Earthworm Populations Related to Soil and Fertilizer Management Practices

By E. J. Deibert and R. A. Utter

North Dakota research is currently evaluating earthworm populations and survival under various tillage and management practices. Populations and survival are influenced by soil water, degree of tillage, residue cover, crop rotation and fertilizer management practices.

THE BENEFITS OF EARTHWORMS in the soil and potential effects on improved soil productivity have been recognized for a long time. Earthworms ingest a large amount of soil and organic matter each day and excrete altered materials (casts) that influence the chemical and physical properties of soil. Earthworm activity has been shown to increase soil aggregation, which improves soil structure, increases water infiltration, retention and availability to plants. Activity also increases soil aeration which promotes plant root growth, assists in decomposition of plant residues, aids the microbial mineralization cycles of nitrogen (N), phosphorus (P) and sulfur (S), and enhances availability of potassium (K) and micronutrients.

Earthworm populations have been severely reduced or eliminated in some dryland cropping areas as a result of excessive tillage and poor management practices. The increased emphasis on residue management, especially no-till, in farm plans to reduce erosion and runoff problems has initiated new interest in earthworms. Residue management practices that conserve soil water, provide a food source, provide surface cover and reduce soil disturbance are essential for earthworm survival.

North Dakota Studies

Recent research in North Dakota has focused on the evaluation of earthworm species and populations in farmer fields under different management and reduced tillage practices. Replicated 6-inch deep soil core samples were collected in 1991 at three sites to measure live earthworm and cocoon populations as influenced by surface cover, crop rotation and N fertilizer application. Adjacent grassland sites were also sampled for comparison. At these sites, only two species of earthworms were found: *Aporrectodea tuberculata* and *Aporrectodea trapezoides*. These species are red or gray in color, leave casts in the soil or on the soil surface, and form horizontal burrows in the A and B horizons of the soil.

Influence of Crop Residues

One site in northeast North Dakota was sampled in June, just after barley had emerged, to determine the influence of crop residue cover. This field was located on a Barnes loam soil with 3 to 5 percent slope which had been in continuous no-till barley for five years. As shown in **Table 1**, the number of live earthworms increased 1.5 times when the residue after planting was doubled.

More significant is the influence residue had on cocoon formation, which gives an indication of both previous adult sexual activity and potential earthworm activity. The number of cocoons found at this site was exceptionally high. As residue doubled, the number of cocoons increased 2.5

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Table 1. Earthworm populations as influenced by surface residue after planting a no-till field.

Variable measured	Percent crop residue after planting	
	40-45	80-90
	---- number per square yard ----	
Earthworms	71	106
Cocoons	204	514
Total	275	620

Langdon Research Center, Northeast ND, 1991

Note: The high residue cover was located in the combine straw-chaff row from the previous year and the low residue cover was located outside the straw-chaff row.

times. The ideal soil water, soil temperature and cover conditions with minimal soil disturbance enhanced cocoon formation by mature adults. The total population, assuming survival and cocoon hatching, increased from 275 to 620 per square yard, with a 100 percent increase in residue cover. This study demonstrates the dramatic influence of residue cover. It also demonstrates the dramatic influence producers can have on managing earthworm populations through reduced tillage and maintaining more residue on the soil surface.

Effects of Rotations, Previous Crop

A site in Southeastern North Dakota was sampled in October to determine the influence of rotation and previous crop on earthworm populations. The field was located on an Overly-Bearden silty clay loam soil, with 1 to 2 percent slope, which had been in a no-till crop rotation system for more than 10 years. A corn-soybean-small grain rotation was currently utilized at this farm site. The number of earthworms found was exceptionally high as a result of good management practices. An adjacent native grassland site contained 355 earthworms per square yard. **Table 2** indicates that although the number of cocoons did not vary greatly among the rotations, the earthworm numbers progressively increased, depending on the crop planted, with wheat similar to soybean and both greater than corn. This increase in earthworm numbers is probably a function of when soybean occurred

Table 2. Earthworm populations in various crop rotations under a no-till system.

Variable measured	1990-1991 crop rotation		
	Wheat-Corn	Corn-Soybean	Soybean-Wheat
	------number per square yard ------		
Earthworms	257	346	443
Cocoons	27	71	35
Total	284	417	478

Breker Farm, Southeast ND, 1991

in the rotation since the highest numbers were obtained where soybean was either the current or previous crop. Earthworms prefer residues with low carbon to nitrogen (C:N) ratios, an important factor to consider when trying to maintain high earthworm populations in a crop rotation.

Effects of N Fertilization

Another site in east central North Dakota was sampled in May after wheat planting to determine the influence of anhydrous ammonia applied the previous fall. This field was located on a Hamerly-Svea loam soil with 3 to 4 percent slope managed in a barley-wheat-oil seed crop rotation with a high surface residue reduced tillage system. The barley residue after planting provided 57 percent cover.

It appeared that the application of ammonia in September did not have any long-term adverse effect on earthworms or cocoons. **Table 3** shows the numbers found were similar to those found where no ammonia was applied. Application of ammonia in September may be at a time when earthworms are quite active and

Table 3. Earthworm populations in the spring after application of anhydrous ammonia.

Variable measured	Ammonia application date N rate lb/A		
	0 N	Sept. 15 50 N	Nov. 1 50 N
	earthworm numbers ---------per square yard --------		
Earthworms	98	98	292
Cocoons	62	71	98
Total	160	169	390

Burchill Farm, East Central ND, 1991

RESEARCH shows that increased residue cover can have a positive effect on earthworm populations.

some short-term loss may occur, at least in the area of ammonia release. However, earthworms were apparently able to rebound by spring to the original levels in the field. It is interesting to note the large number of earthworms found, a three fold increase, when fall application of ammonia was delayed until November. Soil temperatures are considerably cooler by November and the earthworms move deeper in the soil profile and enter their aestivation (resting) period. Potential damage to earthworms from ammonia application may be eliminated during this period.

The stimulation or increase in earthworm number can be explained by the fact that earthworm growth and sexual activity are enhanced by a high N environment. In this case, the ammonia supplied additional N to a soil system with a large amount of surface and incorporated small grain residues having a high C:N ratio. The added N increased biological activity which enhanced earthworm growth and sexual activity to produce increased cocoon numbers and higher populations. For comparison, an adjacent grass site, predominantly bromegrass, contained a total of 257 earthworms per square yard which is much lower than the highest total number found in the reduced tillage field.

Summary

These preliminary data suggest that maintaining a high percentage of residue cover does indeed increase earthworm populations by creating an improved soil environment which is essential for their development and survival in dryland areas. The data also point out the importance of including a legume in the rotation to provide an N-rich or low C:N ratio residue in the cycle to stimulate earthworm populations. Although no definitive proof was found that ammonia reduced earthworm numbers, a delay in application time to when earthworms are inactive increased the positive effects of the application. The beneficial effect of ammonia N appears to be due to the resulting increase in N status of the soil. This may be an important management practice, especially in rotations that contain residues with mostly high C:N ratios. The increased use of management practices that stimulate earthworm populations will enhance soil tilth by improving the physical properties and nutrient availability of the soil. ■

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