**Table S1.** Soil types and physicochemical properties stratified by horizon. \*WRB - World Reference Base for Soil Resources.



**Table S2.** Simulation results of various soil water content scenarios across different soil erosion gradients. Estimation of the root carbon each cultivar was unable to input into the soil due to reduced soil water availability over the past five years.

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|  | Soil water [cm3 cm-3] | RG-ca | Lv-ng | Lv-cc | Rg-co.gl |
|  | Root biomass [g m-2] | | | |
| Ostpreußischer | 18.5 | 208 | 354 | 345 | 279 |
| 21.5 | 171 | 357 | 345 | 273 |
| 24.3 | 202 | 363 | 350 | 284 |
| 27 | 213 | 363 | 362 | 297 |
| 30 | 219 | 366 | 366 | 306 |
| slope linear regression | | 2.2 | 1.1 | 2.1 | 2.7 |
| Hadmerslebener | 18.5 | 185 | 289 | 330 | 215 |
| 21.5 | 181 | 291 | 334 | 211 |
| 24.3 | 210 | 292 | 340 | 229 |
| 27 | 252 | 362 | 419 | 293 |
| 30 | 266 | 381 | 418 | 311 |
| slope linear regression | | 8.3 | 8.9 | 9.1 | 9.6 |
| Ponticus | 18.5 | 182 | 320 | 315 | 223 |
| 21.5 | 168 | 322 | 317 | 219 |
| 24.3 | 198 | 321 | 319 | 226 |
| 27 | 220 | 340 | 350 | 259 |
| 30 | 229 | 346 | 352 | 274 |
| slope linear regression | | 5.1 | 2.4 | 3.8 | 5 |
|  |  | kg C ha-1 | | | |
| Ostpreußischer |  | 9.41 | 4.70 | 8.98 | 11.54 |
| Hadmerslebener |  | 35.48 | 38.05 | 38.90 | 41.04 |
| Ponticus |  | 21.80 | 10.26 | 16.25 | 21.38 |

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Figure S1. Field data. a) Historical data from Lysimeter. b) Precipitation and air temperature from September 2022 to October 2023.

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Figure S2: Crop season root biomass (g m-2) evolution for the three wheat cultivars (Ostpreußischer, Hadmerslebener, and Ponticus) under different soil erosion-deposition gradient: Calacric Regosol (RG-ca), Nudiargic Luvisol (LV-ng), Calcic Luvisol (LV-cc) and Gleyic-Colluvic Regosol (RG-co.gl).

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Figure S3. Root biomass rate (g m-2 day-1) and standard error for the entire crop season for the three wheat cultivars (Ostpreußischer, Hadmerslebener, and Ponticus) under different soil erosional status: Calacric Regosol (RG-ca), Nudiargic Luvisol (LV-ng), Calcic Luvisol (LV-cc) and Gleyic-Colluvic Regosol (RG-co.gl).

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Figure S4. Number of root branches (-), root depth (mm) and root diameter (mm) evolution for the three wheat cultivars (Ostpreußischer, Hadmerslebener, and Ponticus) under different soil erosional status: Calacric Regosol (RG-ca), Nudiargic Luvisol (LV-ng), Calcic Luvisol (LV-cc) and Gleyic-Colluvic Regosol (RG-co.gl). The letters above the boxplots indicate significant differences in grain yield between treatments (p < 0.05), based on post-hoc tests.

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Figure S5. Shoot biomass (g m-2) of three wheat cultivars (Ostpreußischer, Hadmerslebener, and Ponticus) under different soil erosional status: Calacric Regosol (RG-ca), Nudiargic Luvisol (LV-ng), Calcic Luvisol (LV-cc) and Gleyic-Colluvic Regosol (RG-co.gl). The letters above the boxplots indicate significant differences in grain yield between treatments (p < 0.05), based on post-hoc tests.

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Figure S6. Harvest index (-) of three wheat cultivars (Ostpreußischer, Hadmerslebener, and Ponticus) under different soil erosional status: Calacric Regosol (RG-ca), Nudiargic Luvisol (LV-ng), Calcic Luvisol (LV-cc) and Gleyic-Colluvic Regosol (RG-co.gl). The letters above the boxplots indicate significant differences in grain yield between treatments (p < 0.05), based on post-hoc tests.

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Figure S7: Root-shoot ratio (-) of three wheat cultivars (Ostpreußischer, Hadmerslebener, and Ponticus) under different soil erosion-deposition gradient: Calacric Regosol (RG-ca), Nudiargic Luvisol (LV-ng), Calcic Luvisol (LV-cc) and Gleyic-Colluvic Regosol (RG-co.gl). The letters above the boxplots indicate significant differences in grain yield between treatments (p < 0.05), based on post-hoc tests.

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Figure S8. Metrics of supervised machine learning random forest (RF) meta-estimator (mean absolute percentage error (MAPE)).