National Soil Dynamics Laboratory

Highlights

Spring 2022

United States Department of Agriculture

Agricultural Research Service

Improving Yield and Health of Legume Crops: Co-inoculation with Rhizobia and Trichoderma

Trichoderma is a type of fungi that can be used for biocontrol of diseases and plant growth promotion. Legumes have high economic importance as human and animal food sources (e.g., soybean, peanut, alfalfa, common beans), however, legumes are already inoculated with rhizobia to provide the abilities of plants to absorb nitrogen from the air and there is not a clear understanding of how plants will perform when they are inoculated with both.

There has been a lot of research done on this subject, but the results vary greatly between studies. Scientists at the NSDL, in conjunction with Brazilian scientists, undertook a specialized analysis technique called a meta-analysis, which takes all of the published results on this topic from around the world to determine an overarching conclusion. In this case, a global meta-analysis of published studies from 1992 to 2021 on co-inoculation of legumes with both rhizobia and Trichoderma was conducted (Fig. 1). Co-inoculation favored plants by reducing disease incidence (-44%) and increasing root mass (+17%), nodule number (+32%), nodule mass (+37%), nodule nitrogenase activity (+35%), shoot nitrogen content (+8%), and grain yield (+14%). Co-inoculation of legumes can decrease root diseases caused by Fusarium spp., Rhizoctonia spp., Macrophomina phaseolina, Pythium debaryanum, and Sclerotium rolfsii and also has potential as a plant growth promoter, regardless of plant health.

Our meta-analysis indicated that this inoculation with both microorganisms provided multiple plant benefits compared to inoculation exclusively with rhizobia. Co-inoculation increased several root systems attributes, such as growth, disease control, and nodulation (growth and activity), that directly contribute to increases in shoot N content and grain yield. In addition, it is important to highlight that co-inoculation showed agronomic benefits under contrasting conditions involving variations in legume species, rhizobia genus and Trichoderma species, co-inoculation methods, plant health status, experiment type (field or containers), pathogenic fungi species, and edaphic factors. In summary, co-inoculation of legumes has potential to help improve economic and environmental aspects of agroecosystems and should be encouraged as a method to improve legume production.

National Soil Dynamics Laboratory
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Dynamically Speaking

Work at the National Soil Dynamics Laboratory (NSDL) is finally starting to return to normal from our teleworking status due to COVID-19. We have started bringing people back to "in-person" work at the lab, with everyone set to report back to work by May 30. While we managed to continue to work and be productive, we are all looking forward to being able to meet in person. In the last few years, we have had increased funding to expand our research efforts to develop sustainable agriculture production systems and I am glad to announce that we have been able to move forward with hiring new staff. Therefore, I would like to welcome Christy Hicks and Carly Moore to our laboratory technical support staff. I would also like to announce that the US Congress 2022 budget increased our base funding for research focused on the use of biochar in agriculture production systems. Biochar is what is left over when plant residues from crop or forestry harvesting is burned for bioenergy production. With this increased support, we plan to reinforce and expand our current research efforts to develop productive and sustainable agriculture production systems.

H. Allen Torbert
Research Leader

I hope you enjoy reading about some of the research efforts we have included in this issue of National Soil Dynamics Highlights, and please visit our web site for more information about our ongoing projects.

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... Co-Inoculation cont.

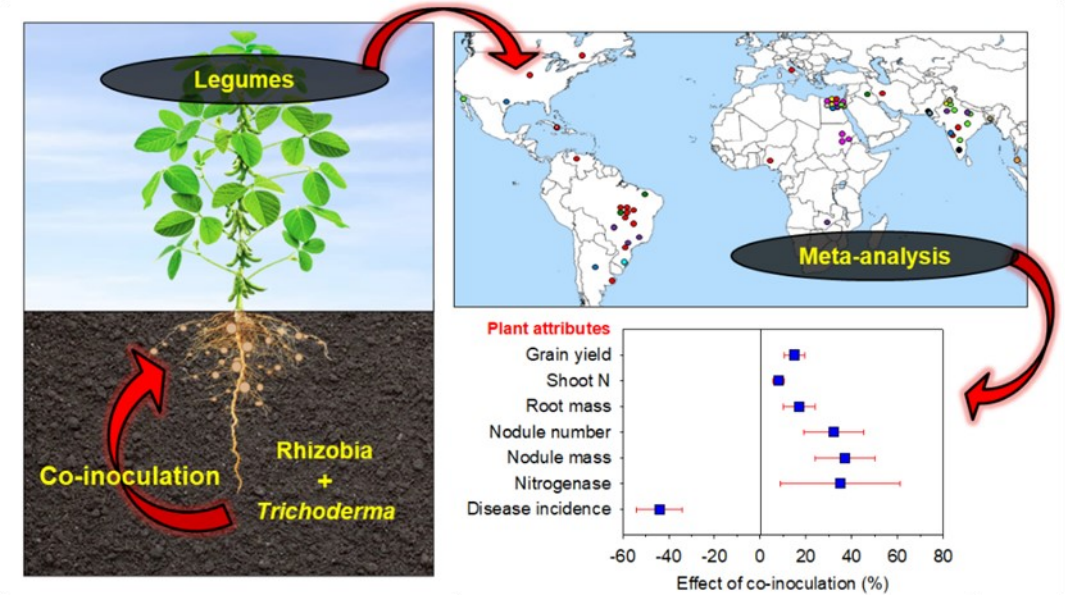

Figure 1. A graphical synopsis of a legume co-inoculated with Rhizobia and Trichoderma. The left picture shows a representative legume crop (in this case, soybean) with a root system that has undergone co-inoculation. The top right picture indicates worldwide locations of studies used in the meta-analysis. The bottom right picture shows the positive effects of co-inoculation with Rhizobia and Trichoderma on various crop attributes.

Cover Crop Biomass Amount, Strip-Tillage Disturbance Width, and Pre-Emergence Herbicide Placement in Cotton

Conservation tillage adoption and retention continues to be threatened by herbicide-resistant Palmer amaranth and other troublesome weeds. Resistant weeds result from evolutionary selection processes and when a weedy plant develops resistance to a herbicide application; a herbicide application kills susceptible individuals, yet the resistant individual survives and reproduces. Over time with repeated herbicide use, isolated weedy plant's seeds quickly spread and dominate weedy populations and the soil seed bank. Troublesome weeds are defined as those that are hard to control due to inherent herbicide tolerance, or reproductive schemes that traditional weed management fail to control.

Our recent cotton weed science research has focused on integrated cultural and chemical weed management strategies to control weeds. Previous weed science research has shown summer annual weed weeds are stimulated to germinate by soil disturbance.

Upcoming Events 2022		
Dates	**Meeting**	**Location**
June 15-17, 2022	Soil and Water Conservation Society (SWCS) - AL Chapter Annual Meeting	Oxford, AL
July 12-14, 2022	American Peanut Research and Education Society (APRES) Annual Meeting	Dallas, TX
July 21-23, 2022	Southern Peanut Growers Conference	Panama City Beach, FL
July 31—Aug. 3, 2022	SWCS International Annual Conference	Denver, CO

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... Cover Crop Biomass cont.

We evaluated the effects of a cereal rye cover crop managed for high- or low-biomass, followed by wide or narrow row strip tillage (Fig. 2 and 3), and three preemergence (PRE) herbicide regimens. The three PRE regimens were (1) pendimethalin plus fomesafen applied broadcast, (2) pendimethalin plus fomesafen applied banded over the row, or (3) no PRE. Each PRE treatment was followed by glyphosate applied postemergence followed by a last postemergence directed application of diuron plus MSMA.

We found that low-residue plots ranged in biomass from 100 to 500 lbs/acre, and high-biomass residue plots ranged from 3,000 to 7,000 lbs/acre. Our previous research has shown that greater than 6,000 lbs/acre is needed to predictably suppress weeds. In most comparisons, surface disturbance width, residue amount, and soil-applied herbicide placement did not influence within-row weed control; however, broadcast PRE resulted in increased carpetweed, large crabgrass, Palmer amaranth, tall morningglory, and yellow nutsedge weed control in row middles compared with plots receiving banded PRE.

In addition, high-residue plots had increased carpetweed, common purslane, large crabgrass, Palmer amaranth, sicklepod, and tall morningglory weed control between rows. Use of banded PRE herbicides resulted in equivalent yield and revenue; however, this would likely result in many between-row weed escapes. Thus, conservation tillage cotton would benefit from broadcast soil-applied herbicide applications regardless of residue amount and tillage width when infested with Palmer amaranth and other troublesome weed species.

Figure 2. A wide residue disturbance (12 in.), 4-row strip till implement equipped with two wavy coulters and rolling baskets.

Figure 3. A narrow residue disturbance (<2 in.) 4- row strip till implement equipped with two pneumatic tires and hard rubber rollers.

Recent Publications

All of our publications are available on our web site: http://www.ars.usda.gov/sea/nsdl

Kavetskiy, A.G., Yakubova, G., Sargsyan, N., Prior, S.A., Torbert III, H.A., Chin, B.A. 2021. Measuring and mapping potassium in agricultural fields using gamma spectroscopy. Inst of Electrical and Electronic Engineers Transactions of Nuclear Science. 68 (10):2550-2558. https://doi.org/10.1109/TNS.2021.3109486.

Kornecki, T.S., Kichler, C.M. 2022. Effectiveness of cover crop termination methods on no-till cantaloupe. Agriculture. 12(1), 66:1-20. https://doi.org/10.3390/agriculture12010066.

Pereira, M., Bassaco, M.V., Motta, A.C., Maeda, S., Prior, S.A., Marques, R., Magri, E., Bognola, I.A., Gomes, J.B. 2022. Influence of industrial forest residue applications on Pinus taeda: soil, litter, growth, nutrition, and wood quality characteristics. New Forests. https://doi.org/10.1007/s11056-021-09902-w.

Schomberg, H.H., Endale D.M., Balkcom, K.S., Raper, R.L., Seman, D.H. 2021. Grazing winter rye cover crop in a cotton no-till system: Soil strength and runoff. Agron. J. 113:1271–1286. https://doi.org/10.1002/agj2.20612

Singh, R., Prasad, R., Delaney, D., Watts, D.B. 2021. Does soybean yield and seed nutrient content change due to broiler litter application? Agronomy. 11, 1523. https://doi.org/10.3390/agronomy11081523.

Singh, R., Prasad, R., Guertal, E., Balkcom, K.S., Lamba, J. 2022. Effects of broiler litter application rate and time on corn yield and environmental nitrogen loss. Agron. J. 114:415-426. https://doi.org/10.1002/agj2.20944.

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Tractor Tire Footprints and Tractive Performance

Greater aggregation in a soil typically corresponds to greater soil structure. As reduced tillage farming systems have become more widespread, a greater proportion of tractor operations occurs on soils which have not been tilled for periods of several months. These soils typically have greater soil structure than tilled soils. We mounted pressure sensors on the tread of a 480/80R38 radial-ply tractor drive tire, to measure soil-tire contact pressures. Using contact pressures, tire rotational angle, and tire dimensions, we estimated the size and shape of the tire footprint on soil. The tire was used on three of the soil bins at the NSDL. The Traction Research Vehicle (Fig. 4) controlled the tire vertical load, tire inflation pressure, and tire slip. The tire was run at 10% slip on a Norfolk sandy loam soil and a Decatur clay loam soil. Each soil had been rotary-tilled, so the initial condition of each soil was a soft soil condition. Also, the tire was run at 10% slip on a Hiwassee clay soil which had not been tilled for several years, so this soil had developed a more defined structure.

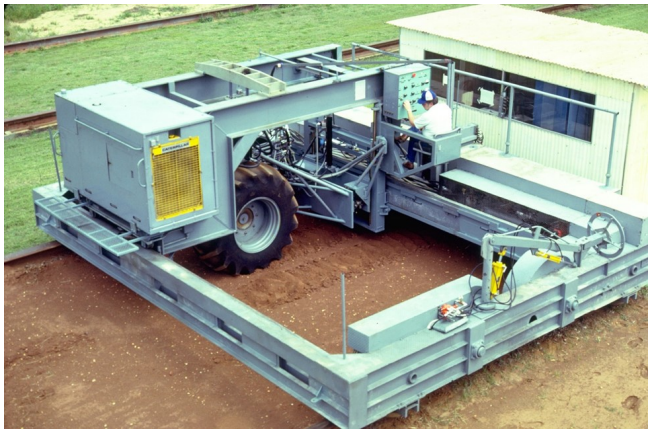

Figure 4. Traction Research Vehicle running on a soil bin at the NSDL. Direction of forward travel is from right to left.

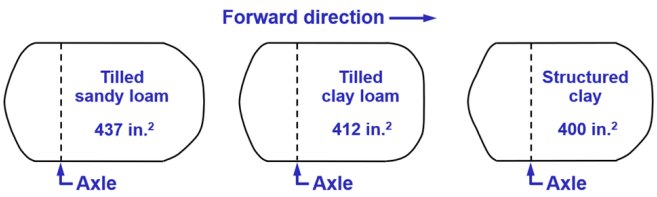

Figure 5. Top views of footprints showing estimated areas and shapes for the 480/80R38 tire running at 10% slip on tilled Norfolk sandy loam, tilled Decatur clay loam, and structured Hiwassee clay.

Happenings

Dr. Andrew Price guest lectured for Dr. Scott McElroy's Weed Science course at Auburn University. Dr Price discussed the management of troublesome weeds in conservation systems.

Dr. Kip Balkcom was invited to present at the 2021 Alabama Certified Crop Advisor Training held in Auburn, AL. The title of his presentation was Nitrogen Credit from Legume Cover Crops. There were 30 participants that attended the training designated for Soil and Water Management credit.

Drs. Kip Balkcom and Andrew Price were invited to present at the Alabama Extension sponsored 2022 Southeast Alabama Cover Crop Field Day. Dr. Balkcom presented information about current and past cover crop management research, while Dr. Price discussed weed suppression associated with cover crops. Approximately 40 people attended the field day. Participants were farmers, ag industry personnel, extension specialists, and NRCS personnel.

A tire vertical load of 5620 lb and the corresponding correct inflation pressure of 16 psi (for a maximum speed of 20 mph) was used for the tire on the tilled sandy loam and tilled clay loam. For the tire on the structured clay, a load of 5690 lb and the corresponding correct inflation pressure of 18 psi (for a maximum speed of 25 mph) was used. For all tests, the tires were actually run at a very slow speed of 0.3 mph, and the reason for the two maximum speed criteria is that the structured clay soil experiment was separate from the experiment in which we used the two tilled soils. The tire footprint areas were 437, 412, and 400 in.² (Fig. 5) and the traction forces developed by the tire were 2590, 2470, and 2000 lb, for the tilled sandy loam, the tilled clay loam, and the structured clay, respectively. For these particular tire and soil conditions, the traction force increased as tire footprint area increased, with the lowest traction force occurring on the structured clay and the greatest traction force occurring on the tilled sandy loam.

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