National Soil Dynamics Laboratory

Highlights

Spring 2020

United States Department of Agriculture

Agricultural Research Service

Bulldozer Blade Analysis using the Discrete Element Method

Bulldozer blades and other scraper blades (Fig. 1) are important in the construction industry. The Discrete Element Method (DEM) is a computer simulation method which simulates a large number of particles and their interactions with solid surfaces which contain them or pass between them. People involved with equipment design and analysis have used DEM to analyze various types of particle movement in agriculture, such as grain flow through combine harvesters. Iowa State University and National Soil Dynamics Laboratory (NSDL) researchers used DEM to analyze bulldozer blades pushing sandy loam soil. Four scaled-down sizes of a bulldozer blade (24%, 14%, 10%, and 5% of full-scale blade dimensions) (Fig. 2) were simulated. During the simulations, the blade cutting depth was held constant at 20% of the blade height and the travel speed was 0.5 mph (0.22 m/s). The blade pushing forces predicted by simulation were compared to forces measured using the four scaled-down blade sizes in a sandy loam soil bin at the NSDL. The DEM simulation (Fig. 3) performed very well in predicting the actual blade forces. These results are expected to be useful in improving the application of DEM to soil-machine interactions, and in promoting the accuracy and usefulness of simulation for development of agricultural and construction soil-engaging equipment.

Figure 1. The scraper blade is the primary soil-engaging component of this motor grader.

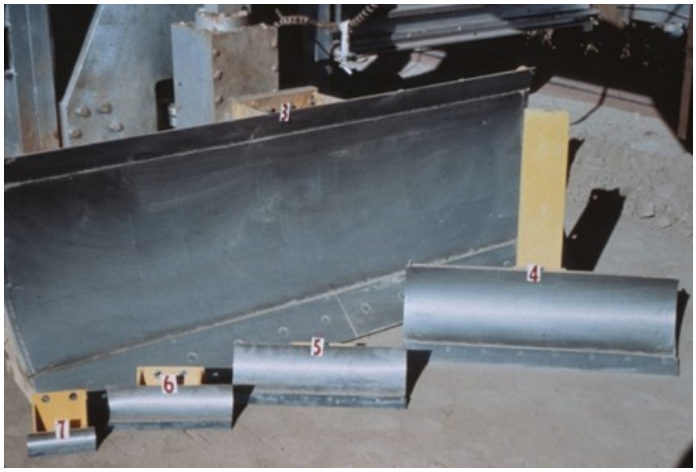

Figure 2. The four smallest of the five scaled-down sizes of a bulldozer blade (24%, 14%, 10%, and 5% of full-scale blade dimensions) were used in the sandy loam soil bin and simulated using the Discrete Element Method.

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Dynamically Speaking

H. Allen Torbert
Research Leader

Like everyone else in the State, this Spring has brought on unusual working conditions for the National Soil Dynamics Laboratory (NSDL) due to the COVID-19 outbreak. We are mostly using technology to work from home, but we are continuing to prepare our field research studies during this planting season as usual. In this letter, I would like to announce that the US Congress 2020 budget substantially increased our base funding for the NSDL, especially for research targeted for cotton field studies. With this increased support, we plan to reinforce and expand our current research efforts to develop productive and sustainable agriculture production systems.

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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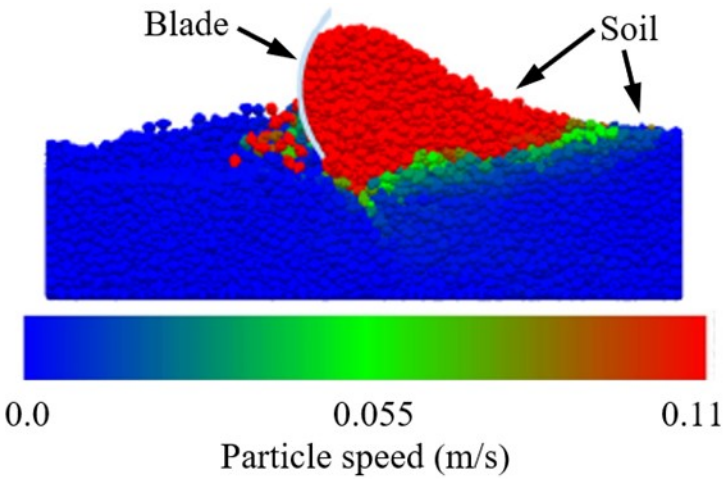

Figure 3. Side view showing Discrete Element Method simulation of bulldozer blade, traveling from left to right.

Upcoming Events 2020

Meetings

*Many upcoming events have not determined whether they will continue at this time. As a result, we are not publishing any upcoming events.

Carbon Storage from Horticultural Growth Substrates

Greenhouse gas emissions must be reduced and carbon (C) storage increased if the agricultural sector is to help mitigate climate change. Agriculture has the opportunity to turn activities which were once carbon dioxide (CO_2) sources into CO_2 sinks by altering management practices that increase C storage in biomass and soils. In this regard, little work has focused on how non-agricultural lands (e.g., urban and suburban) affect C storage which comprise approximately 148 million acres and are often planted with ornamental trees and shrubs. In the Southeast, ornamental plants are commonly grown in containers with pine bark (PB) growth media before being planted into the landscape.

Recently, increased demand for PB has led to a search for other suitable potting substrates. WholeTree (WT) and clean chip residual (CCR) are wood based alternatives which have C levels similar to PB.

In 2016, we discussed data from a study examining the fate of C from these three horticultural growth media (PB, WT, and CCR) when common ornamental plants were transplanted into the landscape. We concluded that PB had a greater potential to increase C storage than WT or CCR. This led us to speculate on how these growth substrates might react, in regard to C loss, when grown in the absence of the plant. A study was installed on a soil bin at the National Soil Dynamics Laboratory filled with a Decatur silt loam soil. To delineate plots, wooded frames (2 foot x 2 foot) were placed in the ground and filled with each substrate alone or each substrate mixed with sand and fertilizer as would be used in an ornamental nursery (Fig. 4). Control plots were frames filled with the Decatur silt loam soil. The study is replicated four times along the length of the outdoor soil bin. An Automated Carbon Efflux System (ACES) is continually monitoring soil CO_2 emissions. Changes in substrate C are also being monitored via reduction in substrate volume within each frame (Fig. 5).

Preliminary results from the volumetric measurements support data from the previous study in that PB appears to maintain a greater volume within the plots than either WT or CCR. This is likely due to the fact that PB is less easily decomposed than WT or CCR which contain wood and/or foliar materials in addition to bark. The ACES are continuing to monitor CO_2 emissions, and this data is being processed for later analysis and presentation.

Figure 4. A single block of the study at initiation. Clockwise from lower left (foreground), plots are: CCR alone; CCR mixed; WT alone; Control; PB alone; PB mixed; and WT mixed.

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... Carbon Storage cont.

Figure 5. The same block after 28 months of exposure to natural conditions. The white lines visible on the inside of the frames shows the original level of media placed in the frames, with the difference being the volume lost to decomposition. The circular devices in each plot are the ACES carbon dioxide sampling chambers.

Innovative Cover Crop Termination

Effective planting of cash crops into desiccated cover crop residue can be a challenge for some growers due to potential cover crop interference with planting operations. Proper management of cover crops in a conservation system is key to ensure success. One aspect of cover crop management includes mechanical termination using a rolling/crimping technique to injure the plant with the crimping bars without cutting stems. To speedup this cover crop termination method, there is a need to consider other ways to enhance cover crop termination including a heat source from an internal combustion engine, such as the exhaust.

To evaluate this concept at a small farm scale, a mechanical pusher using exhaust heat from the internal combustion gasoline engine with supplemental heat from heater strips was developed to terminate a cereal rye cover crop. The prototype was designed for a walk-behind tractor powered by a single cylinder gasoline engine (Fig. 6). Heat to damage plant tissue was directed from the exhaust manifold to a rectangular perforated delivery steel tube. The tube was in continuous contact with the cover crop as the cover crop was flattened by the pusher on the front of the tractor. In addition, a generator powered by the tractor's PTO provided electrical energy for three parallel supplemental heater strips (Fig. 7).

Recent Publications

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

Lamba, J., Srivastava, P., Way, T.R., Malhotra, K. 2019. Effect of broiler litter application method on metal runoff from pastures. Journal of Environmental Quality. 48:1856-1862. https://doi.org/10.2134/jeq2018.08.0318.

Busby, R.R., Torbert III, H.A., Prior, S.A. 2019. Soil and vegetation responses to amendment with pulverized classified paper waste. Soil & Tillage Research. 194. https://doi.org/10.1016/j.still.2019.104328.

Prior, S.A., Runion, G.B., Torbert III, H.A. 2019. Long-term response of a bahiagrass pasture to elevated CO2 and soil fertility management. Soil & Tillage Research. 194. https://doi.org/10.1016/j.still.2019.104326.

Way, T.R., Tewolde, H., Watts, D.B. 2019. Impeller blower performance in conveying broiler litter. Applied Engineering in Agriculture. 35(5):815-822.

Kornecki, T.S., Price, A.J. 2019. Management of high-residue cover crops in a conservation tillage organic vegetable on-farm setting in Alabama. Agronomy. 9(10):640. https://doi.org/10.3390/agronomy9100640.

Ferreira, C., Bassaco, M., Pereira, M., Pauletti, V., Prior, S.A., Motta, A. 2020. Dendrometric analysis of early development of Eucalyptus urophylla x Eucalyptus grandis with gypsum use under subtropical conditions. Floresta e Ambiente (Forest and Environment). 27(1):e20190095. https://doi.org/10.1590/2179-8087.009519.

Lin, Y., Watts, D.B., Kloepper, J.W., Feng, Y., Torbert III, H.A. 2019. Influence of plant growth-promoting rhizobacteria on corn growth under drought stress. Communications in Soil Science and Plant Analysis. 51(2):250-264. https://doi.org/10.1080/00103624.2019.1705329.

Barbosa, J.Z., Poggere, G.C., Teixeira, W.W., Motta, A.C., Curi, N., Prior, S.A. 2019. Assessing soil contamination in automobile scrap yards by portable X-ray fluorescence spectrometry and magnetic susceptibility. Environment Monitoring and Assessment. 192:46. https://doi.org/10.1007/s10661-019-8025-8.

Balkcom, K.S. 2019. No tillage and non-inversion tillage comparisons across wheat nitrogen rates in Alabama. Journal of Soil and Water Conservation. 74:560-570. https://doi.org/10.2489/jswc.74.6.560.

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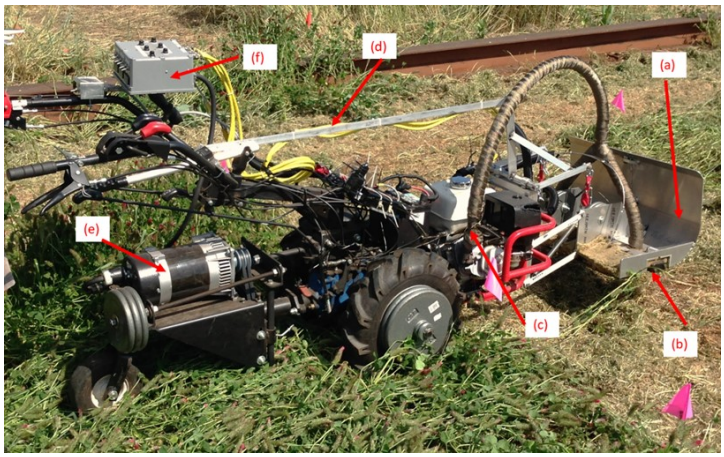


Figure 6. Heat pusher's components: (a) aluminum circular shape cover crop pusher; (b) perforated rectangular steel tube to deliver heat to cover crop; (c) engine's exhaust manifold; (d) control bar linkage to engage pusher (with heated elements) with cover crop; (e) onboard PTO driven generator; and (f) temperature controller for heat strips powered by the generator.

Happenings

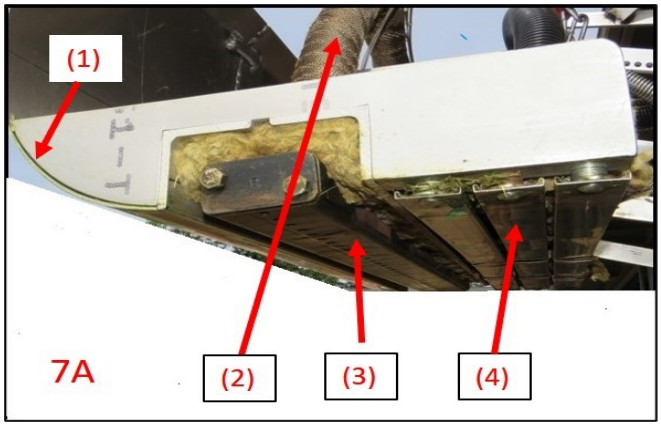
Dr. Torbert, Dr. Balkcom, Dr. Watts attended the 2019 ASA-CSSA-SSSA International Annual Meeting in San Antonio, Texas on November 9-14, 2019. Dr. Torbert presented a paper titled "Status of the US-EPA Risk Evaluation of FGD-Gypsum Uses in Agriculture". Dr. Balkcom presented a paper titled "Cover Crop Mixtures for Cotton Production". Dr. Watts presented a paper titled "What Are the Environmental Implications of FGD Gypsum Use in Agriculture".

Dr. Kavetskiy and Dr. Yakubova attended the ANS Winter Meeting Expo in Washington DC on November 17-21, 2019. Dr. Kavetskiy and Dr. Yakubova presented a paper titled "Application neutron-gamma technology for soil element mapping".

Dr. Kornecki visited Cambodia and Philippines on January 4 - 18, 2020, to participate in workshops related to conservation agriculture and specialized no-till equipment that Dr. Kornecki developed. This invited trip was funded by Sustainable Intensification Innovation Lab at Kansas State University.

Dr. Kip Balkcom was invited to present information about cover crop management and cover crop mixtures to growers at an Alabama Cooperative Extension Service sponsored field day. The meeting was in Belle Mina, AL at the Tennessee Valley Experiment Station on February 24, 2020.

Dr. Kip Balkcom was invited to present management information about cover crops to AGRI-AFC representatives and local growers as part of an information meeting to participants about cover crops. The meeting was at a field site where AGRI-AFC has a cover crop field demo in Ft. Gaines, GA on March 3, 2020.



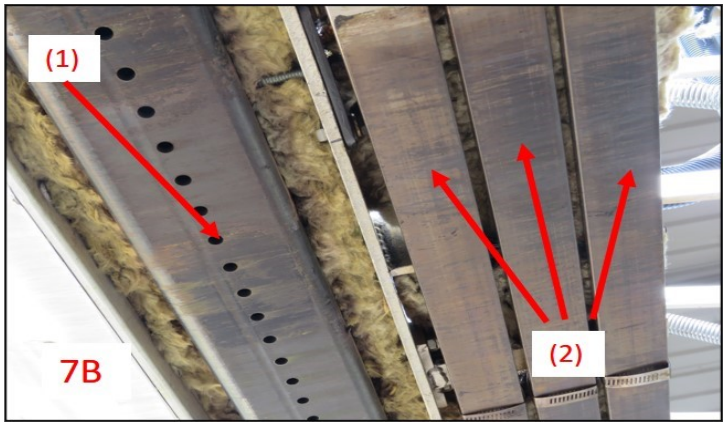


*Figure 7. Heat pusher components: **7A)** Side view of the pusher with exhaust rectangular steel tube with three supplemental heat strips: (1) circular shaped cover crop pusher, (2) exhaust heat delivery insulated pipe to the (3) perforated steel tube, (4) supplemental strip heaters. **7B)** Close-up of the rectangular steel tube (1) with dimensions of 7.6 cm x 3.8 cm, 0.6 cm thick; and (2) close-up of the three supplemental heater strips.*

Results from three growing seasons indicate that combining heat from engine exhaust with supplemental heat strips is a viable alternative for organic production systems with cover crops where commercial herbicides cannot be used and where effective cover crop termination is essential to growth and yield of cash crops. Termination rates for a rye cover crop were higher at lower speed due to longer heat exposure on plant tissue. Results also indicate that this method could be used for weed control in organic systems where herbicide use is prohibited. Water conservation was better for flattened rye since this residue provided better soil coverage that resulted in higher volumetric moisture contents compared to the control (standing rye). This innovative method using exhaust heat (otherwise lost to the environment) is a feasible option to terminate cover crops while conserving soil moisture in small-scale conservation and/or organic farm systems.

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