Climate change mitigation potential of trees in shelter belts of drainage ditches in cropland and grassland

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Technical report

Report on soil GHG fluxes and carbon turnover in the shelter belts[1]

Salaspils, 2023

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1 *V01 – after acceptance or improvements suggested by by ERDF experts will be published online with ISSN number, first published online 2023-11-29 on https://www.silava.lv/en/research/active-projects/climate-change-mitigation-potential-of-trees-in-shelter-belts-of-drainage-ditches-in-cropland-and-grassland*

Measurement if soil GHG fluxes and carbon turnover in the shelter belts

GHG flux measurements were done once per month during the 2022-2023 except frost period of winter (from March to December, randomly between 9:30 and 16:00) in 3 replicates in each ditch (distance between replicates was 10-25 m). To measure GHG fluxes we used a closed-type GHG flux measurement chamber which perpendicular to the longitudinal axis of the drainage ditch covers its entire surface providing GHG flux measurements from full cross-sectional area including ditch bed or water surface and slopes (ditch sides). Cross-sectional area of ditches ranged from 0.7 m^2 to 1.3 m^2. The cover frame is made from metal constructions to which a durable, opaque plastic film is attached; the outer side is white and the inner side is black to reflect sunlight and minimize internal temperature fluctuations in the chamber. The metal construction covers the surface of the drainage ditch, while the plastic film is pressed to the ditch profile using a stainless steel chain placed along the perimeter of the gas exchange chamber. The chamber can be used for GHG flux measurements from drainage ditches with different depths, widths, profiles and water levels, as its length and height can be changed ensuring the possibility of performing measurements in different environmental conditions. During the measurements, selected width (50 cm constantly), height and length of the chamber were fixed. Inside the GHG flux measurement chamber there was a small ventilator installed to ensure that air inside the chamber is continuously mixed. Portable Fourier Transform Infrared (FTIR) spectroscopy (Gasmet DX4040 gas analyzer) was used to measure GHG fluxes. GHG flux measurements – changes of average content of CO_2, CH_4 and N_2O in atmosphere enclosed in the chamber within 2 min time intervals for 30 min period (respectively, every measurement period were characterized by 15 individual measurements per chamber) – were recorded using software “Calcmet Lite v2.0”.

At each GHG measurement event, environmental variables such as GW level (three GW wells were established in each research site next to the ditch; positive values mean that the water level is below the soil surface, negative – the water level is above the soil surface (the area is flooded)), soil and air temperature using Comet Data Logger sensors, atmospheric pressure using Gasmet DX4040, water level in drainage ditches (zero means the ditch is dry) were measured, as well as cloudiness, windiness and atypical environmental conditions were fixed. Water level in the ditch later was not used in the evaluation since all ditches were dry during most of the time

Data are prepared for publishing; however, due to short period of time after completion of the measurements, data are not yet published. Environmental variables (X) such as temperature, water level in ditches, GW level and general chemistry will be used to explain the variance of instantaneous GHG emissions (Y) from drainage ditches in partial least squares (PLS) regression – a multivariate method for dealing with variables which are linearly related to each other, as this method is robust against intercorrelations among X-variables. In PLS, X variables will be ranked according to their relevance in explaining Y, commonly expressed as variables important for projection (VIP values). Only X variables with VIP values exceeding 0.5 will be used in PLS regression, and VIP values exceeding 1.0 will be considered as important X variables (Eriksson et al., 1999; Wold et al., 2001; Kucheryavskiy, 2020).

Measurements were done in four 4 sites distributed in central and easter part of the country (Table 1). Two sites in cropland with organic soil (peat layer depth in average in the sampling area – 25 cm (from 15 to 45 cm), where soil scarification takes place nearly to the side of ditches. Three sampling plots (A, B and C) were established across the ditch in approximately 20 m distance each from other. Shelters belt plots were established in cropland with natural woody and grass vegetation forming at least 5 m wide area between ditch and ploughed area. For gas sampling we selected points with predominant woody vegetation on both sides of ditches. Other side of ditch in both cases was maintained as grassland; however, no management activities were observed during recent years. In all cases ditches were well maintained and did not suffered from overfloating.

Table 1. Measurement plots in drainage ditches in organic soils

Object	Experiment	Management	Coordinates, LKS92[2]	
			X	Y
C1	GHG emissions from drainage ditches	Shelter belt	307542	474539
C2	GHG emissions from drainage ditches	Shelter belt	307542	474539
G1	GHG emissions from drainage ditches	Cropland without shelter belt	269512	428618
G2	GHG emissions from drainage ditches	Cropland without shelter belt	233221	325716

Measurements continued for 18 months including 2 vegetation seasons. Average monthly CO_2 fluxes due to soil heteretrophic respiration (subplots without vegetation in ditches) are shown in Figure 1. Significantly bigger CO_2 fluxes are observed in area without shelter belts during summer months.

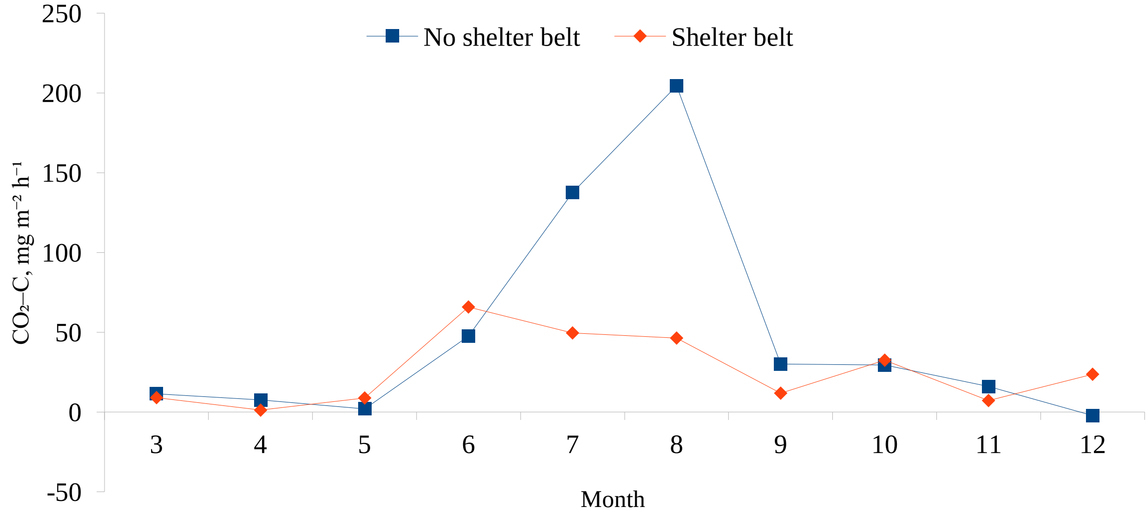

Figure 1. Heterotrophic respiration (CO_2–C, mg m^{-2} h^{-1}) from drainage ditches in organic soils.

Methane (CH_4) fluxes were negative during the most of the year in area without shelter belts and increased only in early spring and middle of summer. In areas with shelter belts CH_4 emissions were positive during the most of the year; however, they were negligible (Figure 2). CH_4 emissions from ditches in shelter belts increased during summer months.

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[2] Coordinates of "A" plot. "B" and "C" is located

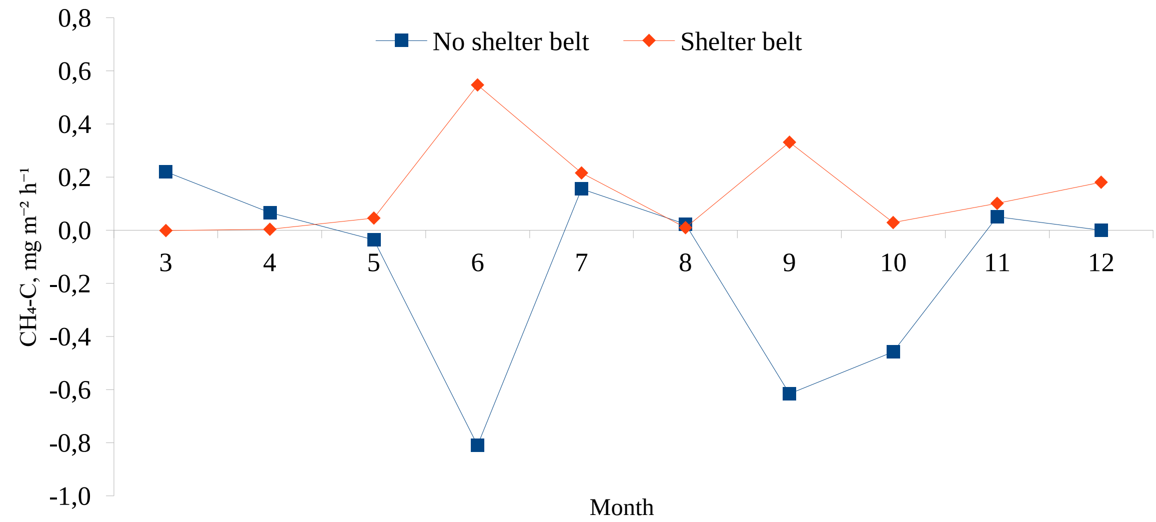

Figure 2. CH_4-C, mg m^{-2} h^{-1} emissions from drainage ditches in organic soils.

Nitrous oxide (N_2O) emissions were negligible during the most of the year in all measurement points; however, during autumn months they increased in ditches surrounded by shelter belts and in ditches neighbouring with ploughed area (Figure 3). This may be associated with soilscvarification in autumn.

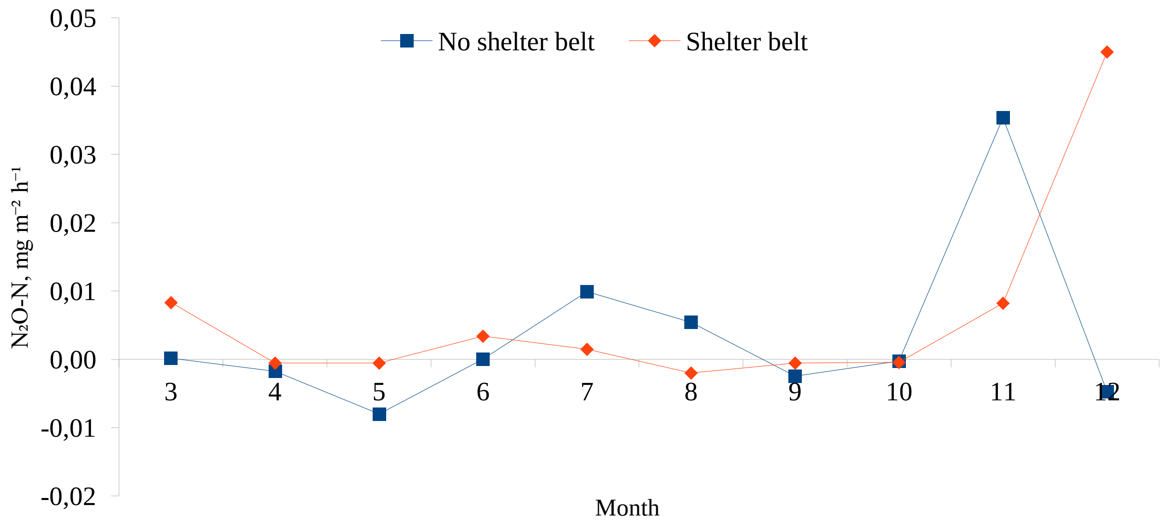

Figure 3. N_2O-N, mg m^{-2} h^{-1} emissions from drainage ditches in organic soils.

Average GHG emissions by gas recalculated to montly values per ha and total annual fluxes including standard error of mean are provided in Table 2. CO_2 emissions in area with shelter belts are nearly twice smaller than in area surrounded by ploughed fields. CH_4 emissions are opposite – area without shelter belts is sunk of CH_4 and area with shelter belts is source of CH_4, however, the rate of the emissions is relatively small (within a range of the emissions factors applied in cropland and grassland in the National GHG inventory. The emissions on N_2O are negligible in all measurement points.

Total GHG emissions in area without shelter belts is 12.883 ± 3.667 tons CO_2 eq. ha^{-1}, and in areas with shelter belts – 7.433 ± 1.119 tons CO_2 eq. ha^{-1}. The difference is statistically significant; however, the difference may be also associated with land use history in the experimental fields. Long term measurements are necessary to evaluate effect of the shelter belts on the GHG emissions from drainage ditches, as well as from surrounding areas.

Table 2. Average monthly and yearly emissions

Parameter	Month										Total
	3	4	5	6	7	8	9	10	11	12	
CO_2–C, tons ha^{-1} yr^{-1}											
No shelter belt	0.084	0.054	0.014	0.342	1.024	1.521	0.217	0.219	0.116	-0.017	3.574
Shelter belt	0.067	0.009	0.066	0.474	0.368	0.344	0.085	0.242	0.052	0.176	1.882
CH_4-C, kg ha^{-1} yr^{-1}											
No shelter belt	1.639	0.478	-0.266	-5.831	1.155	0.169	-4.430	-3.402	0.362	0.000	-10.125
Shelter belt	-0.009	0.031	0.339	3.937	1.602	0.068	2.383	0.211	0.732	1.343	10.638
N_2O-N, kg ha^{-1} yr^{-1}											
No shelter belt	0.001	-0.013	-0.060	0.000	0.074	0.040	-0.018	-0.002	0.255	-0.035	0.243
Shelter belt	0.062	-0.004	-0.004	0.024	0.011	-0.015	-0.004	-0.003	0.059	0.335	0.462
Standard error of mean, CO_2–C, tons ha^{-1} yr^{-1}											
No shelter belt	0.037	0.017	0.086	0.037	0.589	0.158	0.111	0.061	0.048	0.019	0.848
Shelter belt	0.036	0.003	0.016	0.080	0.069	0.102	0.026	0.042	0.013	0.067	0.249
Standard error of mean, CH_4-C, kg ha^{-1} yr^{-1}											
No shelter belt	1.231	0.236	0.249	7.249	1.852	0.170	7.165	2.432	0.198	0.023	14.534
Shelter belt	0.033	0.038	0.205	2.351	1.184	0.036	1.586	0.060	0.311	0.811	3.575
Standard error of mean, N_2O-N, kg ha^{-1} yr^{-1}											
No shelter belt	0.016	0.003	0.118	0.016	0.087	0.016	0.016	0.004	0.139	0.035	0.221
Shelter belt	0.035	0.005	0.005	0.025	0.031	0.014	0.003	0.002	0.029	0.172	0.225
CO_2 eq, tons ha^{-1} yr^{-1}											
No shelter belt	0.363	0.210	0.018	1.066	3.820	5.599	0.647	0.694	0.542	-0.076	12.883
Shelter belt	0.271	0.032	0.250	1.873	1.406	1.258	0.385	0.893	0.238	0.826	7.433
Standard error of mean, CO_2 eq, tons ha^{-1} yr^{-1}											
No shelter belt	0.183	0.070	0.371	0.373	2.257	0.591	0.642	0.302	0.239	0.084	3.667
Shelter belt	0.149	0.015	0.068	0.379	0.304	0.380	0.146	0.156	0.071	0.342	1.119

We evaluated different environmental variables; however, we found that only air temperature demonstrates relatively good correlation with heterotrophic respiration (Figure 4). Drainage ditches with shelter belts were less sensitive to increase of air temperature; however, this may be associated with land use history and growth condition differences.

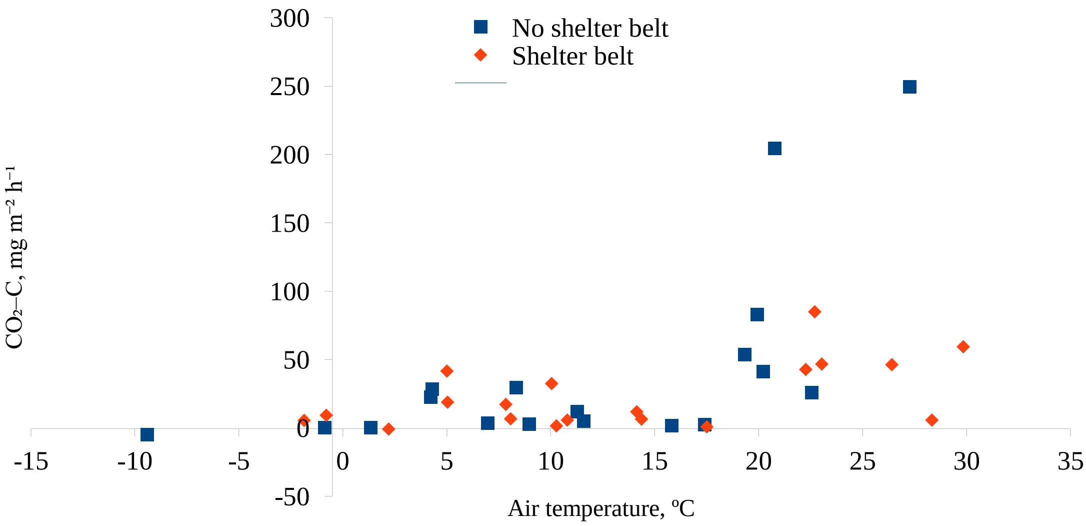

Figure 4. Relationship between air temperature and heterotrophic respiration (CO_2–C, mg m^{-2} h^{-1}) from drainage ditches in organic soils.

N_2O and CH_4 emissions do not demonstrates significant correlation with temperature (Figure 5 and 6), as well as other environmental variables; however, there is a trend that the emissions of these gases increases in spring and are associated with increase of groundwater level, while fluctuations of groundwater level in summer is not affecting the emissions significantly.

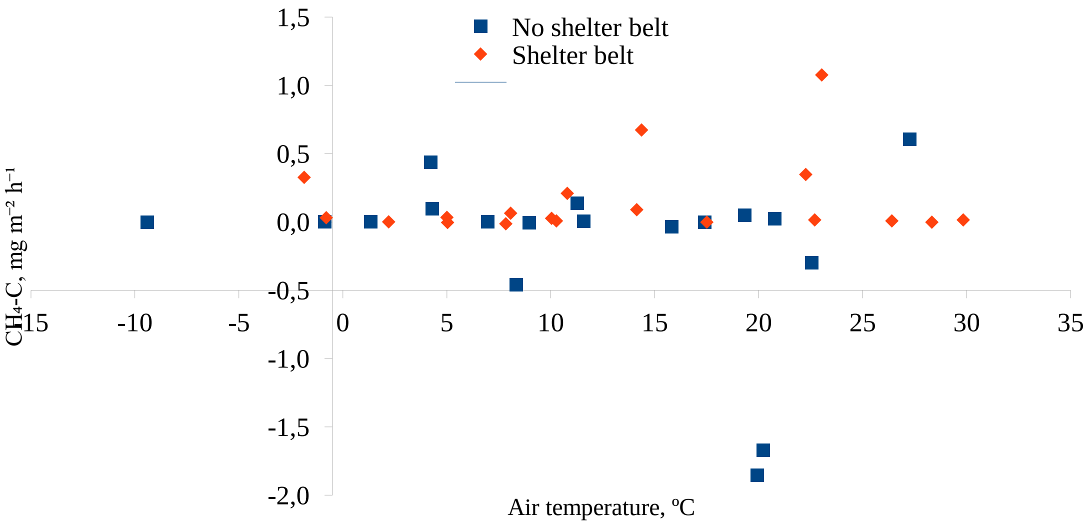

Figure 5. Relationship between air temperature and CH_4-C, mg m^{-2} h^{-1} emissions from drainage ditches in organic soils.

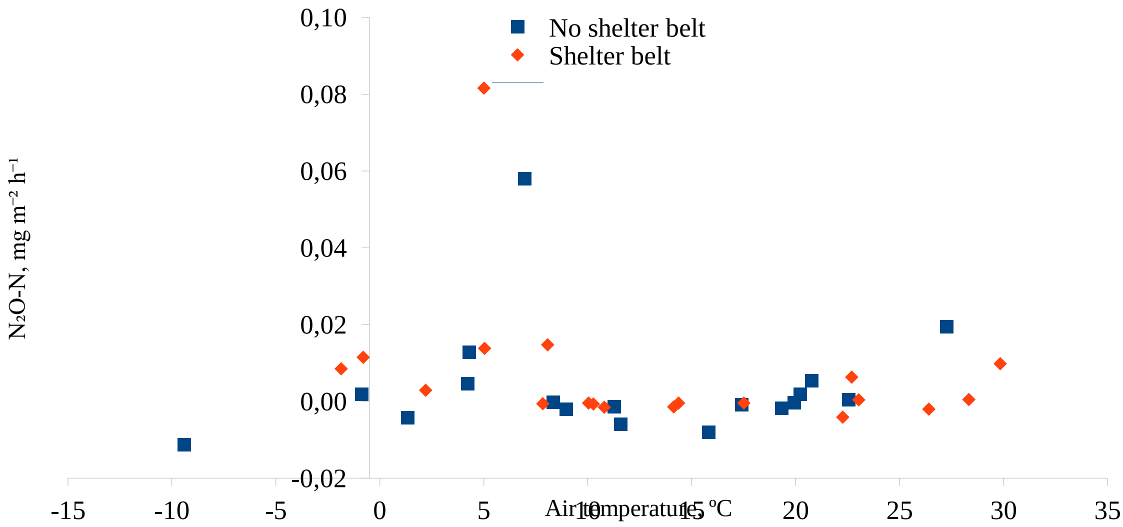

Figure 6. Relationship between air temperature and CH_4-C, mg m^{-2} h^{-1} emissions from drainage ditches in organic soils.

References

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