Impact of Tubificid Worm on Nutrient Dynamics in Paddy Field

著者	ITO Toyoaki, HARA Kota
journal or publication title	Journal of Integrated Field Science
volume	7
page range	47-50
year	2010-03
URL	http://hdl.handle.net/10097/48835

JIFS, 7 : 47 − 50 (2010) Symposium Paper

Impact of Tubificid Worm on Nutrient Dynamics in Paddy Field

Toyoaki ITO* **and Kota HARA**

Field Science Center, Graduate School of Agricultural Science, Tohoku University,
Naruko-Onsen, Osaki, Miyagi, 989-6711, Japan
***e-mail: toyoaki@bios.tohoku.ac.jp**

Keywords: Paddy soil, Overlying water, Nitrogen mineralization, Phosphorus release

Received 1 February 2010; accepted 1 February 2010

Abstract

The soil-water-tubificid microcosm experiments with various densities of tubificid worm (*Branchiura sowerbyi*) were conducted for examining quantitative impact of tubificid on nitrogen and phosphorus dynamics in paddy soil. Tubificid worm increased bioavailable nutrients (nitrogen and phosphorus) in submerged paddy soils and the release rates from soils onto overlying water in proportion to the densities. These effects are presumed to be caused by acceleration of soil organic matter decomposition and enhanced diffusion of the nutrients from soil onto the overlying water. Tubificid worms influenced nutrient dynamics and will impact ecosystem in paddy fields.

Introduction

Tubificid worms (aquatic oligochaete) are known to be one of the dominant zoobenthos in eutrophic lake and influence lake ecosystems through increasing nutrient release to water from the bottom sediments (Fukuhara and Sakamoto, 1987; Fukuhara and Yasuda, 1989; Risnoveanu et al., 2004). Tubificids exist widely in paddy fields as the dominant macroinvertebrate group and showed higher densities in the fields with greater contents of soil organic matter and soil moisture (Simpson et al., 1993). It is also known that tubificids exist at high density in the ricefield with organic farming, and phytoplankton and zooplankton in the overlying water increase in the paddy soil with high density of tubificids more than in that without tubificids (Kikuchi and Kurihara, 1982). The effects on the nutrient dynamics are recognized to be responsible for the bioturbation of tubificids. Tubificid worms are known to be conveyor belt type feeders (Rhoads, 1974). The worms construct burrows and feed on surface sediment or soil and excrete into the surface of the material-water interface. The bioturbation activity of tubificid enhances not only nitrogen and phosphorus dynamics in sediments or soils but also the release into the overlying water and influences the ecosystems of lakes and paddy fields. The effects of tubificid on the formation rates and release rates into surface water of ammonium nitrogen and labile inorganic phosphorus have been measured for lake sediments (Fukuhara and Sakamoto, 1987; Fukuhara and Yasuda, 1989; Risnoveanu et al., 2004). The effects of tubificid worms on formation and release rates of ammonium nitrogen and labile phosphorus in paddy soils have been determined by comparison between the laboratory experiment with and without tubificids (Kikuchi and Kurihara, 1982). However, the quantitative effects of tubificid worm on nutrient dynamics in paddy soils have not been evaluated yet.

In this study, we determined quantitatively the tubificid impact on nitrogen and phosphorus release in paddy soil and onto the overlying water using laboratory microcosm with various densities of tubificid (*Branchiura sowerbyi*).

Materials and methods

We measured the population density of tubificids in the winter-flooded and organically managed ricefield of Oosaki city, Miyagi, Japan.

The soil-water-tubificid microcosm experiments were conducted under continuous dark and dark/light (12/12 hours) conditions at 20 ˚C for 4 weeks using 300 mL glass vials with 7 cm depth of paddy soil and 5 cm depth of overlying water. The luminosity was set to 7,500 lux for the light period. The soil used was alluvial paddy soil, which was collected from plow layer of the winter-flooded and organically managed ricefield of Oosaki city. Air-dried soil samples (<2 mm) and deionized water were used in the experiment. The soil with dry weight of 170 g was packed to each vial. Tubificid worm (*Branchiura sowerbyi*), which was collected from the above-mentioned paddy field, was added to the vials at three levels (0, 110 and 220 mg/vial on the basis of wet weight) with three replications. Because some of tubificid worms died in some treatments with continuous dark condition, we treated all data obtained from nine vials as independent values with no replications.

Concentrations of exchangeable ammonium, available phosphorus and ferrous iron were measured in the submerged soil after 4 weeks. They were extracted with 2M KCl solution, Bray 2 solution (soil to solution ratio of 1:20) and acetate buffer solution (1M, pH2.8), respectively. The values increased from the initial state were calculated. The ammonium-nitrogen and dissolved inorganic phosphorus released onto overlying water from soils were estimated for three weeks. Ninety percent of overlying water was collected weekly and the concentrations of ammonium and dissolved inorganic phosphorus were measured.

Results and discussion

The major species of tubificids were *Limnodrilus socialis* and *Branchiura sowerbyi* in the ricefields surveyed. The population densities of tubificids were higher in the ricefields with organic farming than those of the control ricefields with application of agricultural chemicals (data were not shown).

Amounts of ammonium nitrogen and available phosphorus formed in the soils significantly increased with the increasing of tubificid densities under both of continuous dark and dark/light conditions (Figs. 1 and 2). Tubificid accelerated soil nitrogen mineralization with the rates of 2.3 and 1.4 µg N/mg animal wet weight/kg soil/day in the continuous dark and dark/light conditions, respectively. Also, tubificid increased soil available phosphorus contents with the rates of 11 and 7.2 µg P/mg animal wet weight/kg soil/day in the continuous dark and dark/light conditions, respectively. In comparison with the continuous dark treatment, formation rates of ammonium nitrogen and available phosphorus reduced in the dark/light treatment. Phytoplankton will grow better and release more oxygen in the overlying water for the dark/light treatment than the continuous dark treatment. The surface soil was more oxidized in the dark/light vials than the continuous dark vials. This is

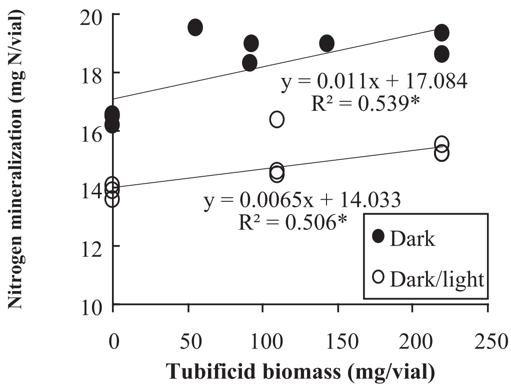

Fig. 1. Relationship between nitrogen mineralization in soil and tubificid biomass

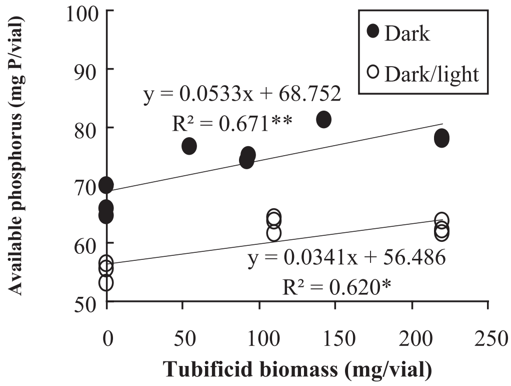

Fig. 2. Relationship between available phosphorus (Bray 2) content in soil and tubificid biomass

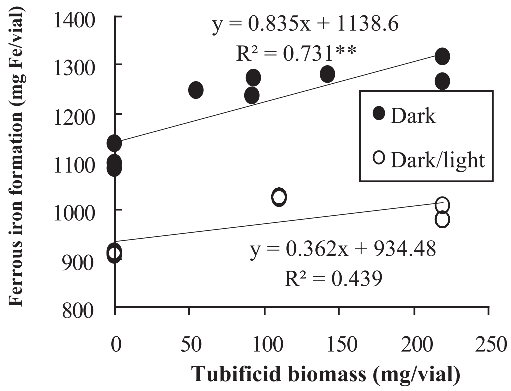

Fig. 3. Relationship between ferrous iron formation in soil and tubificid biomass

suggested by the lower values of ferrous iron contents in the dark/light treatment (Fig. 3). In such environment, ammonium will be easily transformed into nitrate and be lost through denitrification, and released inorganic phosphorus will be rapidly absorbed by ferric iron oxide precipitate produced by oxidation of ferrous iron in the upper layer soils. These processes will cause the lower values of ammonium nitrogen and available phosphorus for the dark/light treatment.

Figure 3 showed that ferrous iron contents formed in the submerged soils increased with the increment of tubificid biomass. This means that tubificid activity stimulated development of reduced condition in the soil through the acceleration of soil organic matter decomposition. From the results mentioned above, the increment of soil nitrogen mineralization and available phosphorus content is presumed to result from hastening decomposition of soil organic nitrogen and dissolution of phosphorus absorbed by ferric iron oxide with development of reduced condition.

Amounts of ammonium and dissolved inorganic phosphorus released from the soils onto the overlying water were significantly increased with the increasing of tubificid densities under continuous dark condition at the rates of 0.22μg N/mg animal wet weight/day and 0.0095μg P/mg animal wet weight/day, respectively (Figs. 4 and 5). The results of the present study agrees with the study conducted on lake sediments (Fukuhara and Sakamoto, 1987). Tubificid worms construct burrows, and feed on and excrete surface soil. Such a physical disturbance of soil by tubificid worm enhances soil-water interface area and accelerates nutrient diffusion from soil into overlying water. The enhanced release rates of inorganic nitrogen and phosphorus are inferred to lead to a multiplication of phytoplankton and other organisms in the overlying water.

On the other hand, no nitrogen and phosphorus releases were found in the dark/light condition. The reason for absence of nitrogen and phosphorus in the overlying water under the dark/light condition can be explained as follows. In the overlying water of the dark/light vials, phytoplankton uptakes inorganic nitrogen and phosphorus. In addition to phytoplankton uptake, ammonium is transformed into nitrate and is lost with denitrification, and released inorganic phosphorus is rapidly absorbed by ferric iron oxide precipitate produced with oxidation of soluble ferrous iron in the oxygen rich overlying water of the dark/light vials.

From the results of this study, it is concluded that bioavailable nutrients in submerged paddy soils increased in proportion to the densities of tubificid worm due to the acceleration of soil organic matter decomposition by tubificid activity, and tubificid enhanced the nutrients (N and P) release from soils onto

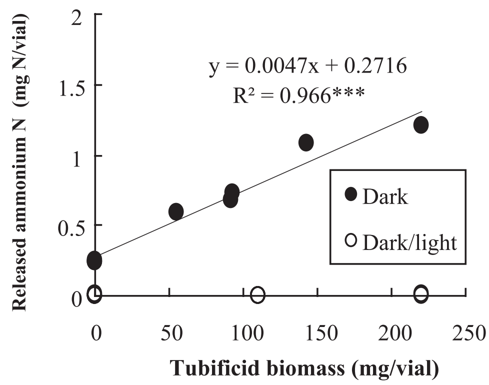

Fig. 4. Relationship between ammonium nitrogen release onto overlying water and tubificid biomass

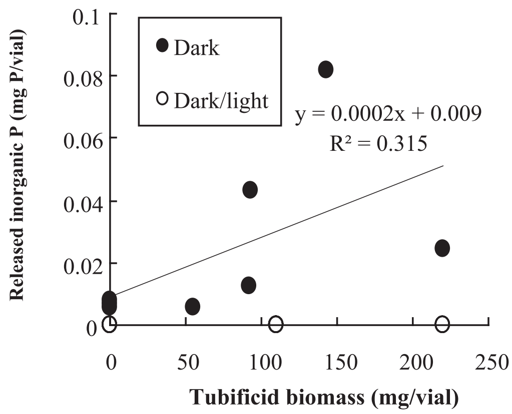

Fig. 5. Relationship between inorganic phosphorus release onto overlying water and tubificid biomass

overlying water in proportion to the animal densities. Tubificid worms influence nutrient dynamics and will impact ecosystem in paddy fields.

References

Fukuhara, H. and K. Yasuda (1989) Ammonium excretion by some freshwater zoobenthos from a eutrophic lake. Hydrobiologia, 173: 1-8.

Fukuhara, H. and M. Sakamoto (1987) Enhancement of inorganic nitrogen and phosphate release from lake sediment by tubificid worms and chironomoid larvae. OIKOS, 48: 312-320.

Risnoveanu, G., P. Carmen and V. Angheluta (2004) Ecological significance of nitrogen cycling by tubiicid communities in shallow eutrophic lakes of the Danube Delta. Hydrobiologia, 524: 193-202.

Simpson, I. C., P. A. Roger, R. Oficial and I. F. Grant

(1993) Density and composition of aquatic oligochaete populations in different farmers' ricefields. Biol. Fertil. Soils, 16: 34-40.

Kikuchi E. and Y. Kurihara (1982) The effects of the oligochaete *Branchiura sowerbyi* Beddard (Tubificidae) on the biological and chemical characteristics of overlying warer and soil in a submerged ricefield soil sustem. Hydrobiologia, 97: 203-208.

Rhoads, D. C. (1974) Organism-sediment relations on the muddy sea floor. Oceanogr. Mar. Biol. A Rev., 12: 263-300.