Annual Report for NC 1197

Project/Activity Number: NC 1197

Project/Activity Title: Practical Management of Nematodes on Corn, Soybean, and Other Crops of Regional Importance

Period Covered: July 2023 – October 2024

Submission Date of This Report: November 14, 2025

Annual Meeting Date(s): November 14-15, 2024

Location of Meeting: Charleston, SC (joint meeting with S 1092)

Accomplishments:

Objective 1: Develop, evaluate, improve, and integrate management techniques for plant-parasitic nematodes in the North Central Region to increase grower profitability.

Surveys of plant parasitic nematodes

To continue monitoring efforts of plant parasitic nematode populations in crop production fields, many programs conducted surveys of plant parasitic nematodes in their states. The combined efforts of the many on-going surveys for plant parasitic nematodes in regionally important crops, such as corn and soybean, help provide regional and national maps that are used to track plant-parasitic nematode populations and their geographic distributions over time. A recent output from these surveys is the publication by Faske et al. (2023. Plant Health Prog. 24:522-524), in which the distribution of the southern root-knot nematode, *Meloidogyne incognita*, in field crops across the United States was summarized.

In Illinois, 1,019 growers' fields were surveyed for soybean cyst nematode (SCN) populations. In Kentucky, 40 samples from corn fields representing 10 counties were sampled, in which most fields had low levels of plant parasitic nematodes. In this survey, root-knot nematode (RKN) was detected in one corn field. In a survey of Kentucky soybean fields that was initiated in 2018 and continued in 2024 (488 samples, representing 35 counties), 38% of the fields had SCN egg populations ≥500 eggs/100 cm^3 soil, and HG Type 2.5.7 was present in 87.5% of the fields tested. Other plant parasitic nematodes detected in Kentucky soybean fields were dagger, lance, lesion, southern RKN, spiral, and stunt. In Missouri, from 64 fields representing 30 counties (132 total samples) that were surveyed, 45% of the samples had SCN populations that exceeded 4,000 eggs/100 cm^3 of soil, while 17% had fewer than 200 eggs/100 cm^3 soil. In addition, RKNs were found in three fields, with two samples having more than 400 RKN/100 cm^3 soil, and other plant parasitic nematodes were detected but were below thresholds for yield loss. In Nebraska, a soybean checkoff-funded testing program for Nebraska growers to identify fields that have SCN and to characterize HG types of SCN is underway. In Ohio, soil samples from growers continue to be received to assist with updating the survey on SCN abundance and distribution throughout Ohio. Over 450 soil samples are expected to be processed for SCN

testing in 2024. In Ontario, Canada, a 3-year Provincial nematode survey for field crops as well as horticultural and ornamental crops is underway, which will help establish baseline distribution and population levels (maps) for future assessment of spread, changes in specific nematode species population levels, assess risk locally, regionally, etc., as well as target management and extension efforts based on needs. In South Dakota, surveys for SCN were conducted in 45 counties, and multiple new counties were confirmed to have fields infested with SCN.

Evaluation of cultivars and germplasm for nematode resistance

Programs across different areas screened commercial soybean cultivars and germplasm lines for resistance to SCN, which is the most destructive nematode that affects soybean in the North Central region. In Illinois, the impact of SCN was evaluated on 132 soybean cultivars, and the results of these trials help direct grower recommendations for maximizing yield in the face of nematode pressure. In Kentucky, soybean cultivars that contained different sources of resistance to SCN (PI 88788 vs. Peking) were evaluated for their performance in a field infested with an HG Type 2.5.7 population. As expected, the results of this research showed that cultivars with the Peking source of resistance resulted in lower SCN reproduction factors and greater yields. As cultivars with Peking as a source of SCN resistance are just beginning to make their way into cultivars with relative maturities suitable for production in Kentucky, this information is important in helping to inform farmers and other stakeholders of their potential impact on SCN management. In Minnesota, a total of 45 commercial soybean cultivars and 29 breeding lines were assayed for their resistance to SCN HG Type 7 in the greenhouse in 2024. Additional research in Minnesota was focues on assessing intraspecific variability in nematode virulence and pathogenicity. As part of this research, the genomes of 178 SCN inbred lines have been re-sequenced and preliminary analysis has been conducted, which included identifying a dataset of 482,335 single nucleotide polymorphisms (SNPs). A Genome-Wide Association Study (GWAS) was conducted to associate these SNPs with the virulence of the inbred SCN lines against six major SCN-resistance source soybean germplasm: Pickett (PI 548988), Peking (PI 548402), PI 88788, PI 90763, PI 438489B, and PI 567516C. The GWAS identified 17 SNPs associated with SCN virulence, each corresponding to virulence against the resistance of one specific soybean line. In North Dakota, A total of 152 soybean breeding lines from the North Dakota State University (NDSU) soybean breeding program (117) and commercial soybean cultivars (35) from various companies were acquired. Out of these, 12 cultivars and all breeding lines were screened for resistance against an SCN HG Type 7 population, and 23 cultivars were screened against an SCN HG type 0 population, and all soybean breeding lines and cultivars were screened for resistance against an SCN HG type 2.5.7 population. Among the 35 commercial soybean cultivars tested against HG type 0 or 7, 9 cultivars were resistant (FI: 0.0 to 9.6%), eight cultivars were moderately resistant (FI: 14.5 to 27.1%), 13 cultivars were moderately susceptible (FI: 33.5 to 58.5%), and the remaining 5 cultivars were susceptible (FI: 60.2 to 89.6%). When screened against HG type 2.5.7, 6 cultivars were resistant (FI: 2.4 to 8.7%), 7 cultivars were moderately resistant (FI: 15.2 to 29.9%), 10 cultivars were moderately susceptible (FI: 32.3 to 59.8%), and the remaining 12 cultivars were susceptible (FI: 60.5 to 120.2%). Interestingly, twelve of the cultivars were resistant or moderately resistant to both the SCN populations (HG type 2.5.7 and HG type 0/7). Among the 117 NDSU breeding lines screened against HG type 7, 6 lines were resistant (FI: 7.8 to 9.9%), 34 lines were moderately resistant (FI: 12.9 to 29.9%), 22 lines were moderately susceptible (FI: 34.8 to 59.6%), and the remaining 55 lines were susceptible (FI: 60.0 to 91.3%). When screened against HG type 2.5.7, none of the lines were

resistant, 25 lines were moderately resistant (FI: 22.0 to 28.7%), 18 lines were moderately susceptible (FI: 30.5 to 59.8%), and the remaining 74 lines were susceptible (FI: 60.1 to 90.1%). 'ND21-11516(GT)' had the lowest female index value for both HG type 7 (7.8%) and HG type 2.5.7 (22.0%). A total of 25 breeding lines among the 117 breeding lines showed resistant or moderately resistant reaction to both the HG types. In Ohio, more than 115 soybean cultivars from the Ohio Soybean Variety Performance Trial were evaluated for SCN resistance using two SCN populations (HG types 0 and 2.5.7). In Ontario, Canada, soybean cultivar screening for SCN and sudden death syndrome resistance was conducted to help improve disease ratings for seed providers as well as performance expectations for growers. Public breeding programs at the University of Guelph, University of Guelph - Ridgetown Campus, and at Agriculture and Agri-Food Canada stations in Ottawa and Harrow are evaluating germplasm for SCN resistance as well as various SCN resistance sources.

In addition to screening soybean cultivars and germplasm for resistance to SCN, in Minnesota, pennycress germplasm lines were evaluated for their resistance to SCN. In some areas in the North Central region, pennycress is being evaluated and grown as a new rotational crop for the region, but it is susceptible to SCN. Researchers in Minnesota plan to evaluate approximately 430 pennycress germplasm and breeding lines for resistance to SCN. So far, a total of 209 lines have been evaluated. The SCN female index (FI) on pennycress lines ranged from 10.3 to 50.3, indicating that no highly resistant pennycress lines have been discovered to date. As part of this work 14 pennycress germplasm lines representing various levels of SCN susceptibility (based on previous studies) were evaluated for their reaction to 16 inbred lines and 4 field populations of SCN that represented various HG types found in Minnesota.

In Minnesota, common bean (*Phaseolus vulgaris*) germplasm and breeding lines also were evaluated for their resistance to SCN. As part of this work, a total of 694 germplasm accessions from the USDA were evaluated for their resistance to SCN populations from Minnesota. Among them, 90 lines were identified as resistant (FI < 10), and 260 as moderately resistant (FI between 10 and 29) to one ore more of 5 SCN populations. An additional 504 germplasm lines were tested using a single plant against HG Type 7.

In North Dakota, 37 wheat cultivars were screened for their resistance to the root-lesion nematode (RLN), *Pratylenchus neglectus*, which is a migratory endoparasite that is a major soilborne pathogen of wheat. The cultivars were evaluated in greenhouse experiments, and included 26 hexaploid wheat, 6 durum wheat, 2 synthetic hexaploidy wheat, 1 emmer wheat, and 2 triticale accessions. Out of the 37 accessions tested, one was classified as resistant, 18 as moderately resistant, 11 as moderately susceptible, and 7 as susceptible. This research provides information about *P. neglectus* resistance among wheat and triticale cultivars used in the Upper Midwest region.

Ultimately, this research that is focused on screening cultivars, breeding lines, and germplasm lines of regionally important crops for their resistance to the major plant parasitic nematodes present in the north central region, provides breeding programs, farmers, and other important stakeholder information that can be used to help successfully manage these economically threatening nematodes.

Evaluation of nematode protectant seed treatments

As more and more nematode protectant seed treatment products are registered and arrive on the market, it is important that these products are evaluated in non-biased field trials across the region. The results of this research help support decision makers (farmers, crop consultants, and

others) by providing them with non-biased data that show efficacy (or lack thereof) and the economics of utilizing the different products available. A recent output from this research is the publication by Bissonnette et al. (2024. Plant Dis. 108:1729-1739) that provides results from field trials conducted across 51 site-years (includes multiple U.S. states and Ontario, Canada) that uniformly tested the effect of nematode protectant seed treatments for their effect on SCN and soybean performance. This research highlights the importance of collaborations across members of NC 1197.

Research in this area continues in Kentucky, where field trials evaluating the effect of nematode protectant seed treatments were conducted on corn and soybean. On corn, field trials were conducted in fields that have a history of moderate to high levels of lance, lesion, and spiral nematodes, which are common across Kentucky. On soybean, field trials were conducted to evaluate the effect of nematode protectant seed treatments on SCN and in another trial that focused on SCN and interactions with the seedling disease pathogen, *Fusarium graminearum*. In Missouri, strip trials on farmer fields were conducted to assess the impact of seed treatments on SCN populations, as well as small plot research trials to evaluate the efficacy of PI 88788 and Peking resistance programs and rotations of these types of resistance with different seed treatments. In Ohio, trials were conducted to assess soybeans with various SCN resistance sources (Peking/PI88788) and examine the effect of seed protectants, both with and without nematode seed protectants, in fields infested with SCN. In Ontario, various seed treatments (traditional and biological) were tested in soybean at two locations.

Development of innovative methods to detect and quantify plant parasitic nematodes
Increasing the efficiency of quantifying and detecting plant parasitic nematodes is an important goal that could reduce bottlenecks that can delay critical management decisions. In Ohio, the effectiveness of an automated soil sampler compared to a traditional hand sampling was assessed for its ability to measure SCN abundance and its efficiency for use in on-farm trials across multiple locations. Similarity between the two methods was measured using concordance correlation coefficient (CCC) analysis. In addition, a visual comparison of the spatial distribution of SCN obtained with the automated and manual sampling was conducted using QGIS with the inverse distance weighting (IDW) interpolation analysis. Results of the CCC analysis showed a significant positive relationship between automated and manual sampling for two locations (ρc=0.71-0.77), but a lower correlation was observed for a third location (ρc=0.47). These results demonstrate the potential use of automated technologies in large soybean fields to determine SCN population densities and their spatial distribution.

Objective 2: Determine the relationships among nematode population characteristics, crop injury, and soil health.

Research that can help provide a better understanding of the relationships of nematodes with their crop hosts, their microbiome, and their relationship with soil health can provide insight into the overall biological processes occurring across agricultural landscapes

In Michigan, a major focus has been analysis of nematode community structure (NCS), nutrient cycling and soil health data with the SFW model. Specifically, how the regenerative agricultural practices (RAPs) influence the measured parameters and how the data relate to the disturbed and enriched, stable and enriched, stable and depleted, and depleted and degraded soil

health conditions that the model describes. Consequently, establishing cause-and-effect relationships that explain the outcomes and potentially benefit the environment is anticipated. In addition, two long-term studies are maintained in Michigan where various combinations of RAPs such as tillage, cropping system, cover crop and/or nutrient amendments are applied that test adaptation of SCN and changes in NCS, nutrient cycling and soil health. Northern root-knot nematode (NRKN) cultures are maintained from different regions of Michigan soils with varying degrees of soil health conditions, and research is focused on using the Soil Food Web (SFW) model to elucidate the specificity of associations between NRKN populations' parasitic variability (PV) and soil microbiome. In Ohio, the relationship between soil health parameters and the reproduction of SCN reproduction is being evaluated. Additionally, research is focused on exploring how these parameters are linked to other plant parasitic nematodes. Reports of soil nutrient and soil health analyses, in conjunction with nematode evaluations, are provided to growers. Additional research in Ohio has examined the impact of soybean cyst nematode abundance in soils on changes in soil fungal communities. The results from this research have been published recently (Medina López et al. 2024. Phytobiomes J. 8:568-577).

As production systems that utilize cover crop practices increase across the North Central region, it has become increasingly important to evaluate the effect of cover crops on nematode populations. In Minnesota, the effect of pennycress, as a cover crop, on SCN in fields is being evaluated. Experiments were initiated at one field site in 2019, and two field sites in 2022 to study the effect of planting dates of oilseed cover crop pennycress on the SCN population densities in corn-pennycress/soybean-corn production system. In addition, microplots were also established with more even initial SCN populations for the study of the cover crop effect. So far, no increase of SCN population density by winter cover crop for the next soybean-growing season was observed. In North Dakota, two growth chamber experiments were conducted to assess ten cover crops for their impacts on SCN hatching and penetration into the roots. For each experiment, crops were planted in naturally infested soil in two separate sets to be harvested 15 and 30 days after planting (DAP). SCN susceptible soybean cv. 'Barnes' and unplanted natural soil (fallow) were used as controls. Faba bean cv. 'Petite', a non-host of SCN, induced the greatest hatching among the cover crops and was statistically similar to soybean. Root staining revealed that the highest number of J2s penetrated the faba bean roots at 15 DAP. While J2s penetrated all tested crops, they completed their development to become adult females only in soybean and turnip. Soybean cyst nematode development to adult females did not occur in faba bean, and the number of SCN inside the faba bean roots 30 DAP was significantly lower than at 15 DAP and lower than in soybean.

Objective 3: Develop and disseminate research-based information on the biology and management of plant parasitic nematodes of economically important crops in the North Central region.

Members of NC 1197 disseminate timely, research-based information on the biology and management of important plant parasitic nematodes through a variety of methods that include presentations at extension and industry meetings, webinars, field days, podcasts, social media, online videos, newsletters, extension fact sheets, technical reports, variety performance trial reports, and interviews with the agricultural press which are delivered through media such as magazine and newspaper articles, radio, and television. In addition to disseminating information

through their own programs and universities, NC 1197 members also work together to increase awareness of plant parasitic nematodes and to provide unified messages through The SCN Coalition (https://www.thescncoalition.com/) and the Crop Protection Network (https://cropprotectionnetwork.org/). The SCN Coalition works to provide information to stakeholders that will help decrease the economic impact of all nematodes that infect soybean through sampling and management. In June 2024, The SCN coalition worked with *Progressive Farmer* magazine to include a multi-page insert focused on soybean cyst nematode, which reached thousands of readers across multiple states. In addition, in 2023, the "SCN Profit Checker" was made available through The SCN Coalition, which is a tool that farmers can use to determine the yield loss and economic impact caused by SCN on a field-by-field basis. This tool has helped increase awareness of the losses that SCN is causing and strives to help farmers make better decisions on how to manage SCN in their soybean fields. In late 2024, the leadership team of The SCN Coalition assembled to initiate the development of management guides for SCN, RKN, and root-lesion nematodes, which will be important resources for farmers and other stakeholders. Members of NC 1197 also work together to annually provide corn, soybean, and wheat yield loss estimates that are caused by nematodes and other plant pathogens for each state. This annual yield loss information is compiled and made available on the "Field Crop Disease and Insect Loss Calculator" on the Crop Protection Network and helps define the annual impact that plant parasitic nematodes have on regionally important crops grown in the North Central region.

Impacts:

- The "SCN Profit Checker" was released through The SCN Coalition, which is an online tool that helps farmers better understand the losses caused by soybean cyst nematode on their own form on a field-by-field basis (https://www.thescncoalition.com/profitchecker/).
- Members of NC 1197 reached thousands of farmers and stakeholders to increase awareness and management of plant parasitic nematodes that affect regionally important crops grown in the North Central region.
- Members of NC 1197 contributed towards the summarization of 51 site-years of field research focused on management of soybean cyst nematode with nematode protectant seed treatments (Bissonnette et al. 2024. Plant Dis. 108:1729-1739). https://doi.org/10.1094/PDIS-02-23-0292-RE), which provided a non-biased evaluation of the efficacy and economics of utilizing different treatments that stakeholders can utilize to make decisions on their own farms.
- Surveys for plant parasitic nematodes are occurring in several states (many of which are "free" to farmers), which helps increase awareness of these important plant pathogens, and ultimately helps inform management decisions.
- Several NC 1197 members are conducting evaluations of cultivars, breeding lines, and germplasm lines for their resistance to plant parasitic nematodes, which ultimately leads to better management through improved host resistance.
- The relationship of nematodes and soil health is being better defined through the Soil Food Web (SFW), Fertilizer Use Efficiency (FUE), and Integrated Productivity Efficiency (IPE) models.
- A first draft genome assembly of *Pratylenchus scribneri* was generated using long-read DNA sequencing.

- The effectiveness of an automated soil sampler in measuring soybean cyst nematode abundance was demonstrated in Ohio, which can lead to more efficient methods of detecting and monitoring important plant parasitic nematodes across the North Central region.

Publications:

Book Chapters:

Lopez-Nicora, H., Peng, D., Saikai, K., and Rashidifard, M. Nematode problems in maize and their sustainable management, in M. R. Khan and M. Quintanilla (ed.), Nematode Diseases of Crops and Their Sustainable Management, Elsevier Science & Technology, Academic Press Inc., Oxford, United Kingdom (ISBN: 9780323912266).

Owen, K., Walia, R. K., Yan, G. P., and Khan, M. R. 2023. Nematode problems in wheat and barley and their sustainable management, in: M. R. Khan and M. Quintanilla (ed.), Nematode Diseases of Crops and Their Sustainable Management, Elsevier Science & Technology, Academic Press Inc., Oxford, United Kingdom (ISBN: 9780323912266).

Refereed Journal Articles:

Arora, D., Hernandez, A. G., Walden, K. K. O., Fields, C. J., and Yan, G. P. 2023. First draft genome assembly of root-lesion nematode *Pratylenchus scribneri* generated using long-read sequencing. Int. J. Mol. Sci. 24:7311. https://doi.org/10.3390/ijms24087311.

Bissonnette, K. M., Barizon, J., Adee, E., Ames, K. A., Becker, T., Biggs, M., Bradley, C. A., Brown, M., Byamukama, E., Chilvers, M. I., Faske, T. R., Harbach, C. J., Jackson-Ziems, T. A., Kandel, Y., R., Kleczewski, N. M., Koehler, A. M., Markell, S. G., Mueller, D. S., Sjarpe, D. A., Smith, D. L., Telenko, D. E. P., Tenuta, A. U. 2024. Management of soybean cyst nematode and sudden death syndrome with nematode-protectant seed treatments across multiple environments in soybean. Plant Dis. 108:1729-1739. https://doi.org/10.1094/PDIS-02-23-0292-RE.

Chen, J., Guo, X., Yan, G. P., and Hu, Y. 2023. Editorial: Plant-parasitic nematode and plant interaction under abiotic and biotic stresses. Frontiers in Plant Sci. 14:1321382. https://doi.org/10.3389/fpls.2023.1321382.

Faske, T. R., Mueller, J., Becker, J. O., Bernard, E. C., Bradley, C., Bond, J., Desager, J., Eisenback, J., Grabau, Z., Hu, J., Kemerait, R., Koehler, A., Lawrence, K., Mehl, H., Rudolph, R. E., Sikora, E. J., Thomas, S., Walker, N., Wheeler, T., Wrather, A. J., Ye, W., and Zhang, L. 2023. Summarized distribution of the southern root-knot nematode, *Meloidogyne incognita*, in field crops in the United States. Plant Health Prog. 24:522-524. https://doi.org/10.1094/PHP-04-23-0031-BR.

Goraya, M., Yan, G. P., Plaisance, A., and Handoo, Z. A. 2023. Identification and reproduction of dagger nematode (*Xiphinema americanum*), in potato. Nematology 25:1127-1139. https://doi.org/10.1163/15685411-bja10281.

Guzmán-Piedrahita, Ó. A., Zamorano-Montañez, C., Aguilar-Marín, S. B., and Lopez-Nicora, H. D. 2024. First report of foliar nematode (*Aphelenchoides pseudobesseyi*) on soybean in Colombia. Plant Dis. 108:535. https://doi.org/10.1094/PDIS-06-23-1117-PDN

Han, J., Ficca, A., Kleczewski, N. M., and Schroeder, N. 2023. Effects of fluopyram on *Pratylenchus penetrans* on corn in the field and in vitro. Plant Dis. 108:342-347. https://doi.org/10.1094/PDIS-04-23-0725-RE.

Lawaju, B. R. Yan, G. P., and Whitworth, J. 2023. Development of a droplet digital PCR assay for detection and quantification of stubby root nematode, *Paratrichodorus allius*, in soil. Plant Dis. 107:3344-3353. https://doi.org/10.1094/PDIS-03-23-0439-SR.

Li, N., Bullock D., Butts-Wilmsmeyer, C., Gentry, L., Goodwin, G., Han J., Kleczewski, N., Martin, N., Paulausky, P., Pistorius, P., Seiter, N., Schroeder, N., and Margenot, A. 2023. Distinct soil health indicators are associated with variation in maize yield and tile drain nitrate losses. Soil Sci. Amer. J. 87:1332-1347 https://doi.org/10.1002/saj2.20586.

Medina López, M., Lopez-Nicora, H. D., and Benitez Ponce, S. 2024. Fungal communities shift with soybean cyst nematode abundance in soils. Phytobiomes J. 8:568-577. https://doi.org/10.1094/PBIOMES-02-24-0021-R.

Mondal, S., Burgos-Hernandez, T., Ralston, T., Simon, A. C. M., Slater, B. K., Niblack, T. L., and Lopez-Nicora, H. D. 2024. The distribution of nematodes in an urban ecosystem: belowground life at The Ohio State University. Ecological Indicators 166:112399. https://doi.org/10.1016/j.ecolind.2024.112399.

Mondal, S., Purohit, A., Hazra, A., Das, S., Chakrabarti, M., Khan, M. R., Lopez-Nicora, H. D., Chakraborti, D., and Mukherjee, A. 2024. Intraspecific variability of rice root knot nematodes across diverse agroecosystems for sustainable management. Sci. Rep. 14:1-14. https://doi.org/10.1038/s41598-024-73980-x.

Mueller, D. S., Sisson, A. J., Eide, B., Allen, T. W., Bradley, C. A., Faske, T. R., Friskop, A., Lawrence, K., Musser, F., Reisig, D., Tenuta, A. U., and Wise, K. A. 2024. Field crop yield loss calculator for disease and invertebrate pests: an online tool from the Crop Protection Network. PhytoFrontiers 4:255-258. https://doi.org/10.1094/PHYTOFR-08-23-0109-A

Neupane, K. and Yan, G. P. 2023. Effects of cover crops on hatching of and root penetration by *Heterodera glycines*. Nematology 26:155-167. https://doi.org/10.1163/15685411-bja10299.

Neupane, K. and Yan, G. P. 2023. Host suitability of cover crops to the root-lesion nematode, *Pratylenchus penetrans*, associated with potato. Plant Dis. 107:2096-2103. https://doi.org/10.1094/PDIS-08-22-2001-RE.

Reed, H. M., Han, Z., and Schroeder, N. E. 2023. GABA immunoreactivity and pharmacological effects varies among three stylet-bearing nematodes. J. Nematology. 55:e2023-1. https://doi.org/10.2478/jofnem-2023-0049.

Singh, G., KC, A., Sandhu, K. S., Friskop, A. J., Liu, Z., and Yan, G. P. 2023. Evaluation of wheat cultivars and germplasm lines for resistance to *Pratylenchus neglectus* populations collected in North Dakota. Plant Dis. 107:3817-3824. https://doi.org/10.1094/PDIS-03-23-0590-RE.

Torabi, S., Seifi, S., Geddes-McAlister, J., Tenuta, A., Wally, O., Torkamaneh, D., and Eskandari, M. 2023. Soybean-SCN battle: novel insight into soybean's defense strategies against *Heterodera glycines*. Int. J. Mol. Sci. 24:16232. https://doi.org/10.3390/ijms242216232.

Conference Abstracts:

Docherty, L., Ramasubramanian, V, Lorenz, A., and Chen, S. 2024. Virulence genetics of soybean cyst nematode. J. Nematology 56 (Abstracts from 2024 Society of Nematologists Annual Meeting. Park City, UT). https://doi.org/10.2478/jofnem-2024-0036.

González Aquino, R. S. and Lopez-Nicora, H. D. 2024. Innovative soil sampling technology for swift and accurate detection of soybean cyst nematode. Plant Health 2024, Memphis, TN, July 27-30, 2024.

Goraya, M., Yan, G. P., and Handoo, Z. A. 2023. Identification and reproduction of dagger nematode (*Xiphinema americanum*) in potato. 107th Annual Meeting of the Potato Association of America, Charlottetown, Prince Edward Island, Canada, July 23-27, 2023.

Goraya, M. and Yan, G. P. 2023. Development of a recombinase polymerase amplification assay for rapid detection of the stubby root nematode, *Paratrichodorus allius* in potato fields. 107th Annual Meeting of the Potato Association of America, Charlottetown, Prince Edward Island, Canada, July 23-27, 2023.

Han, J., Thompson, A., Boudreaux, J., and Schroeder, N. E.. 2024. Reconstruction of the esophageal connectome suggests rewiring of the nervous system in *Heterodera glycines*. J. Nematology 56 (Abstracts from 2024 Society of Nematologists Annual Meeting. Park City, UT). https://doi.org/10.2478/jofnem-2024-0036.

Karki, N. 2024. Soybean cyst nematodes in South Dakota. 2024 Annual Meeting of the North Central Division of the American Phytopathological Society, Manhattan, KS, June 10-12, 2024.

Kaur, H., Osorno, J. M., and Yan, G. P. 2023. Screening dry edible bean germplasm for resistance to soybean cyst nematode (*Heterodera glycines*). Bean Improvement Cooperative (BIC) and North American Pulse Improvement Association (NAPIA) Biennial Meeting, Greenville, SC November 5-9, 2023.

Lawaju, B. R. and Yan, G. P. 2023. Quantitative detection of *Paratrichodorus allius* in soil by droplet digital polymerase chain reaction (ddPCR). Plant Health 2023, Denver, CO, August 12-16, 2023.

Medina López, M., Cohen, A., Ralston, T., Lopez-Nicora, H. D., and Benitez Ponce, S. 2024. Within field spatial variability of soil fungal communities and soybean cyst nematode interactions. Accepted for an oral presentation at the 2024 Soil Ecology Society Biennial Meeting.

Melakeberhan, H. Lartey, I., G. M. N. Benucci, T. Marsh, and G. Bonito (2024). The soil food web model reveals connections among *Meloidogyne hapla* parasitic variability (PV), soil health and soil microbiome. Soil Ecology Society Meeting. May 22-24, 2024, Grand Rapids, MI.

Mondal, S., Johnson, C., Ralston, T., Lindsey, L., and Lopez-Nicora, H. D. 2024. Beyond SCN numbers for maximizing soybean yield: Know your SCN Type! Presented at the 2024 CFAES Annual Research Forum and Poster Competition in Columbus, OH.

Moore, S., Grainger, C., Yoosefzadeh, N., Wally, O., Tenuta, A., Eskandari, M., and Rajcan, I. 2024. Genome Wide Association Study of Soybean Germplasm Derived from elite Canadian and Chinese Soybean Cultivars to Identify Novel Genes Conferring Soybean Cyst Nematode Resistance. 2024 ASA, CCSA, SSSA Tri-Societies Annual Conference, Nov 10-13, 2024, San Antonio, TX.

Moore, J., Mondal, S., Ralston, T., and Lopez-Nicora, H. D. 2024. Advancing soybean cyst nematode management though evaluation of chemical and biological seed treatments in Ohio. J. Nematology 56 (Abstracts from 2024 Society of Nematologists Annual Meeting. Park City, UT). https://doi.org/10.2478/jofnem-2024-0036.

Poudel, D. and Yan, G. P. 2023. Evaluation of soybean accessions with soybean cyst nematode resistance for resistance to the fungus *Clonostachys rosea*. Plant Health 2023, Denver, CO, August 12-16, 2023.

Ralston, T., Mondal, S., and Lopez-Nicora, H. D. 2024. Update of distribution and abundance of soybean cyst nematode (SCN) in Ohio. Presented at the 2024 CFAES Annual Research Forum and Poster Competition in Columbus, OH.

Small, A., and Lopez-Nicora, H. D. 2024. Soil health insights for soybean cyst nematode management: A case study approach. J. Nematology 56 (Abstracts from 2024 Society of Nematologists Annual Meeting. Park City, UT). https://doi.org/10.2478/jofnem-2024-0036.

Warner, L. Barlow, W., Wise, K.A. 2024. Surveying plant-parasitic nematodes in Kentucky corn fields. 2024 Annual Meeting of the North Central Division of the American Phytopathological Society, Manhattan, KS, June 10-12, 2024.

Yan, G. P., Lawaju, B. R., Pasche, J., Whitworth, J., and Grimm, K. S. (2023). Detection of Tobacco rattle virus in viruliferous stubby root nematodes (*Paratrichodorus allius*) using reverse

transcription PCR. 107th Annual Meeting of the Potato Association of America, Charlottetown, Prince Edward Island, Canada, July 23-27, 2023.

Yan, G. P., and Neupane, K. 2023. Hosting and population reduction abilities of cover crops to the root-lesion nematode *Pratylenchus penetrans* associated with potato. 107th Annual Meeting of the Potato Association of America, Charlottetown, Prince Edward Island, Canada, July 23-27, 2023.

Yan, G. P., Poudel, D., Nelson, B., Ebert, M., Mathew, F., Markell, S., and Webster, R. 2023. First detection of the fungal species *Clonostachys rosea* from infected soybean plants in North Dakota. Plant Health 2023, Denver, CO, August 12-16, 2023.

Extension/Outreach Publications:

Bradley, C. A. 2023. Management of Soybean Cyst Nematode Starts with Soil Sampling this Fall, Kentucky Pest News. October 3, 2023. https://kentuckypestnews.wordpress.com/2023/10/03/management-of-soybean-cyst-nematode-starts-with-soil-sampling-this-fall-2/.

Bish, M. D. 2024. Mizzou Crop & Pest Newsletter: "Is soybean cyst nematode reducing the yield potential of your soybean?". Mizzou Crop & Pest Newsletter, April 2024. https://ipm.missouri.edu/croppest/2024/4/scn_reduced_yield-mb/.

Lopez-Nicora, H. D. 2024. Celebrate National Nematode Day and Collect a Soil Sample for SCN Testing. C.O.R.N. Newsletter. https://agcrops.osu.edu/newsletter/corn-newsletter/2024-34/celebrate-national-nematode-day-and-collect-soil-sample-scn.

Lopez-Nicora, H. D. 2024. SCN and Soil Health Testing Opportunity for Ohio Growers. C.O.R.N. Newsletter. https://agcrops.osu.edu/newsletter/corn-newsletter/2024-15/scn-and-soil-health-testing-opportunity-ohio-growers.

Mangel, D. 10/25/24. It's the Season for Controlling Soybean Cyst Nematode. CropWatch. Nebraska Extension. https://cropwatch.unl.edu/2022/sample-soybean-cyst-nematode-fall

Yan, G. P., Osorno, J., and Kaur, H. 2023. Evaluation of dry bean varieties and breeding lines for resistance to soybean cyst nematode, Northarvest BeanGrower Magazine 29 (2): 17-19 (2023 Research edition issue). https://northarvestbean.org/download/2023/Special-Edition-2023-volume-29-issue-2.pdf.

Yan, G. P. and Friskop, A. 2023. Genome sequencing and assembly of the root-lesion nematode Pratylenchus scribneri, an important nematode pest of corn, North Dakota Corn Utilization Council, Annual Report and Year in Review, Page 19. https://ndcorncouncil.org/2023-ndcuc-annual-report/.

Yan, G. P., Miranda, C., and Markell, S. 2023. Resistance of soybean cultivars and breeding lines to soybean cyst nematode, North Dakota Soybean Council, 2023 Research Update, Page 5.

Yan, G. P. 2023. Develop a New Recombinase Polymerase Amplification Assay for Rapid Detection of the Root-Lesion Nematode Pratylenchus dakotaensis from Soil, North Dakota Soybean Council, 2023 Research Update, Page 6.

Markell, S. and Yan, G. P. 2023. Soybean cyst nematode sampling program: 2022. North Dakota Soybean Council, 2023 Research Update, Page 14.

Yan, G. P., John, M., and Plaisance, A. 2023. Identification of effective cover crops for managing the root-lesion nematode, Pratylenchus penetrans, Minnesota Area II Potato Research and Promotion Council and Northland Potato Growers Association, 2023 Research Reports, Pages 10-26. https://www.northlandpotatoes.com/wp-content/uploads/2023/02/2023-Complied-Research-Reports-updated.pdf