Tillage System Influence on Earthworms (Lumbricidae) in North Dakota

E.J. Deibert, R.A. Utter and D.P. Schwert

The earthworm is one of the most important natural workhorses in the soil. Earthworm activities provide many beneficial aspects related to chemical and physical properties of the soil. Increased activity potentially favors increased aeration, increased aggregate stability, increased water infiltration, increased mixing and decomposition of plant residue, pH modification and increased availability of organic and inorganic nutrients which directly or indierctly enhances the productivity of the soil (4).

Earthworm population and species are also controlled by the environmental factors that influence their biological cycles, such as temperature, moisture and organic carbon supply. Many crop and soil management practices, especially tillage, have a potentially negative effect on earthworm populations by drying the soil, disturbing the worm holes, compacting the soil, providing rapid destruction of organic matter and removing protective cover essential for survival during winter months (4).

Environmental concerns over soil erosion, rapid loss of soil organic matter, and deterioration of physical conditions in the soil caused by excessive tillage practices have induced consideration of soil management systems that favor reduced tillage practices. How reduced tillage systems in North Dakota influence the chemical and physical conditions of the soil are well documented (1,2), but minimal data are available on the interaction of tillage with earthworms. A better understanding of earthworm species and populations in relation to tillage practices is essential if sustainable crop production practices are to be maintained.

Unfortunately, little information is available on earthworm species distribution or population abundance in North Dakota. Earthworms were collected in one southwestern North Dakota survey (5), with three species identified (6): *Aporrectodea rosea* was found in a riverbottom floodplain under green ash (*Fraxinus pennsylvanica*) and boxelder (*Acer negundo*) forest, *Dendrobaena octaedra* was found in a green ash-birch (*Betula papyrifera*) forest in the Killdeer Mountains, and *Aporrectodea tuberculata* was found in deciduous forest, wooded draws, riverbottoms, shelterbelts and in an irrigated cultivated sugarbeet field. This survey was very limited and gave no indication of population distribution. Few earthworms were collected from grassland or cultivated fields.

Deibert is professor and Utter is research specialist, Department of Soil Science; Schwert is associate professor, Department of Geology.

PROCEDURE

Our study was conducted in 1990 at the North Central Research Center near Minot, where a long-term tillage trial has been in progress since 1978. Soil at the site is classified as a Williams loam (Typic Argiboroll). Organic matter in the surface 3-inches of this soil ranges from 3.8 to 4.0 percent, total N ranged from 0.186 to 0.202 percent and pH ranges from 6.2 to 6.8. Particle size analysis of this soil indicates 20 percent clay, 39 percent silt and 41 percent sand.

A cultivated and a grass site were sampled for determining earthworm population and species identification. The cultivated site was planted to continuous spring wheat (*Triticum aestivum*) and consisted of three tillage systems: [a] spring plow, [b] spring sweep and [c] no-till (3). The grass site is located just adjacent to the tillage site at the lower end of the landscape position. The grass site is predominantly smooth brome (*Bromus inermis*) that was either hayed or grazed by livestock.

Three random samples were collected on July 12 from each tillage system and the grass site. A metal 8-inch diameter by 6-inch deep metal sampling core was forced into the soil. The entire core with intact soil was extracted and transported to the lab, where the samples were stored in a walk-in cooler. Each sample was removed from cold storage and the soil hand sorted for collection of earthworms. Earthworm traits were noted before being killed with 70 percent ethanol and placed in a glass vial containing 10 percent formalin solution (7). Individual earthworms were removed from the formalin solution, measured for length, identified using a recently published key (7) and separated into adults and juveniles. Adults are sexually mature worms, whereas juveniles are those worms without well-developed clitellum and other sexually-mature characteristics. The entire soil sample was mechanically washed through a set of mesh or set of three sieves with small worms and cocoons collected on the middle sieve. Adult and juvenile earthworms from each site were removed from the formalin solution, placed on blotting paper until body surface was dry, and then weighed for the combined total wet biomass determination. Combined earthworm samples were also oven dried overnight to obtain total dry biomass.

RESULTS

Climatic conditions at sampling time were ideal for assessing earthworm populations, as soil moisture was adequate from the 4.13 inches of precipitation received during the previous two weeks. Maximum and minimum air temperatures were 85 degrees Fahrenheit and 52 F, respectively, on the day of sampling and averaged 86 F and 58 F during the previous week. Soil temperatures at the 4-inch depth in an adjacent area averaged 80 F under bare soil and 76 F under grass at sampling time with similar values during the week prior to sampling. The only species identified in either grass or cultivated area was *Aporrectodea tuberculata*. Juvenile, small and cocoons were assumed to be the same earthworm species.

The grass site contained the largest number of adult (230 per square yard) and juvenile (142 per square yard) earthworms (Table 1). It should be pointed out, however, that the earthworm population on the grass area may be higher than normal since samples were collected at a lower landscape position than the cultivated site; this would favor earthworm populations, especially in the dry climatic regions of central North Dakota.

No-till contained the highest number of adult and juvenile earthworms of the three continuous wheat sites, even though adult and juvenile numbers were respectively 38 percent and 63 percent lower than the grass site. The spring sweep, which consisted of shallow tillage with residue mixing in the surface 3 to 4 inches, had a higher number of adult earthworms (62 per square yard) than the spring plow (18 per square yard), which completely inverts or buries the crop residue. This difference suggests that a reduction in degree of tillage can indeed increase earthworm numbers. However, both cultivated plots (sweep and plow) had significantly lower adult worm numbers than the no-till or grass sites.

It is interesting to note that no juvenile earthworms, small earthworms, or cocoons were found on the sweep or plow sites. This suggests that the earthworm population either reached adult status at a quicker pace, which seems unlikely under climatic conditions at this location, or adults have moved into the cultivated areas after tillage was performed. The latter seems more likely, since the worms were longer, as least with the spring plow, and these larger adults are more likely to move from one area to another. A sequential sampling over the crop growing season should add some insight into this speculation. The larger number of cocoons in the no-till (higher than grass) indicates that this management practice provides a suitable environment for the reproductive process, which will eventually help rejuvenate the earthworm population to a level equal to that found in the uncultivated grass area.

The total earthworm biomass (wet or dry) values were low due to the small size worms collected at the sites. This low biomass is probably typical of dryland areas where the earthworm is subjected to frequent dry summertime periods forcing dormancy and thus limiting feeding activity and growth. Dry biomass on the grass site was less than 400 pounds per acre with progressively less biomass as the degree of tillage increased on the cultivated sites. The no-till site, although only 67 percent of the grass site, produced the highest earthworm biomass of the cultivated systems. The dry biomass on the sweep and plow were only 60 and 20 percent, respectively, of the no-till. The higher earthworm biomass with no-till is probably a result of the increased surface residue which reduces soil water loss by evaporation and thus lessening the chance for dry soil periods that limit earthworm activity.

Table 1. Length, population and total biomass of earthworm *(Aporrectodea tuberculata)* under grass and three cultivated tillage systems at Minot, N.D. (July 1990).

Variable Measured	Sampling Site[1]			
		Cultivated Tillage System		
	Grass	No-till	Spring Sweep	Spring Plow
Length (inches)				
Adult	2.4(.1)[2]	2.5(.2)	2.3(.4)	3.2(.7)
Juvenile	1.3(.2)	1.1(.1)	—	—
Population (no/yd²)[3]				
Adult	230(85)	142(31)	64(41)	18(15)
Juvenile	142(81)	53(27)	0	0
Small	27(27)	27(27)	0	0
Cocoon	80(80)	106(70)	0	0
Total	479(46)	328(134)	62(41)	18(15)
Total Biomass (lb/yd²)[3,4]				
Wet	0.26(.06)	0.16(.03)	0.07(.05)	0.03(.03)
Dry	0.08(.02)	0.05(.01)	0.03(.02)	0.01(.01)

[1] Sampling sites include grass that is predominantly brome grass and three cultivated tillage systems planted to continuous spring wheat which includes no-till planting or primary tillage with a sweep or plow implement prior to planting.

[2] Values in parenthesis are standard deviations.

[3] Values multiplied by 4840 will give units per acre.

[4] Includes only combined weight of adult + juvenile. Wet is air dry after removed from formalin preservation and dry is after subjected to oven heat at 221° F.

SUMMARY

Although these data are limited, the grassland and cultivated sites in this Northern Plains dryland area of North Dakota appear to be inhabited mainly by the earthworm species *Aporrectodea tuberculata*. Cultivated sites tend to have lower population numbers and biomass than the grassland sites. Decreasing tillage over long periods of time with practices like no-till can increase earthworm populations that approach grassland areas. The increased earthworm activity can only have a positive effect on the ideal chemical and physical properties of the soil normally associated with grassland areas.

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