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КОНЦЕПТУАЛЬНЫЕ И ПРИКЛАДНЫЕ АСПЕКТЫ НАУЧНЫХ ИССЛЕДОВАНИЙ И ОБРАЗОВАНИЯ В ОБЛАСТИ ЗООЛОГИИ БЕСПОЗВОНОЧНЫХ

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SPRINGTAILS *PARISOTOMA NOTABIILIS* (COLLEMBOLA: ISOTOMIDAE) INDICATE FAVOURABLE CONDITIONS FOR *FUSARIUM* SPECIES IN ARABLE SOIL: AN EXPERIMENTAL STUDY IN A WINTER WHEAT FIELD

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Annotation. The effect of the addition of detrital subsidy on the winter wheat ecosystem was evaluated. Already during the first growing season after the addition, detrital subsidy led to an increase in yield by 17% and twofold population growth of soil saprophagous macrofauna. A significant correlation (r = 0.39) between abundance of Collembola species *P. notabilis* and *Fusarium* species in soil was revealed.

Keywords. Arable ecosystems; biological control; soil-borne pathogens; soil invertebrates; detrital food webs.

PARISOTOMA NOTABIILIS (COLLEMBOLA: ISOTOMIDAE) КАК ПОКАЗАТЕЛЬ БЛАГОПРИЯТНЫХ УСЛОВИЙ ДЛЯ ВИДОВ ФУЗАРИЯ В ДРЕВЕСНЫХ ПОЧВАХ: ЭКСПЕРИМЕНТАЛЬНОЕ ИССЛЕДОВАНИЕ НА ЗИМНЕМ ПОЛЕ ПШЕНИЦЫ

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Аннотация. В агроэкосистеме озимой пшеницы была произведена оценка влияния детритной субсидии на урожайность пшеницы и трофическую структуру сообщества почвенных беспозвоночных. Добавление детритной субсидии привело к увеличению урожайности пшеницы на 17% и двукратному росту численности почвенных сапрофагов. Выявлена достоверная ($r = 0.39$) корреляция между обилием коллембол *P. notabilis* и фузариевыми грибами.
Ключевые слова. Пахотные экосистемы; биологический контроль; почвенные патогены; почвенные беспозвоночные; детритные пищевые сети.

Introduction. The addition of organic residues to the surface or topsoil is a well-known agricultural practice that contributes to improving soil fertility. However, the exact mechanisms of the effect of detrital subsidy on the structure of food webs in arable ecosystems are poorly understood [1]. Soil invertebrates can serve as a model object for studying and assessing the effect of detrital subsidy on the trophic structure of the arable ecosystem. The activity of soil saprophages is limited by the availability of carbon [2], and biodiversity of soil fauna is significantly lower in agricultural ecosystems compared to natural ones [3]. The increased availability of carbon and nitrogen caused by the addition of a detrital subsidy can lead to increased activity of soil saprophages [4] and contribute to decrease of soil-borne pathogens including *Fusarium* species [5]. In this work, we tested the following hypothesis: adding of detrital subsidy leads to an increase in the both yield of winter wheat and population number of soil invertebrates as well as decrease of *Fusarium* species abundance.

Material and methods. The experiment was carried out on a winter wheat field located in the Kaluga region, Russia (54°29'N, 34°54'E, 220 m a.s.l.). Fifteen plots (5 × 5 m) arranged in three rows at a distance of 3 m from each other were assigned randomly to one of three treatments on April 16, 2019. The treatments were (1) control (no subsidy), (2) addition of a N-poor detrital subsidy, and (3) addition of a N-rich detrital subsidy. The detrital subsidy was added as a 3–5 cm thick mulch laid on the soil surface. The detrital subsidy consisted of shredded wheat straw (average length 7 cm) and cow-manure-based compost collected on the organic farm. The amount of added detrital subsidy was 200 g C m^{-2}. The N-poor detrital subsidy consisted of 430 g of straw (wet wt.) and 150 g of compost mixed and added per square meter of soil surface. The N-rich detrital subsidy was obtained by adding a mixture of 240 g of straw and 720 g of compost. Samples were taken at days 0, 21, 48 and 95 of the experiment. Soil arthropods were extracted from samples by Tullgren's funnels, counted, identified to the species or genus level and were assigned to key trophic groups. The soil sample weight was 350 g (wet wt.) for mesofauna count, and 1000 g for macrofauna count. The contents of the ITS ribosomal regions of *Fusarium* (i.e number of *Fusarium* gene copies) were quantified by real-time polymerase chain reaction in a Real-Time CFX96 Touch (Bio-Rad) amplifier using Tri5f/Tri5r primers [6]. Abundance values of both soil invertebrates and *Fusarium* species represent averaged estimates based on four samples collected during the experiment. Student's t-test and Pearson's correlation of log-transformed values were used for statistical processing of the results.

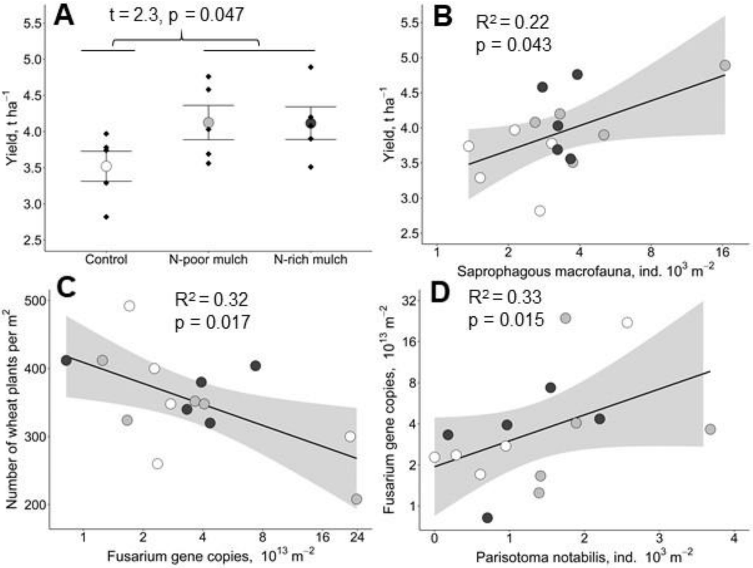

Figure 1. Wheat yield on experimental plots (A). Correlation plots: wheat yield vs. abundance of saprophagous macrofauna (B), number of *Fusarium* gene copies vs. number of wheat plants (C), number of *Fusarium* gene copies vs. abundance of *P. notabilis* (D).
Whiskers and shaded area represent standard error of mean

Results and discussion. The addition of both tested types of detrital subsidy led to the significant yield increase by 17% (Fig. 1A) and twofold population growth of saprophagous macrofauna. Abundance of *Fusarium* species was affected by adding of detrital subsidy. Abundance of saprophagous macrofauna (that was mainly represented by centipedes and insect larvae) had significant positive correlation ($r = 0.53$) with the winter wheat yield (Fig. 1B). Number of winter wheat shoots per square meter of the field was correlated negatively ($r = -0.60$) with gene copies number of *Fusarium* species (Fig. 1C). Herewith, gene copies number of *Fusarium* species had significant positive correlation ($r = 0.39$) with population size of *Parisotoma notabilis* springtails (Fig. 1D). Our observation confirms findings that *P. notabilis* are more closely associated with fungal resources rather than bacterial energy channel [7]. Pathogen-soil fauna interactions in arable ecosystems may be important for the development of ecological control methods for cereal diseases caused by pathogenic *Fusarium* species.

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