a standardized test protocol including controls for routine diagnostics (i.e., high-throughput sequencing [HTS] test). The HTS test can be performed on single nematode specimens and outperforms the Sanger-based sequencing by producing less ambiguous consensus sequences and by yielding additional sequence data offering additional diagnostic resolution when needed. Compared with Sanger sequencing, the HTS test represents a reduction in hands-on time. The HTS test is regarded as fit for the purpose of the molecular identification of single nematode specimens in support of nematode diagnostics of regulatory concern.

PLANT NEMATODE ASSOCIATED WITH CROP PLANTS IN AL-JOUF REGION, NORTHERN SAUDI ARABIA [NEMATODOS DE PLANTAS ASOCIADOS CON PLANTAS DE CULTIVO EN LA REGIÓN DE AL-JOUF].

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A survey of plant-parasitic nematode genera associated with different crops in field and greenhouses in Al- Jouf region, northern of Saudi Arabia, was carried out during the 2021 - 2022 growing season. A total of 362 plant roots and rhizosphere soil samples were collected. Samples were extracted in the laboratory used centrifugal-flotation method for soil samples, and direct examination for plant roots. Results indicated the presence of 42 plant-parasitic nematode genera associated with the 10 fruit crops - fig, grape, pomegranate, citrus, peach, olive, date palm, Jojoba (*Zizyphus* spp.), mulberry and prickly pear. Seven genera were associated with 10 vegetable crops including, tomato, squash, melon, bean, eggplant, and pumpkin, and seven genera associated with the seven field crops that included alfalfa, maize, wheat, barley, sorghum, and fava bean. The survey showed that the most fruit, vegetable and field crops were infected by root-knot nematodes (*Meloidogyne* spp.). Other dominant genera were lesion nematode (*Pratylenchus* spp.), stunt nematode (*Tylenchorhynchus* spp.), spiral nematode (*Helicotylenchus* spp), citrus nematode (*Tylenchulus semipenetrans*), *Tylenchus* nematode (*Tylenchus* spp.), lance nematodes (*Hoplolaimus* sp.), needle nematode (*Longidorus* spp.), dagger nematode (*Xiphinema* sp.), bud and leaf nematode (*Aphelenchoides* sp.), and stubby-root nematode (*Trichodorus* sp.). Most of these genera were recorded for

the first time associated with their mentioned hosts.

BOOSTING INDUCTION RESISTANCE IN BANANA AGAINST *Meloidogyne javanica* USING ABIOTIC INDUCERS: SALICYLIC ACID, ACETYL SALICYLIC ACID AND ASCORBIC ACID [IMPULSO DE LA RESISTENCIA A LA INDUCCIÓN EN BANANO CONTRA *Meloidogyne javanica* UTILIZANDO LOS INDUCTORES ABIÓTICOS ÁCIDO SALICÍLICO, ÁCIDO ACETIL SALICÍLICO Y ÁCIDO ASCÓRBICO].

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Two concentrations (100 ppm and 200 ppm) of the systemic acquired resistance (SAR) elicitors, salicylic acid (SA), acetylsalicylic acid (ASA) and ascorbic acid (AS), were used to induce resistance to *Meloidogyne javanica* in banana seedlings as leaf spray or soil drench seven-days after inoculation. Results showed that there were significant differences within the treatments between foliar spraying and soil drenching, as well as between both concentrations. Foliar spraying at higher concentration gave better values than soil drenching. Based on percentage nematode reduction, SA as foliar spraying at higher concentrations (200 ppm) achieved the highest percentage reduction of *M. javanica* second-stage juveniles (J2)/100g soil (66.6%), females/5 g roots (70.8%), egg masses/5 g roots (66.4%), and galls/5 g roots (74.5%). Also,

the foliar spray with 200 ppm SA showed the highest percentage increase in fresh shoot and root weights and lengths (53.01, 54.69, 81.53 and 74.35%), respectively. The highest level of proline (shoot and root, 0.837, 0.768) was measured in plants treated with SA by foliar spraying at 200 ppm. The maximum activity of total phenols (2.31) and maximum carbohydrate concentration (76.91) were also observed in plants treated with SA as foliar sprays at 200 ppm. Moreover, these resistance inducers enhanced the synthesis and activity of defense enzymes in banana plants. Catalase, peroxidase and polyphenol oxidase at 0.26, 0.04 and 10.76, respectively, drastically increased in the treated plants compared with un-treated control where the maximum enzymes activity was observed in plants sprayed at 200 ppm.

OVERVIEW OF DIMETHYL DISULFIDE (DMDS), SOIL SUSTAINABLE TREATMENT, IN EGYPT AND AT GLOBAL LEVEL IN STRAWBERRIES AND VEGETABLES [RESUMEN GENERAL DEL DISULFURO DE DIMETILO (DMDS), TRATAMIENTO SOSTENIBLE DEL SUELO, EN EGIPTO Y A NIVEL MUNDIAL EN FRESAS Y HORTICOLAS].

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Dimethyl disulfide (DMDS) is a naturally occurring compound and a major component of the sulfur cycle. DMDS belongs to a new chemical family resulting in a different and unique mode of action compared to other existing soil

treatments. DMDS has been successful to control nematodes including root-knot nematodes (*Meloidogyne* spp.), cyst nematodes (*Heterodera* spp., and *Globodera* spp.), lesion nematodes (*Pratylenchus* spp.) and *Nacobus aberrans*, other soil-borne pathogens occurring along with nematodes in every crop, and several weed species. In addition to technical efficacy, compatible profile with Integrated Pest Management programs, limited persistence in the environment, no long-term toxicological effects, and no adverse effect on the ozone layer, DMDS is an innovative and modern technology. DMDS has shown high effectiveness across a wide spectrum in many efficacy studies and commercial applications in Europe, Africa, Middle East, Asia, Australia and America. Many results have been published in international conferences and symposium; a summary of these results will be presented.

METABARCODING SEQUENCING SUGGESTS THE SIGNIFICANCE OF STOCHASTIC ASSEMBLY PROCESSES IN SOIL NEMATODE METACOMMUNITIES [LA SECUENCIACION POR METABARCODING SUGIERE LA IMPORTANCIA DE LOS PROCESOS DE ENSAMBLAJE ESTOCÁSTICOS EN LAS METACOMUNIDADES DE NEMATODOS DEL SUELO].

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Nematodes play an important role in ecosystems; however, very little is known about their assembly processes and the factors influencing them. We studied nematode communities in bulk soils from three Asian mountain ecosystems to

determine the assembly processes of free-living nematode metacommunities and their driving factors. On each mountain, elevations span a range of climatic conditions with the potential to reveal assembly processes that predominate across multiple biomes. A phylogenetic null modeling framework was used to analyze 18S rRNA gene amplicons to quantify various assembly processes. We found that phylogenetic turnover between nematode communities on all mountains was dominated by stochastic processes, with “undominated processes” being the most predominant stochastic factor. Elevation has a significant impact on the relative importance of deterministic and stochastic processes. A variety of climatic and edaphic variables significantly influenced the variations in community assembly processes with elevation, even though their impacts were not consistent between the mountains. Overall, our results indicate that free-living nematode metacommunities in a wide range of environments are largely structured by stochastic processes rather than by niche-based deterministic processes, suggesting that metacommunities of soil free-living nematodes may respond to climate change in a largely unpredictable way.

EFFECT OF SOYBEAN CYST NEMATODE (*Heterodera glycines*) ON SOYBEAN TEMPERATURE [EFFECTO DEL NEMATODO DEL QUISTE DE LA SOJA (*Heterodera glycines*) SOBRE LA TEMPERATURA DE LA SOJA].

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Soybean cyst nematode (SCN) is a significant pest that reduces soybean yield in the United States. Infected roots are shorter, stunted, and have fewer nitrogen-fixing nodules. Diseased plants often experience stress and could exhibit changes in their ability to thermoregulate, resulting in increased plant temperature. This project aims to investigate the changes in plant temperature caused by SCN infection. Two trials were conducted: a greenhouse trial and a field trial. In the greenhouse trial, 10 soybean plants at the cotyledon stage were infested with 3,000 female eggs from race 2, HG type 1.2.5.7, and thermal pictures were captured weekly using an ICI8640 camera after inoculation. After 60 days, the roots were blasted, and the number of female eggs was counted. In the field trial, three soybean varieties with varying levels of susceptibility were evaluated which included: a susceptible (SUS) variety (PI 88788), PI 548402, SUS + PI 88788, SUS + PI 548402, PI 88788 + PI 548402, and SUS + PI 88788 + PI 548402. Soil cysts and eggs were evaluated before planting, in the middle of the season, and after harvest. Root samples were analyzed for the number of eggs and cysts in the middle of the season. The difference in the number of eggs between sample dates was calculated to determine the reproduction factor. In the greenhouse trial, the egg density ranged from 3 to 540 in the infested plants. There was no significant difference in leaf surface temperature between the inoculated and non-inoculated treatments, nor was there a correlation between the number of eggs and leaf temperature. In the field trial, the nematode population increased between the first and last collection dates, but there was no significant difference in

the reproduction factor among the treatments. Treatment PI 548402 had the highest yield, while the susceptible variety had the lowest yield. As the proportion of resistant plants in the mix increased, the yield also increased. The yield increased as the plant temperature declined ($R^2 = 0.67$). A tendency in increasing temperature and lowering yield was observed as the reproduction factor increased, but there was a very low correlation between variables for both comparisons. Further research is needed to improve the use of thermal imaging for detecting nematode infection, particularly under higher population densities.

EFFECT OF SOYBEAN CYST NEMATODE (*Heterodera glycines*) ON SOYBEAN TEMPERATURE [EFECTO DEL NEMATODO DEL QUISTE DE LA SOJA (*Heterodera glycines*) SOBRE LA TEMPERATURA DE LA SOJA].

Zuchelli, E.¹, H. Kelly¹, N. Virlet², M. Hawkesford², and L. Schumacher³. ¹West Tennessee AgResearch Station, University of Tennessee, Jackson, TN, USA, ²Rothamsted Research, Harpenden, Hertfordshire, United Kingdom, ³Crop Genetics Research Unit, United States Department of Agriculture, Agricultural Research Service (USDA-ARS), Jackson, TN, USA. ezuchell@utk.edu

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