Tagungsbeitrag zu: Jahrestagung der DBG 2023, Titel der Tagung: „Böden – divers & multifunktional“
Veranstalter: Kommission III der DBG
vom 02. bis 08.09.2023 in Halle (Saale)
Berichte der DBG (nicht begutachtete online Publikation)
http://www.dbges.de

Earthworms in the soil under a beet-cereal rotation after 24 years of no plowing with and without green manure

J. Mangerich, P. Haßler, T. Appel *

Keywords: Earthworms, no plowing, green manure, long-term soil tillage experiment, beet-cereal rotation

Introduction

Annual plowing is helpful in controlling weeds, but it can also be detrimental to earthworms in the soil. This conclusion is mostly based on long-term experiments up to 15 years, and by a single observation (Ernst & Emmerich 2009, Pelosi et al. 2016, Bai et al. 2018, Dekamati et al. 2019, Torppa & Taylor 2022). On the other hand Pelosi et al. 2016 studied earthworm populations for several years over a 16-year period (1995 to 2011). They found that the effect of tillage wore off after only 6 to 8 years, and therefore felt that long-term experiments with longer time spans are essential to evaluate the effects of cropping systems on earthworm populations.

Technische Hochschule Bingen, Berlinstr. 109, 55411 Bingen - Prof. Dr. Thomas Appel, Tel.: 06721 409 174, Email: t.appel@th-bingen.de

In a now 24-year long-term trial in the drylands of southwest Germany, it was investigated how the intensity of tillage (plow 30 cm deep vs. goose share cultivator 15 cm deep) and the implementation of a green manure every 3rd year within the crop rotation (with vs. without) affects earthworm population. The following two questions were the main focus:
(1) Does the earthworm population suffer over time due to the low humus regeneration capacity of the beet-cereal crop rotation with straw removal and without organic fertilization?
(2) Can the negative effect of low humus-regeneration capacity be compensated by earthworm-promoting measures such as no plowing and green manuring?

Material and Methods

The long-term field experiment started in 1998. The experimental site in the southwest German dry region is diluvial high flood loam with sandy clay loam as soil texture. The average (2001 to 2022) annual rainfall was 488 mm, the average annual temperature was 11.2 °C with an average of 1934 hours of sunshine at the agricultural meteorological station Bingen-Gaulsheim. The humus content is on average 2% in the topsoil 0-30 cm. During the summer months, the soil dries out and then forms deep shrinkage cracks.
Eight plots (43 m x 24 m) were established respectively on three adjacent fields (South, Middle, North) as shown schematically in Fig. 1 with the crop rotation sugar beet - winter wheat - winter barley (staggered by one year in each case). The straw was removed in most years, and the beet leaf together with the top of the beets was always left on the field. Nutrients were supplied exclusively in the form of minerals (= low humus regeneration capacity). Four variants were proved: with and without crumb-deep plowing (plow vs. cultivator), in

each case with and without yellow mustard for green manuring before cropping the beets (with vs. without green manure). Yields on the trial plots are recorded every year (Appel 2022). In 2012, 2013 and 2014, as well as in 2021, 2022 and 2023, earthworms were counted in the soil at two positions per plot in the spring shortly before or after beet sowing, and their mass was determined, divided into endogeic and anecic species. From the topsoil, the earthworms were picked out by hand. From the subsoil, the anecic earthworms (deep burrowers) were expelled with allyl isothiocyanate.

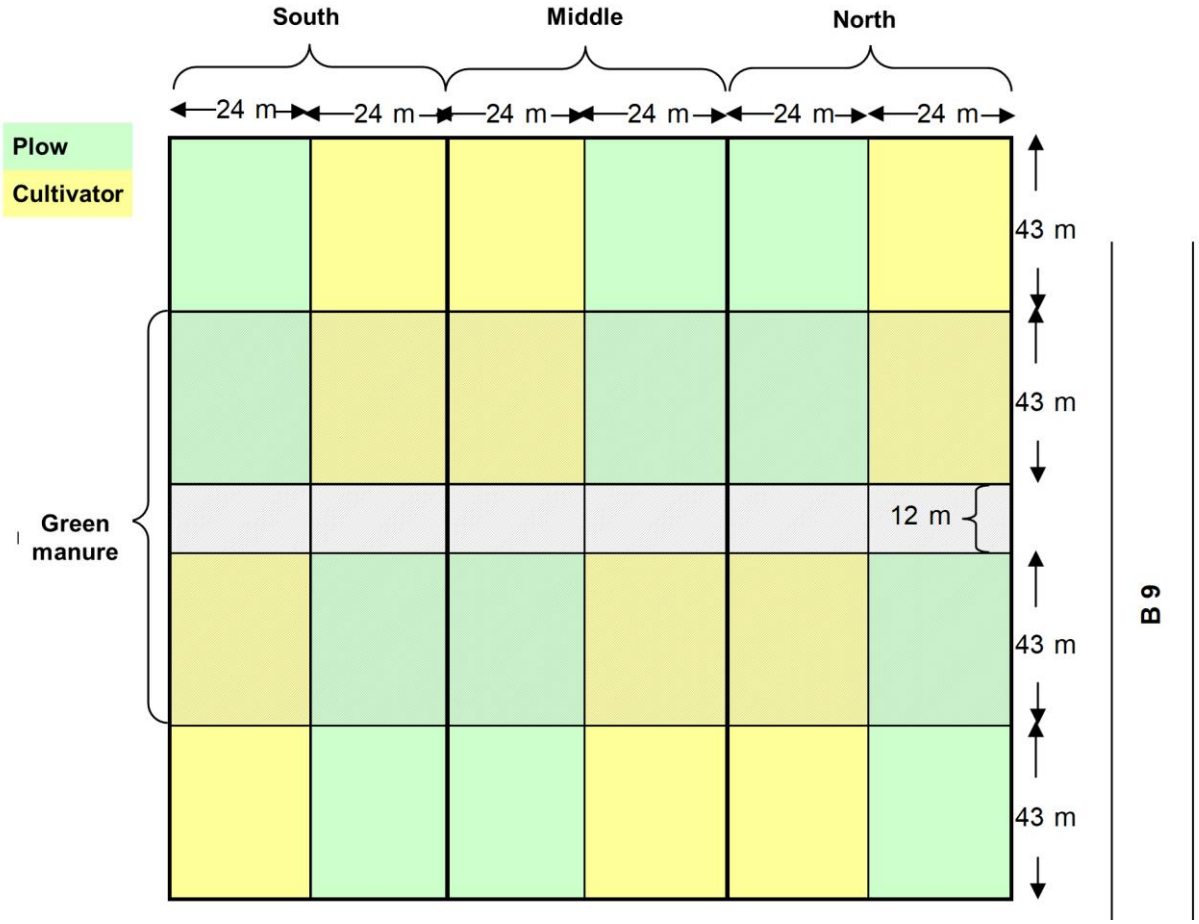

Fig. 1: Long-term field experiment schematically

Results

With one exception, earthworm biomass was always lower in the plowed soil than in the corresponding cultivator variant (Fig. 2). The exception was cultivation with green manure: On average from 2021 to 2023, earthworm biomass here was higher in the plowed variant than in the cultivator variant. No plowing did not significantly affect the anecic earthworms. For endogeic earthworms, plowing - especially in combination with green manure - was even rather positive (not significant, $p = 0.19$). In the 2nd measurement campaign, the mass of earthworms was on average ca. 62% higher in plots with green manure than in plots without for both anecic ($p = 0.029$) and endogeic ($p = 0.021$). In the 9 years from the first to the second campaign, earthworm biomass decreased by about 30 % (mean across all variants). This decrease was mainly due to the decrease of anecic earthworms but starting from a very high initial level in the variants with green manure in the first campaign.

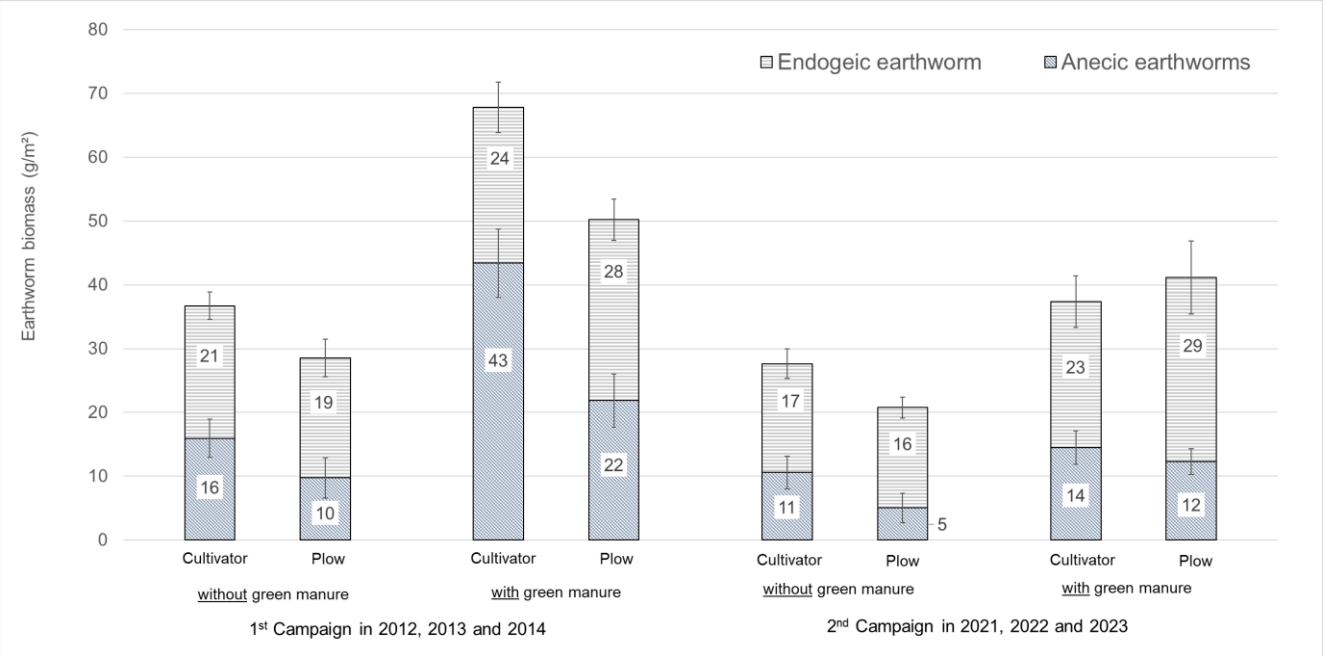

Fig. 2: Earthworm biomass in 2012 to 2014 and 2021 to 2023 as a function of long-term management: plow vs. cultivator, with and without green manure before beets; error bars denote standard error between n = 6 plot means

Discussion

Changing site factors, weather and management are possible causes for the decline of earthworms. As site factors and management have not changed in the last 24 years, a look at weather conditions is needed (agrarmeterological station Bingen-Gaulsheim): During the last period of the long-term trail from the year 2015 to 2022, the average annual temperature was 0.8 °C higher than during the period before in the years 2008 to 2014. The number of sunshine hours increased from Ø 1656 h per year in the years 2008 to 2014 to Ø 2107 h per year in the following period from 2015 to 2022, with a decrease in the average annual precipitation of -101 mm. Hence, the weather during and just few years before the first measurement campaign was more temperate and humid compared to the weather during the last 8 years.

The obvious differences in weather conditions, respectively during and before the first (rather wet) and the second (warm and dry) measurement campaign may explain the decline of the earthworm population despite the earthworm-promoting measures, especially for the deep-digging anecic species. A decrease in anecic earthworms caused by hot weather over several years was also assumed by Ehrmann 2012 and Walter & Burmeister 2022.

Conclusion

Earthworms benefited more from green manuring than from reduced tillage, as the effect of reduced tillage on anecic earthworms seems to be overridden by the extreme weather conditions of recent years. A positive effect on earthworm-biomass is emerging from the interaction of plowing and green manuring (mainly endogeic earthworms). For regenerative agriculture, this means that attention should be focused much more on intercropping than on tillage intensity. However, green manuring was not necessary for maintaining soil fertility (as measured by yields, Appel 2022) at this site in the northwest German dry region.

Literatur

APPEL, T., 2022: Validierung der VDLUFA-Humusbilanz für eine Rüben-Getreide-Fruchtfolge anhand eines Dauerversuchs im südwestdeutschen Trockengebiet. VDLUFA-Schriftenreihe Bd. 78, 176-185, Kongressband 2023 Halle, VDLUFA-Verlag, Darmstadt

BAI, Z., CASPARI, TH., GONZALEZ, M. R., BATJES, N. H., MÄDER, P., BÜNEMANN, E. K., DE GOEDE, R., BRUSSAARD, L., XU, M., FERREIRA, C. S. S., REINTAM, E., FAN, H., MIH LIČ, R., GLAVAN, M, TÓTH, Z., 2018: Effects of agricultural management practices on soil quality: A review of long-term experiments for Europe and China. Agriculture, Ecosystems & Environment 265: 1-7 https://doi.org/10.1016/j.agee.2018.05.028

DEKEMATI, I., SIMON, B., VINOGRADOV, S., BIRKÁS M., 2019: The effects of various tillage treatments on soil physical properties, earthworm abundance and crop yield in Hungary. Soil and Tillage Research 194: 104334 https://doi.org/10.1016/j.still.2019.104334

EHRMANN, O., 2012. Auswirkungen des Klimawandels auf die Regenwürmer Baden-Württembergs. - Hrsg. LUBW. 64 S. (aufgerufen am 26.01.2015). https://pudi.lubw.de/detailseite/-/publication/43264-Literaturstudie_zur_Bedeutung_von_Regenw%C3%BCrmern_und_den_m%C3%B6glichen_Auswirkungen_des_Klimawandels_auf_A.pdf

ERNST, G. UND EMMERLING, C., 2009: Impact of five different tillage systems on soil organic carbon content and the density, biomass, and community composition of earthworms after a ten year period, European Journal of Soil Biology 45, 247-251

PELOSI, C., PEY, B., CARO, G., CLUZEAU, D., PEIGNÉ, J., BERTRAND, M., HEDDE, M., 2016: Dynamics of earthworm taxonomic and functional diversity in ploughed and no-tilled cropping systems. Soil and Tillage Research 156: 25-32 https://doi.org/10.1016/j.still.2015.07.016

TORPPA, K. A. & TAYLOR, A. R., 2022: Alternative combinations of tillage practices and crop rotations can foster earthworm density and bioturbation. Applied Soil Ecology 175: 104460. https://doi.org/10.1016/j.apsoil.2022.104460

WALTER, R. & BURMEISTER, J., 2022: 35 Jahre Bodendauerbeobachtung landwirtschaftlich genutzter Flächen in Bayern. Band 5: Regenwürmer. LfL-Schriftenreihe 2/2022. Bayerische Landesanstalt für Landwirtschaft – LfL (Hrsg.). 83 S. URL: https://www.lfl.bayern.de/mam/cms07/publikationen/daten/schriftenreihe/35-jahre-bdf-landwirtschaft-regenwuermer-lfl-schriftenreihe.pdf