SOIL DISRUPTION BY FIRE ANTS IN CONSERVATION AND CONVENTIONAL TILLAGE TREATMENTS

W. Busscher[1], D. Manley[2], P. Bauer[1], and J. Frederick[3]

AUTHORS: [1]Coastal Plains Soil, Water, and Plant Research Center, USDA-ARS, 2611 W Lucas St., Florence, SC 29501-1242; [2] Entomology Department, and [3]Department of Crop and Soil Environmental Science, Pee Dee Research and Education Center, Clemson University, 2200 Pocket Road, Florence, SC 29506-9706. Corresponding author: W. Busscher (busscher@florence.ars.usda.gov).

ABSTRACT

In the southeastern Coastal Plains, fire ants *(Solenopsis invicta* Buren) can, at times, produce a significant number of mounds/A. It was our objective to analyze amount and shape of soil disruption within conventional and innovative (conservation) tillage systems and determine if management system affects disruption of soil by ants. Using strength probes with detachable handles, soil disruption by fire ants was measured in a field split on conventional and innovative tillage management systems. Soil strength readings were also taken near the fire ant mounds to measure conditions outside the mounds. Preliminary results show that the conventional treatment had a greater volume of soil disruption by ant activity while the innovative treatment had greater depth of disruption. When readings taken in the mounds were corrected for strength readings taken outside the mounds, innovative management had greater depth and volume of soil loosening as a result of ant activity than conventional management, probably because innovative deep tillage disrupted more of the subsoil than conventional tillage. The deeper disruption in the innovative treatment may cause more rapid leaching of surface applied nutrients and pesticides.

INTRODUCTION

Red imported fire ants cause an estimated $2.77 billion annual damage in the southeastern United States (Thompson *et al.,* 1999). Fire ants were introduced to the country in about 1930 in the Mobile, Alabama area. Since then, they have spread by various degrees throughout the southern part of the USA. Now, red imported fire ants are endemic to the southeastern Coastal Plains (http://www.aphis.usda.gov/oa/antmap.html, http://entweb.clemson.edu/caps/regional/rif/rifdist.htm, http://uts.cc.utexas.edu/~gilbert/research//fireants/ faqans.html#import). With normal weather conditions and large-scale use of irrigation, they are expected to spread, especially north along coastal areas (Thompson *et al.,* 1999).

Numbers of fire ant mounds can vary with differing habitat (Coulson et al., 1999) and tillage treatment (Manley, 1999). However, the amount and shape of soil disruption per mound among differing environmental conditions have not yet been determined.

It was our objective to analyze soil disruption per mound within conventional and conservation tillage systems and determine if differences in amount and shape of soil disruption by ants was affected by management system.

MATERIALS AND METHODS

In 1997, a long-term study was initiated to quantify improvements of profitability, environmental protection, and pest management between conventional and innovative management techniques (http://agroecology.clemson.edu/). The study was performed using a 14-acre field at the Pee Dee Research Center in Florence, SC. The field was split in half with common soils on both sides. The two sides were treated with conventional or innovative management practices. The conventional side used standard management practices traditionally used by producers in 1995, including disking, planting soybean in 30-inch row spacings, and chiseling or in-row subsoiling with a 45' forward angled, straight shank. The innovative side used more advanced practices, including no surface tillage, drilling soybean at 7.5-inch row spacings, and paratillage[1] at 26-inch spacing.

In 1997, both sides of the field were planted to corn using conventional management to standardize the initial conditions of the experiment. In 1998, while both were double cropped to wheat and soybean, the two sides had separate management practices instituted on them. On the conventional side, soil was disked, chisel plowed, and smoothed before wheat planting (variety Pioneer 2384). After wheat harvest, straw was burned; the soil was disked, in-row subsoiled, and soybean (NK S75-55) planted in 30-inch row widths. Conventional herbicides were applied and the soil was cultivated between rows twice during the growing season. After harvest the conventional side was disked for weed control.

On the innovative side, soil was paratilled before planting wheat (variety Pioneer 2384) into a non-disked surface. After wheat harvest, the soil was paratilled again and soybean (Roundup Ready variety N.K. S73-Z5) were drilled using 7.5-inch row widths. Roundup was applied preplant and again 3 weeks after planting (1 qt/A). Nutrients for both sides of the field were applied based upon Clemson University Extension Service recommendations. On the conventional side, nutrients were applied on a field scale; on the innovative side, they were applied based on soil type. Both sides were harvested with a CASE 2366 combine equipped with yield monitor and GPS technologies. The field was left fallow in the winter of 1999 in preparation for corn planting.

In March 1999, twelve mounds were located in the field (six on each side) and paired based on soil type and surface appearance. Mounds were located at four sites that were mapped as Norfolk loamy sand (fine-loamy, kaolinitic, thermic Typic Kandiudult) and two that were mapped as Noboco loamy sand (fine-loamy, siliceous, subactive, thermic Typic Paleudult).

Strings were attached to a 3- by 3-ft frame at 4-inch spacings to make a 4- by 4-inch grid to locate positions across the surface of mounds where depth measurements of ant disruption would be taken. Grids were placed over mounds slightly raised to not disturb the soil and attract swarms of ants. Grids were oriented with one dimension along the row and the other perpendicular to the row.

For depth measurements of ant disruption, 3-ft long, 0.25-inch diameter rods were marked at 4-inch depth intervals. These rods were attached to a custom made proving ring and handle with a quick release thumbscrew. Rods were pushed into the ground until they passed through the zone disrupted by fire ants, estimated by a sudden increase in force registered on the proving ring, standardized to a pressure of 15 atm. Handles were detached from the rods while the ants swarmed over the rods. Other rods were pushed into other points on the grid in a similar manner. When ant activity subsided, depth readings were taken based on markings on each rod and recorded. Readings recorded position across the row, location along the row, and depth into the soil. Depth readings were corrected to the height of the soil when the measurement grid and/or ant mound was above it.

To determine how much of the soil disruption was based on ant activity and how much on tillage,

[1]Mention of trade names or commercial products in this article is solely for the purpose of providing specific information and does not imply recommendation or endorsement by the U.S. Department of Agriculture or Clemson University.

cone index readings were also taken across the rows about 2 ft from the ant mound. Cone index data were taken with a 0.5-inch diameter cone-tipped penetrometer (Carter, 1967). Cone indices were measured by pushing the penetrometer into the soil to a depth of 2 ft at nine positions across the rows; cone index positions included the same positions across the row as those measured in the fire ant mounds. Cone index data were digitized into the computer at 2-inch depth intervals using the method of Busscher *et al.* (1986). Data for all positions across the plot and depth were combined to produce cross-sectional contours of soil cone indices.

Gravimetric soil water content samples were taken along with cone indices. They were taken at the mid-position of cone index readings. Water contents were measured at 4-inch depth intervals to the 2-ft depth. These water contents were taken as representative of the water contents where penetrometer data were taken and representative of the soil just outside the disrupted volume of the ant mound where the 15 atm data were measured.

Depths outside the mounds where soil strength was 15 atm due to tillage were determined by interpolation of cone index data. These depths were subtracted from the depths measured at 15 atm in the fire ant mounds. The difference determined the amount of soil disruption by ants beyond the disruption of tillage alone. Depths were used to calculate volume of disruption by the ants, mean depth of disruption with and without correction for ant activity, and maximum depth of disruption with and without correction for ant activity.

RESULTS

Soil disruption by fire ants was greater in the conventional management treatment than in the innovative management treatment (Table 1). Though the amount of soil disruption was only a couple of cubic feet per mound, disruption could be substantial across an agricultural field since there can be a significant number of mounds/A. For example, we counted anywhere from 5 to 49 mounds/A in this experiment, ranging from 7 to 49 mounds on the conventional and 5 to 44 mounds on the innovative side. Neither management treatment had consistently more mounds/A than the other over all the measurement dates. Mounds appear to be more associated with soil type, with densities ranging from 0 to 73 mounds/A for different soils (Donald Manley, Personal Communication, 2000).

The shapes of soil volume disrupted by ant activity were different for the two management systems. Soil disruption tended to be broader and shallower on the conventional side, perhaps encouraged by disking. Soil disruption was deeper and more confined on the innovative management side, perhaps encouraged by its more extensive deep tillage (Table 1 and Fig.1). In the conventional treatment, the dip in readings on the left side of the zones of fire ant disruption (Fig. 1) was a result of readings taken in the row for the in-row subsoiled treatment. We stopped taking readings when we had no indication of ant activity on the surface and when we started to measure low strengths in the zone loosened by the subsoil shank.

Different tillage management systems lead to differences in soil strength (cone index, see Fig. 2) which may affect mound shape and amount of soil disruption by ants. Mean cone indices for the top 22 inches across 30 inches of row were greater on the conventional (31.3 atm) than on the innovative side (24.6 atm), even though the conventional side had a higher water content at the time of cone index measurement (8.4 vs. 7.2% on a dry weight basis).

We estimated the end of the soil disruption by ants at a force of 15 atm as measured by our modified probe. We assumed that the modified probe and the penetrometer measured comparable soil strengths. Therefore, we corrected the depth readings measured in the ant mounds by subtracting depths measured in the mounds by depths measured at 15 atm by the penetrometer in the soil near the mounds. Depth corrections were significantly greater for the conventional management treatment (5.4 inches) than for the innovative treatment (3.4 inches) (Table 1 and Fig. 2). Because of the greater correction for the conventional management treatment, volume of disruption after correction (i.e. volume of disruption by ants) was greater for the innovative treatment than for the conventional treatment. Despite the larger correction for the conventional management treatment, maximum depth of ant disruption for the innovative treatment was significantly greater both before and after correction. Since looser soils generally have greater infiltration rates, the greater depth of disruption for the innovative management treatment would have a greater risk for deep percolation of nutrients and pesticides than the conventional treatment.

CONCLUSIONS

Preliminary results indicate that, before correction of the data for disruption by tillage, volume of soil disruption by fire ant activity was greater in the conventional treatment while depth of disruption was deeper in the innovative treatment. After readings within the mounds were corrected for tillage treatment, volume of disruption and depth were greater for innovative than conventional tillage, probably because innovative tillage disrupted more of the subsoil than the conventional tillage treatment, providing a more suitable environment for ant activity. Deep disruption in the innovative treatment may cause greater infiltration and more leaching of nutrients and pesticides to the groundwater. We are continuing to take readings to increase the data base for this experiment. Readings in similar paired fields would also increase confidence of the results.

REFERENCES

Busscher, W.J., R.E. Sojka, and C.W. Doty. 1986. Residual effects of tillage on Coastal Plain soil strength. Soil Sci. 141:144-148.

Carter, L.M. 1967. Portable penetrometer measures soil strength profiles. Agric. Eng. 48:348-349.

Coulson, R.N., S.T. O'Keefe, D.F. Wunneburger, R.P. Meegan, and S.B. Vinson. 1999. Landscape ecology of the red imported fire ant in a post oak savanna. Proceedings of the Imported Fire Ant conference, 3-5 March, Charleston, SC, pp. 37-45.

Thompson, L.C., M.D. Korzkukhin, and S.D. Porter. 1999. Modeling range expansion of the red imported fire ant in the United States. Proceedings of the Imported Fire Ant conference, 3-5 March, Charleston, SC, pp. 13-19.

Manley, D. 1999. Red imported fire ant distribution and mound size under different cropping systems. Proceedings of the Imported Fire Ant conference, 3-5 March, Charleston, SC, pp. 30.

Table 1. Characteristics of fire ant mound disruption as measured by a probe until a force of 15 atm was reached. Numbers in parentheses are standard deviations.

	Treatments	
Before Correction	**Conventional**	**Innovative**
Volume, ft^3/mound	**2.40 (0.92)**	**2.05 (0.55)**
Mean depth, in	**8.81 (3.80)**	**7.50 (3.86)**
Maximum depth, in	**16.3 (3.92)**	**21.8 (8.29)**
After correction		
Volume, ft^3/mound	**0.97 (0.35)**	**1.09 (0.28)**
Mean depth, in	**3.58 (2.33)**	**4.00 (3.65)**
Maximum depth, in	**9.37 (2.28)**	**18.8 (7.66)**

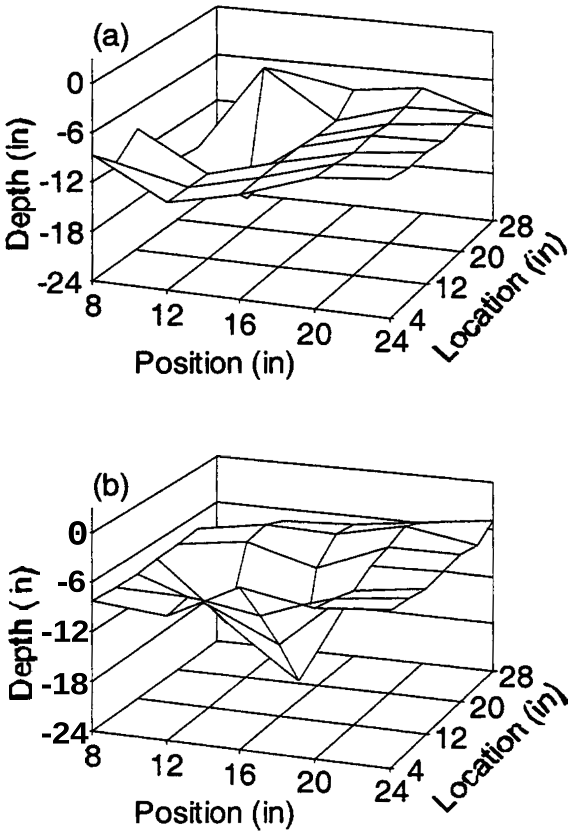

Figure 1. Depth of soil disrupted by fire ants for (a) the conventional management treatment and (b) the innovative management treatment.

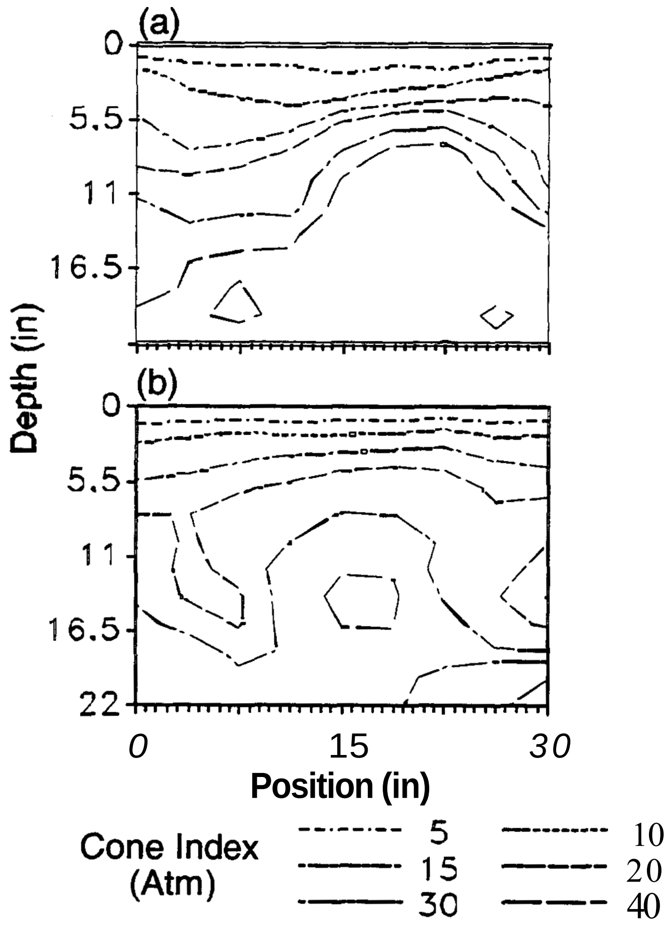

Figure 2. Soil strength patterns for (a) the conventional management treatment and (b) the innovative management treatment.