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Data Article

Data from extensive monitoring of agricultural practices, soil health, and wheat grain production in 44 farms in Northwestern France from 2021 to 2023

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ABSTRACT

This article presents data measured in 44 farms covering a range of cropping practices, soil, and production parameters under contrasted types of crop management: conventional and conservation agriculture. Eighty-six winter wheat fields in Northwestern France were monitored for two growing seasons (2021–2023). The dataset encompasses data about cropping practices (tillage, soil cover, rotation, pesticide use, nutrition), soils (chemical, biological, and physical parameters, including texture), and grain production (nutritional, technological, and sanitary indicators). This article provides a detailed methodology of one of the first applications of a systemic on-farm study of the food production system, aiming to adopt a "One Health" perspective of the crop production system. *The data presented here can be accessed* at https://doi.org/10.18167/DVN1/SI026U.

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Specifications Table

Subject	*Agronomy and Crop Science, Food Science, Soil Science*
Specific subject area	*Systemic on-farm assessment of the cropping practices-soil-grain production nexus on 86 plots (44 farms) grown with winter wheat in conservation agriculture and conventional agriculture in Northwestern France in 2021–2022 and 2022–2023 cropping seasons.*
Type of data	2 Dataset Tables (.csv format) Metadata table (.csv format) Supporting materials (.docx format) (text version of farmers survey)
Data collection	Data on cropping practices were collected through surveys and one-on-one interviews with farmers. Data on soil and grain production were measured on-field or in certified laboratories using diverse methodologies, such as mass spectroscopy or chromatography.
Data source location	Northwestern France on an area of 155 km per 208 km on an axis going from the cities of La Rochelle to Poitiers (East-West) and Tours to Angoulême (North-South). Data is stored in France at the Toulouse National Public School of Agronomy (INP-ENSAT Toulouse).
Data accessibility	Repository name: CIRAD Dataverse Direct URL to data: https://doi.org/10.18167/DVN1/SI026U
Related research article	None

1. Value of the Data

- This dataset provides an unprecedented broad range of cropping practices, soil, and production parameters corresponding to a systemic vision of the cropping system. It was collected using a rigorous approach, enabling a reliable analysis of on-farm data.
- The information in this dataset can be used to further analyze the specific effects of cropping systems on specific soil or production parameters under real conditions.
- It can also be reused for meta-analysis of the effects of conservation as well as conventional agriculture systems on soil health or food quality, information that is mostly lacking in the literature.

2. Background

This data results from a two-year on-farm monitoring of 44 conservation agriculture (CA) and conventional (CONV) farms in Northwestern France (2021–2023). Our objective was to operationalise a One Health approach adapted to cropping practices, following the framework for One Health research adapted to cropping practices. To our knowledge, it is the first on-farm study proposing hard data on different compartments of the food production system, from practices to production. The data was collected on a farm and field scale. Data collection and analysis were organised through multi-stakeholder collaborations.

3. Data Description

This article describes an extensive dataset of cropping practices, soil, plant and grain data collected on 44 farms between 2021 and 2023. On each farm, two fields were monitored, *i.e.* one in the growing campaign 2021–2022 and one in the growing campaign 2022–2023 (except for 6 farmers who provided the same field for two consecutive years and two other farmers who left the study in the second year). Growing campaigns 2021–2022 and 2022–2023 are written as "Year 1″ and "Year 2," respectively, in the rest of the text to facilitate reading. In total, 86 winter wheat fields were monitored for one campaign over two consecutive years in Northwestern France (Fig. 1). The 86 monitored fields included 43 fields conducted in CA and 43 fields conducted in CONV.

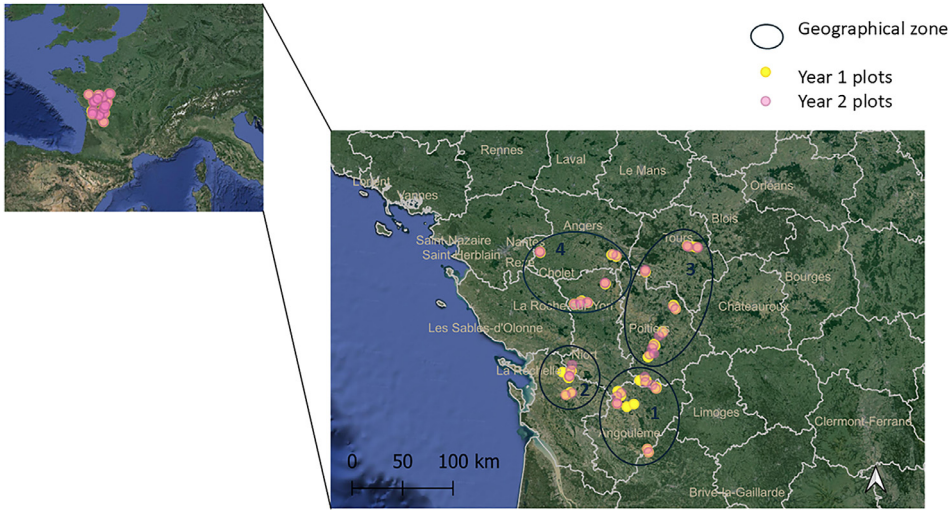


Fig. 1. Location of study plots in the 2021–2022 campaign (Year 1, yellow) and 2022–2023 campaign (Year 2, pink). Farmers taking part in the study were the same between study Years 1 and 2 (except for two farmers who withdrew from the study in Year 2). The study was carried out on winter wheat crops. Therefore, most farmers proposed two different plots between Years 1 and 2, since most of them did not grow wheat on the same plot in two consecutive years. However, six farmers who proposed the same plots in the two successive years, therefore grew wheat for two successive years. Grey lines correspond to the limits of the French administrative departments. To facilitate the analyses, study plots were clustered in four zones according to their geographic and pedoclimatic positions: Zone 1 = plots from Charente and south Vienne, Zone 2 = North Charente-Maritime, and south of Deux-Sèvres, Zone 3 = Indre-et-Loire and north and middle Vienne, Zone 4 = West of Deux-Sèvres and Maine-et-Loire.

The dataset is made of one .xlsx file (*data_field.xlsx*) containing all the measured and computed variables separated into the different related compartments of the food system (column *"Compartment"*) (*i.e.* Practice, soil, plant, grain, bread, performance) and associated sub-compartments (Column *"Sub_Compartment"*) (*e.g.* grain: nutritional, technological, sanitary). The dataset has already been formatted and adapted for use on statistical software such as RStudio® [1]. This dataset shows one variable per plot, referring, depending on the assessment method, to a unique measurement on a composite sample or to an averaged value of multiple replicates for on-field measured data. Two datasets are available for on-field measured data. The first (*dataABC.xlsx*) shows results for in-field measurements at each inner replicate. The second (*planthealth.xlsx*) presents the results of plant pest and disease assessments run in Year 2 on volunteer farmers' fields. Indicators presented in these two .xlsx files are averaged and named identically in the *data.field.xlsx* file and will be described only once in the rest of this article.

The three datasets are complemented by one metadata file (*metadata.xlsx*) providing supplementary information for each variable, such as a short description in English (*Description_EN*) and in French (*Description_FR*), the variable unit (*Unit*), the laboratory or institution in charge of the indicator measurement or computation (*Laboratory_Insitution*), the method of calculation or measurement (*Method_Protocol*), the indicator orientation (*i.e.* more the better, optimum, less the better) (*Orientation*) and the date of sampling or acquisition (*Date_of_sampling*). Each studied variable is classified according to its compartment (*Compartment*), *i.e.* "General", "Local_Condition", "Soil", "Plant", "Grain", "Bread", "Performance" and sub-compartment (*Sub-compartment*), *e.g.* for the compartment "Soil": "Biological", "Chemical", or "Physical". The description of indicators in the rest of this article follows this Compartment/Sub-compartment hierarchy.

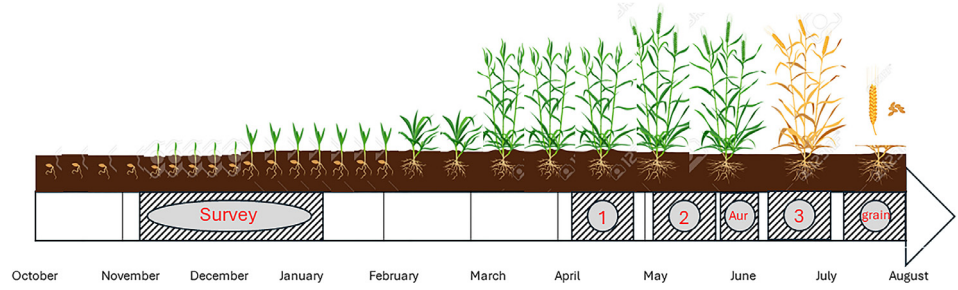


Fig. 2. Organisation of field monitoring for each monitored year. “Survey” corresponds to the cropping practices data collection phase, “1” corresponds to the first sampling campaign in spring, “2” to the second sampling campaign in spring, and “3” to the third sampling campaign just before the harvest. “Aur” corresponds to the soil sampling by the Aurea laboratory, and "Grain" corresponds to the grain collection after harvests in summer.

The dataset also contains one .docx document (*Template_Farmers_survey_2023.docx*), corresponding to the survey provided to farmers in Years 1 and 2 (in Year 1, the survey was filled with farmers through in-person interviews) to record their five-year historical cropping practices on their monitored field. The information deriving from this survey is noted as "Farmers" in the metadata file for the column *Laboratory_Institution*.

4. Experimental Design, Materials and Methods

4.1. Experimental design

As each plot was of a different size (from 1 to 30 hectares) (*FieldSize*), zones of homogeneous size were defined on each plot to standardise studied zones throughout the experimental set up.

Each field was monitored for one campaign, as indicated in Fig. 2. Data linked to the cropping system was collected each year during winter and cropping management data collection lasted during the whole campaign period, especially since some data concerned the harvested products (*e.g.* yield) and, therefore, was not yet available in winter. Soil data were obtained through three sessions of sampling (Fig. 2, Table 1). A rectangular area of about one hectare was defined on each study plot, on which five points A, B, C, D, and E were laid out in a “W” pattern on the principal study zone (*Zone* = *P*) (Fig. 3). In Year 2, volunteer farmers were proposed to leave a non-treated strip (control zone, *Zone* = C) of about 1 ha where they would not apply any fungicide or insecticide. Four inner replicates were set on that zone positioned in transect, *i.e.* T1, T2, T3 and T4. The C zone was used to monitor plant pests and diseases in non-treated conditions and allowed to compare plant health between non-treated and treated conditions in one field and between two non-treated zones of the same pair of farmers with contrasted cropping systems (CA and CONV). Each study zone (P, C) was positioned on the most homogeneous possible areas of the plots, and plot edges were avoided to prevent possible edge effects (Fig. 3). A buffer zone of about 3 m was considered between the C and the P zones.

4.2. Description of indicators

The description of the dataset variables is organised in sections. Each section corresponds to the *Compartment* column, and each sub-section corresponds to the *Sub-compartment* column of the main dataset.

Table 1
Explanation of the different sampling campaigns and corresponding measured variables.

Indicator	Dates		Type of sampling	Corresponding collected data
	Year 1	Year 2		
Sampling 1 (*SD_1*)	5/04/22 to 15/04/22	17/04/23 to 28/04/23	Three inner replicates (A, B, C)	Soil data: Setting the lamina_baits in 2022 (*Lamina*) and litter bags in 2023 (*Litter_bags*), Visual Evaluation of Soil Structure (*VESS*), Soil water infiltration (*Beerkan*), soil aggregate stability (*Agg*), soil moisture (*Moist_s1*), temperature (*Temp_s1*), and water conductivity (*ECp_s1*). Only in 2023: bulk conductivity (*ECb_s1*) and permittivity (*Perm_s1*).
Sampling 2 (*SD_2*)	25/04/22 to 3/05/22	7/05/23 to 17/05/23	Three inner replicates (A, B, C)	Soil data: sampling for paramagnetism (*Paramag_LF* and *Paramag_Xld*) and enzymatic activities (*NAG, Beta_Glu* and *Phosphatase*) measurements, soil respiration with Biofunctool® method (*SituResp*24 and *SituResp48*) [2], soil moisture (*Moist_s2*), temperature (*Temp_s2*), water conductivity (*ECp_s2*). Only in 2023: soil and plant data: bulk conductivity (*ECb_s2*), permittivity (*Perm_s2*) and foliar pest and disease.
Aurea (*SD_Aurea*)	19/05/22 to 31/05/22	25/05/23 to 9/06/23	One composite sample across the "W"	All soil data analysed by Aurea Agrosciences laboratory.
Sampling 3 (*SD_3*)	16/06/22 to 7/07/22	23/06/23 to 7/07/23	Three inner replicates (A, B, C)	Soil data: removing lamina baits (in 2022) (*Lamina*) and litter bags (2023) (*Litter_bags*). Grain technological parameters: Wheat sampling for measurement of all grain technological parameters, plant growth, diseases visible on ears (*Fusarium* and eyespot) and experimental yield (*ExpYield_n*).
Grain	1 to 15/08/22	1 to 15/08/23	One composite sample from P zone	Grain collection for measurement of parameters analysed by Phytocontrol laboratory, Valorex, James Hutton Institute, University of Pennsylvania and Moulins Girardeau.

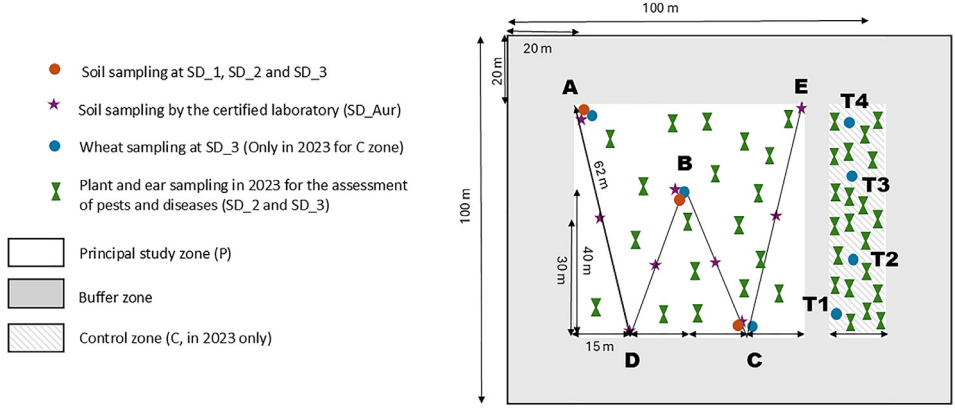


Fig. 3. On-field experimental design in 2022 and 2023 for soil, plant and wheat sampling. SD_1, SD_2 and SD_3 refer to the three sampling dates, as described in Fig. 2 and Table 1. No samplings were taken in the "buffer zones" to avoid any edge effects that could influence the results.

4.3. General

4.3.1. Identification

Plots were arranged in pairs of neighbouring plots (*Pair*), a pair was defined as two plots of neighbouring farmers with contrasted cropping systems (*Type*), *i.e.* conventional agriculture (*Type* = CONV) and conservation agriculture (*Type* = CA) for at least five years. The pairs of farmers were selected according to specific criteria on pedo-climatic conditions and management practices defined at the beginning of the study. Since the monitoring was carried out over two years, *Year* indicated the corresponding study campaign for each studied plot. *Zone* differentiated the principal study zone (Zone=*P*), where farmers' practices were monitored without any request to adapt treatments or operations, and the control zone (Zone=C), where in Year 2, twenty-four farmers accepted to leave a non-treated strip allowing to monitor plant health under non-treated conditions.

4.3.2. Dates

As explained previously, as part of the plot monitoring, several sampling campaigns were carried out, and specific data was collected at each sampling campaign, as described in Table 1. Wheat seeding date (*date_seeding*) and harvesting date (*date_harvest*) were also recorded for the two years of study. Since it is difficult to make calculations with date formats on software such as RStudio®, these dates were converted into a number of days to enable their inclusion into calculations and models. *d.samp1* represented the number of days between seeding in 2021 or 2022 and the first spring sampling in 2022 or 2023, *d.samp2* was the number of days between seeding in 2021 or 2022 and the second spring sampling in 2022 or 2023 and *d.samp3* was the number of days between seeding wheat in 2021 or 2022 and the summer sampling in 2022 or 2023. *d.samp_aur* was the number of days between seeding in 2021 or 2022 and the laboratory sampling in 2022 or 2023. *d.seed* was the number of days between 1/01/2021 or 01/01/2022 and the seeding date in 2021 or 2022, while *d.harv* was the number of days between 1/01/2022 or 2023 and the harvest date in 2022 or 2023. The difference *d.harv-d.seed* led to *d.growth,* which was the number of days of wheat growth in 2022 or 2023.

4.3.3. Farm and field

Farms were classified according to their type (*Farmtype*) since some farms involved livestock or other animals' breeding (*Farmtype* = 1), and others did not involve livestock or other animals' breeding but only crops (*Farmtype* = 0). Field size (*FieldSize*) was also recorded, although the monitoring was conducted on a standardised square of one hectare in each field.

4.4. Local conditions

4.4.1. Location

Longitude (*GPS_X*) and latitude (*GPS_Y*) corresponded to the GPS coordinates expressed in WGS84 at point A of the P zone (Fig. 3). The variable was summarised in *Location* which specified the field administrative department (*i.e.* 16: Charente, 17: Charente-Maritime, 37: Indre-et-Loire, 49: Maine-et-Loire, 79: Deux-Sèvres and 86: Vienne) and their geographic position in the administrative department (south, north, east, west). These geographic zones were subsequently clustered into four zones corresponding to similar pedo-climatic basins in the analyses, as follows: (1) Charente and south of Vienne departments, (2) north of Charente-Maritime and south of Deux-Sèvres, (3) Indre-et-Loire and north/middle Vienne, and (4) West of Deux-Sèvres and east/west of Maine-et-Loire (Fig. 1).

4.4.2. Soil texture

Soil texture was measured at the laboratory (https://aurea.eu/) according to the protocol NF X31–107. Texture was measured with decarbonation (*Clay, Silt, Sand*) in 2022 and 2023. Likewise, $CaCO_3$ concentration (*CaCO3*) was analysed following the protocol NF ISO 10 693. Dry matter

(*DM*) was measured following the ISO 11,465:1993 protocol. Texture with no decarbonation was analysed in 2023 only (*Clay_no_decarb, Silt_no_decarb, Sand_no_decarb*), as well as coarse elements (*Coarse_elements*). Soil texture with decarbonation was also expressed in the USDA referential (*Texture_USDA*). An attempt to measure soil bulk density was made but failed, since most soils were either too hard because of spring drought in 2022, or with too many coarse elements to allow for a correct sampling.

4.4.3. Semi-natural habitats

We considered three types of semi-natural habitats, *i.e.* hedges, forests, and water streams. *Hedge* corresponds to the presence (*Hedge* = 1) or absence (*Hedge* = 0) of a hedge at a 200-meter distance from the P zone. *SNH* is a score from 0 to 3 defined as follows:

- 3 points if forest (as identified by the Corine Land Cover 2021) and/or watercourse <200 m from the P zone,
- 2 points if forest AND watercourse are >200 m from the study area but <1 km from the P zone,
- 1 point if forest OR watercourse is >200 m from the study area but <1 km from the P zone,
- 0 if neither forest nor watercourse is within 1 km of the P zone.

Distance calculations were made using QGIS [3] and the layers © IGN BD Ortho® 50 cm 2021 edition. Forests were derived from the CORINE Land Cover 2021 version with 20 cm resolution and watercourses with the BCAE georeferenced watercourses 2021, which are watercourses concerned by the European regulation over the good agricultural and environmental conditions ("Règles des Bonnes conditions agricoles and environnementales" – BCAE).

4.5. Cropping practices

Information on management practices in each of the 86 selected fields was collected whether at the five-year historical management period and monitored campaign (called "rotation" in the rest of the document") or at the year scale, corresponding to the monitored year, *i.e.* Year 1 and Year 2. Data collection in year 1 was carried out through in-person interviews. In year 2 we provided farmers with a paperwork to fill, containing the same content asked in year 1. Complementary information was obtained through personal communications with farmers using emails, phone or text messages. Cropping practices were classified into six sub-compartments and two indexes as follows:

4.5.1. Tillage

The tillage classification for the seeding at the year scale in year 1 or 2 (*Tillage_n*) corresponds to a score from 0 to 3 with:

- 3 if direct seeding,
- 2 if light tillage, *i.e.* up to three machinery interventions and none of them exceeded 10 cm depth,
- 1 if heavy tillage, *i.e.* more than three machinery interventions needed for seeding and/or one the tillage operations was >10 cm depth,
- 0 if ploughing

This tillage score from 0 to 3 was also calculated for the five previous years of field management history and the studied year, leading to a score going up to 18 at the rotation scale (*Tillage_intensity_rot*), a score of 18 meaning that all crops were implanted through direct seeding, and 0 meaning that all crops were implanted after ploughing. The variable *LastPlough* corresponds to the number of years without ploughing on the monitored field. The reference year is 2021 for the plots monitored year 1 and 2022 for plots monitored in year 2. *System_age* derives from *LastPlough* as follows:

- “Very old” if the last ploughing was done >20 years before the monitored year,
- “Old” if the last ploughing was done 10 to 20 years before the monitored year,
- “Recent” if the last ploughing was done between 4 and 10 years before the monitored year,
- "Very recent" if the last ploughing was done in the four years preceding the monitored year.

4.5.2. Pesticide use

For each of the two monitored campaigns, we recorded the number of applied fungicides, herbicides, insecticides and molluscicides (*nbFungi_n, nbHerbi_n, nbIns_n, nbMoll_n*) as well as the number of applications of a specific fungicide family called succinate dehydrogenase inhibitors (*nbSDHI_n*). The frequency treatment index for herbicides (*TFI_h_n*) and insecticides, herbicides, and molluscicides taken together (*TFI_eh_n*) was calculated based on the information provided by the French Ministry of Agriculture (https://alim.agriculture.gouv.fr/ift/). Pesticide use average consumptions were not calculated at the rotation scale.

4.5.3. Crop nutrition

Mineral N, K_2O, SO_3 and P_2O_5 fertilisation were recorded at the year and rotation scale (respectively *minN_n* and *minN_rot*, K_2O_n and K_2O_rot, SO_3_n and SO_3_rot, P_2O_5_n and P_2O_5_*rot*). At the rotation scale, we calculated the average yearly mineral fertilisation. Average yearly organic fertilisation was recorded at the year scale for N (*ON_rot*) and C (*C_entries_rot*). These organic fertilisation inputs were estimated using the SIMEOS-AMG model (https://simeos-amg.org/) and corresponded to the quantity of C and N returned to soil through organic matter additions, crop roots, and crops returned to soils (cover crops or crop residues). The cumulated number of legumes cropped at the rotation scale was also recorded (*nbLeg_rot*).

4.5.4. Crop variety

Three indicators of different complexity were used to describe wheat varieties used by farmers. First, *Var_mix* equalled to 0 if a unique variety was grown on the field and 1 if a mix of varieties was grown. Second, *nbVar* gives the precise number, when available, of varieties contained in the mixes when *Var_mix* equalled to 1. Third, *Wheatvar* provides farmers’ used names of varieties when available. Some farmers produced their own wheat mixes from year to year and were unable to provide specific information on the available varieties in their mix.

4.5.5. Crop diversification

The preceding crop to monitored wheat was recorded (*Prec_crop_n*). In the rest of the analyses, previous crops were clustered into different groups, i.e.: (1) Spring Cereal including buckwheat, grain maize, grain sorghum, seed maize and silage maize, (2) Legume including alfalfa, lentil, meslin dominated by legumes and pea, (3) Winter Cereal including winter barley and winter wheat (4) Oilseed including oilseed flax, rapeseed, rapeseed + legumes in co-culture and sunflower. The number of crops grown at the rotation scale including cover crops and lays, was calculated (*CropDiv_rot*). We also counted the number of years before the previous wheat crop (*Time_return_wheat*). When the period was bigger than five years, it was noted as “6″ in the database.

4.5.6. Soil cover

We recorded the number of intercrops seeded at the rotation scale (*nbCC_rot*). Values ranged from 0 (no intercrop seeded) to 5 (cover seeded at each intercrop period). The presence of volunteer oilseed rape in the intercropping period, in the case of no-tillage, was counted as a plant cover. In addition, we calculated the number of opportunities to implant a cover crop in the crop succession at the rotation scale (*OppCC_rot*). To be considered as an opportunity; there must be a period of eight weeks or more between the harvesting of one crop and the seeding of the next one. We considered no opportunity when the soil was permanently covered by a perennial crop (*e.g.* alfalfa), by a meadow, or by a catch crop. The ratio *OppCC_rot: nbCC_rot* provides information on the cover efficiency (*EffCC_rot*). The ratio ranges from 0 (of all the opportunities to plant a cover crop, none were seized) to 1 (of all the opportunities to plant a cover crop, all

were seized). Finally, *RestitRes_n* corresponds to 1 if the residues of the previous crop have been returned to soil and 0 if the residues of the previous crop have been exported. The equivalent of *RestitRes_n* was computed at the rotation scale (*RestitRes_rot)* indicating the cumulated number of residue returns of the principal crops (cover crops were excluded) over the five-year historical management and the monitored years. *RestitRes_rot* therefore corresponds to a score ranging from 0 (residues were never returned at the rotation scale) to 6 (residues were systematically returned at the rotation scale).

4.5.7. Indexes

Two indexes were calculated at farm (*RI_farm*) and field (*RI_field*) scales. At the farm scale, an agronomic diagnosis called the "Regeneration Index" was run in each of the 44 selected farms from December 2021 to February 2022. RI farm scores were calculated for each farm based on data from the growing campaign 2019–2020, at the farm scale. *RI_farm* was measured through a one-to-one interview with each farmer using the tool available on https://agroecologie.org/indice-de-regeneration in winter 2021.

4.5.8. Soil health

To ensure to avoid any experimenter bias, all the soil health in-field monitoring diseases and pests monitoring were performed by the same observer.

4.5.8.1. Physical properties. The Visual Evaluation of Soil Structure *(VESS)*, Aggregate stability in water (*Agg)* and water infiltration *(Beerkan)* tests available in the Biofunctool® kit, as described in Thoumazeau et al. [4,5], were measured in-field on three replicates at A, B, and C positions. We adapted the Beerkan protocol as follows: the measurement time was limited to a maximum of 30 min instead of 40 min as indicated in the original protocol. In other words, if the ten water bottles were not all poured after 30 min of measurement, the test was interrupted. An adaptation of “VESS” calculation score was also performed to shift the orientation of results from an optimum to a "more the better" response curve. Also, we set a different optimum value of VESS scores compared with the one proposed in [5] (*scoreVESS*). Indeed, in our case, soil horizons were rated from 0.5 (very friable) to 5 (very compacted), instead of 1 to 5 in the original protocol [6]. We set the optimum value as the interval (1.2–1.9]. New adapted VESS scores ranged from 0 to 4 as follows (*scoreVESS*):

- scoreVESS = 4 if the initial rating was in the interval (1.2,1.9],
- scoreVESS = 3 if the initial rating was in the interval [0.5,1.2] or (1.9,2.6],
- scoreVESS =2 if the initial rating was in the interval (2.6,3.3],
- scoreVESS =1 if the initial rating was in the interval (3.3,4],
- scoreVESS =0 if the initial rating was in the interval (4,4.7]

Soil moisture (*Moist_s1* and *Moist_s2*) and temperature (*Temp_s1* and *Temp_s2*) were measured twice in spring, during the two sampling sessions using a WET Sensor kit (Photo 1). Specifically for these indicators, three sub-replicates were measured at each A, B, and C point at 0–10 cm depth and averaged to obtain one value per position.

A crusting index (*CIndex*) was calculated according to Rémy and Marin-Laflèche [7] based on the following formula :

$$CIndex = \frac{\%\ \text{fine silt} + 0,75\ \text{x coarse silt}}{\%\text{clay} + 10\ \text{x}\ \%\ \text{OM}} - C$$

if pH < 7, C = 0; if pH > 7, C = 0,2 (pH – 7)

Since the crusting index was calculated based on texture data measured by Aurea, only one value per plot based on composite soil samples was available.

4.5.8.2. Chemical properties. Soil total and bioavailable elements were analysed on a composite soil sample at the laboratory (https://aurea.eu/): Nitrogen (N, *s.TN*), Magnesium (Mg, *s.TMg* and *s.AMg*), Potassium (K_2O, only in 2023: *s.TK2O* and *s.AK2O*), Sodium (Na_2O, *s.TNa2O* and *s.Ana2O*),

Photo 1. WET sensor on a CA plot, after VESS measurement. WET sensors measurements were done on the non-disturbed part of the VESS measurement square. Note the visible darker soil colour in the superficial horizon. © Clara Lefèvre, April 2023.

Zinc (Zn, *s.TZn* and *s.AZn*), Manganese (Mn, *s.TMn* and *s.AMn),* Iron (Fe, *s.TFe* and *s.AFe*), Boron (B, *s.TB* and *s.AB)*, Sulphur (S, *s.TS* and *s.ASO4)*, Molybdenum (Mo, *s.TMo* and *s.AMo)* and Copper (Cu, *s.TCu* and *s.ACu). A*ssociated extraction protocols are given in Table 2. Ratios of bioavailable: total elements were calculated (*s.ratioMg, s.ratioK2O* −2023 only-, *s.ratioNa, s.ratioZn, s.ratioMn, s.ratioFe, s.ratioB, s.ratioS, s.ratioMo* and *s.ratioCu*), allowing to understand the proportion of bioavailable element as part of the total.

Organic Carbon (OC) and Organic matter (OM) concentrations were determined by dry combustion after NF ISO 10 694. C/N was then calculated as the ratio between *OC:s.TN* (*C_N*). Soil water pH (pH) was measured according to NF ISO 1039. Metson Cation exchange capacity (*CEC*) was measured after NF X 31–130. It involved an exchange by percolation of cations (or bases) fixed to the soil with neutral ammonium acetate at pH 7. The solution was rinsed with alcohol, and then fixed ammonium (NH_4^+) was measured on soil. The quantity of ammonium absorbed or fixed was then determined.

Biologically mineralisable nitrogen (BMN) was measured based on the incubation of a raw soil sample sieved to 2 mm under controlled conditions. Samples were completely immersed in water (anaerobic environment) and incubated at 40 °C for seven days. Since these anaerobic conditions block nitrification (conversion of NH_4 to NO_3), only the conversion of organic nitrogen to ammoniacal nitrogen was monitored. The difference between ammonia levels at the start and end of incubation was used to calculate the BMN. Since there is no measurement standard,

Table 2
Extraction protocols for available soil nutrients.

Available element	Protocol
B, Mo	Standard NF X31–122: 25 g fine earth was mixed with a 50 mL calcium chloride solution and boiled for 5 min. The mixture was homogenised and filtered, then measurement was done by plasma spectrometry (ICP).
K_2O, Mg, Na_2O	Spectrometry according to NF X 31–108.
Cu, Fe Mn, Zn	NF X 31–120: 5 g fine earth was mixed with 50 mL EDTA extraction solution. The mixture was shaken for 2 h and centrifuged. Measurement was then made by ICP.
N	NF ISO 13 878: Ground soil was burned in the presence of oxygen in an oven at 950 °C. After the combustion gases were purified, the N produced was determined by scatterometry.
P	NF ISO 11 263: Extraction was carried out using a 0.5 M sodium bicarbonate solution.
S	Aqueous sulphur (SO_4^{2-}): 1/5 extraction and IPC dosage.

the laboratory based its method on the protocols developed by Waring and Bremner [8] and subsequently adopted by Stanford and Smith [9]. BMN was expressed as a percentage of total N (*BMN_Ntot*) and in mg/kg of dry soil (*BMN_tot*).

The concentration of $KMnO_4$ carbon (also known as Permanganate Oxidisable Carbon - POXC) was analysed based on Weil et al. [10] and Culman et al. [11]. After sampling, soils were dried at 38 °C and sieved to 2 mm and coldly oxidised by a potassium permanganate solution, causing the reagent to discolour. The decolourisation was measured using spectrophotocolourimetry. The result was expressed as a percentage of total OC (*s.POXC_OC*) or as mg/kg of dry matter at 38 °C (*s.TPOXC*).

Granulometric fractionation of OC (*C_0_50, C_200_2000, C_50_200, C_50_2000*), N (*N_0_50, N_200_2000, N_50_200, N_50_2000*) and C/N (*C_N_0_50, C_N_200_2000, C_N_50_200, C_N_50_2000*) in the 0–50, 50–200, 200–2000 and 50–2000 µm fractions were measured based on standard NF X31–516. Samples were dried at 38 °C and sieved to 2 mm underwater to separate the 0–50 µm, 50–200 µm and 200–2000 µm fractions. After drying and weighing, OC was measured in the 50–200 µm and 200–2000 µm fractions (by sulphochromic oxidation). These proportions of OC in the fractions were expressed as a percentage of total OC, the proportion of N, as a percentage of total N, and the C/N corresponded to the C/N of each of the soil fractions. For the 0–50 µm fraction, the results were obtained by difference with the total fraction.

Pore water conductivity (*ECp_s1* and *ECp_s2*), soil bulk electrical conductivity (*ECb_s1* and *ECb_s2*) and soil permittivity (*Perm_s1* and *Perm_s2*) at 0–10 cm depth were measured in-field on three sub-replicates in the two spring sampling sessions year 2 using the WET Sensor kit (Fig. 3). Pore water conductivity refers to the electrical conductivity of the water within soil pores, while soil bulk electrical conductivity measures the overall ability of soil to conduct electricity, including pore water and soil solid particles. Permittivity reflects the quantity of electrical energy that can be stored in soils [12,13]

Measurements of paramagnetism in low frequency (*Paramag_LF*) and high frequency (not shown in the dataset) were realised on year 1 samples at CIRAD research Centre (Montpellier) on dry soil sieved at 2 mm. Measurement was run using a Barrington MS3 device associated with an MS2B sensor, measuring at two frequencies (465 Hz and 4.65 kHz) in 10 ml containers with very low magnetic susceptibility ($<10^{-8}$). Measurement was brought down to the mass of the sample (Mass Magnetic Susceptibility, m^3/kg). *Paramag_Xld* derives from these two measurements according to the following formula:

$$Xld\ (\%)\ =\ (LF - HF)/LF$$

Based on the information provided by Aurea Laboratory.

4.5.8.3. Biological properties. Biological properties were measured whether on-field or by the certified "Auréa Agrosciences" laboratory.

As part of the Biofunctool® kit, lamina baits (*Laminas*) were analysed in year 1. Lamina baits were settled during the first spring sampling campaign and removed during the second spring campaign. In total, they stayed in-field for 21 days on average. The indicator was replaced in year 2 by Litter bag analyses (*Litter_bags*). Litter bags were handmade using organic cotton (cellulose 100 %) squares of 10×8 cm, previously dried at 70 °C for 48 h. Each cotton square was weighed before insertion in small PVC cages of 5 mm mesh. Litter bags were inserted in soils with two replicates for each of the three sampling positions (A, B, C) on the first spring sampling session and removed in the summer sampling session. Overall, they were incubated on average for 70 days (Fig. 4). After soil removal, litter bags were stored in a cool place and frozen after arrival at the Toulouse laboratory at −18 °C. Cotton squares were then removed from the cages, slightly cleaned with water, and dried at 90 °C for 48 h. Cotton squares were then weighed. *Litter_bags* values corresponded to the difference in weight before – and after incubation, expressed in grams. Soil basal respiration at 0–10 cm was also measured in-field after 24 h of incubation (*SituResp24*) after the protocol developed by Thoumazeau et al. [2]. Since the SituResp® protocol was originally developed in tropical countries and our measurements were performed in a tem-

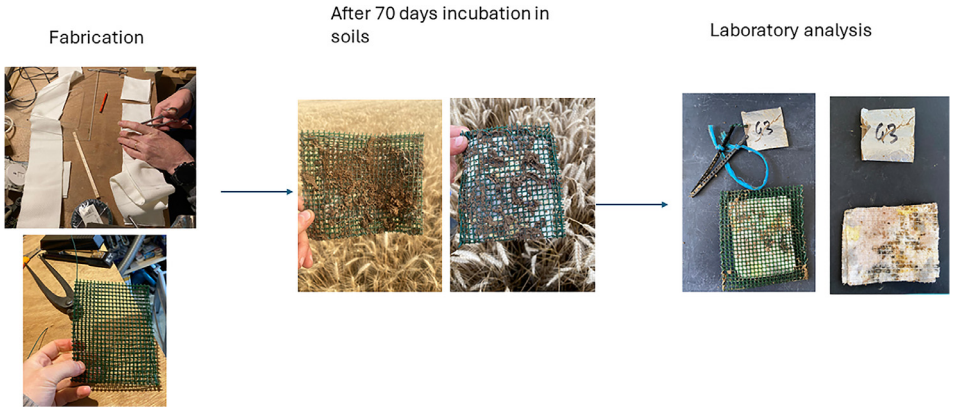


Fig. 4. Fabrication process for litter bags analysis. Litter bags were made by cutting cotton squares of 10×8 cm, dried at 70 °C for 48 h, weighed and inserted in small PVC cages of 5 mm mesh. They were ten incubated in soils at 10 cm depth at the first sampling session and removed about 70 days later in the summer sampling session, just before harvest. They were then stored at 4 °C to stop degradation, cleaned with water, and dried in the oven at 90 °C for 48 h before weighing.

perate climate and in spring, we also measured SituResp after 48 h of incubation (*SituResp48*), to ensure a colour difference in gels. All gels were prepared at the laboratory in Toulouse a few days before the field campaign and were stored at ambient temperature in a hermetic box filled with soda lime until their use.

For enzymatic activities, soil samples were taken at a 0–10 cm depth during the second spring sampling session of years 1 and 2 (Table 1). Once taken, samples were immediately placed in a cool place. Samples taken in year 1 were stored in a freezer at −20 °C from the end of the sampling campaign in early May 2022, and the samples taken in year 2 were stored in a cold room at 4 °C on their return to the laboratory in mid-May 2023. Activity analysis of N-acetylglucosaminidase (*NAG*), β-glucosidase (*Beta_Glu*), and phosphatase (*Phosphatase*) was carried out in Toulouse CNRS from June 1 to July 11, 2023, according to the protocol proposed by Jassey et al. [14,15].

The other biological soil properties were measured by Aurea laboratory after soil sampling at 0–20 cm depth.

Carbon mineralisation after 3, 7, 14, 21 and 28 days of incubation was measured based on standard NF EN ISO 16,072. Soil samples were incubated at 28 °C, at optimum humidity (80 % of field capacity humidity), for 28 days in the dark. Soil was incubated in a closed container in a flask containing a sodium hydroxide solution. The CO_2 produced during incubation was absorbed into this solution. The quantity of C–CO_2 produced was measured by UV spectrometry. The cumulative amount of C–CO_2 released on each measurement date was used to calculate the carbon mineralised over 28 days, expressed in mg of C–CO_2/kg of dry soil (*minC_3d_OC, minC_7d_OC, minC_14d_OC, minC_21d_OC, minC_28d_OC*) or as a percentage of total OC (*minC_3d, minC_7d, minC_14d, minC_21d, minC_28d*). N mineralisation after 0, 7, 14, 21 and 28 days of incubation was measured following ISO 14,238 (2012). Similarly, soil samples were incubated at 28 °C, at optimum humidity (80 % of field capacity humidity), for a period of 28 days in the dark. Five sub-samples of the same soil were incubated in pots (for the five extraction dates, the analysis was destructive). After incubation, mineral N was extracted by shaking in a KCl solution and then measured by continuous flow colourimetry. Mineralised N includes nitric N ($N–NO_3$) and ammoniacal N ($N–NH_4$). The difference between the mineral N measured after 28 days of incubation and that measured at the start of incubation constituted the quantity of potentially mineralisable N. The result was expressed as mg of mineral N ($N–NH_4$ + $N–NO_3$)/kg of dry soil (*minN_7d, minN_14d, minN_21d, minN_28d*) or as a percentage of total N (*minN_7d_Ntot,*

minN_14d_Ntot, minN_21d_Ntot, minN_28d_Ntot). The database does not include N mineralisation at 0 days since minN_0d = 0.

Total DNA was extracted according to standard NF EN ISO 11,063 (2020), adapted by Terrat et al. [16]. On receipt at the laboratory, soil samples were sieved fresh to 2 mm and then air-dried. Microbial DNA was extracted from 1 g of dried soil and quantified by agarose gel electrophoresis. The molecular microbial biomass (*MMB*) was then estimated from this quantity of DNA. *MMB* is expressed in μg of DNA/g of soil. Similarly, Total Microbial Carbon (*TMC*) was analysed based on standard NF ISO 14,240–2. Soils were sieved to 2 mm; then, a sub-sample was brought into contact with chloroform vapour (fumigation) to lyse the microbial cells leading to C dissolution. Dissolved C was extracted using a K_2SO_4 solution and then measured by UV spectrometry. The difference with the C extracted from another non-fumigated sub-sample was used to calculate *TMC*, expressed in mg of C per kg of dry soil (*TMC*) or as a percentage of the total OC concentration (*TMC_OC*).

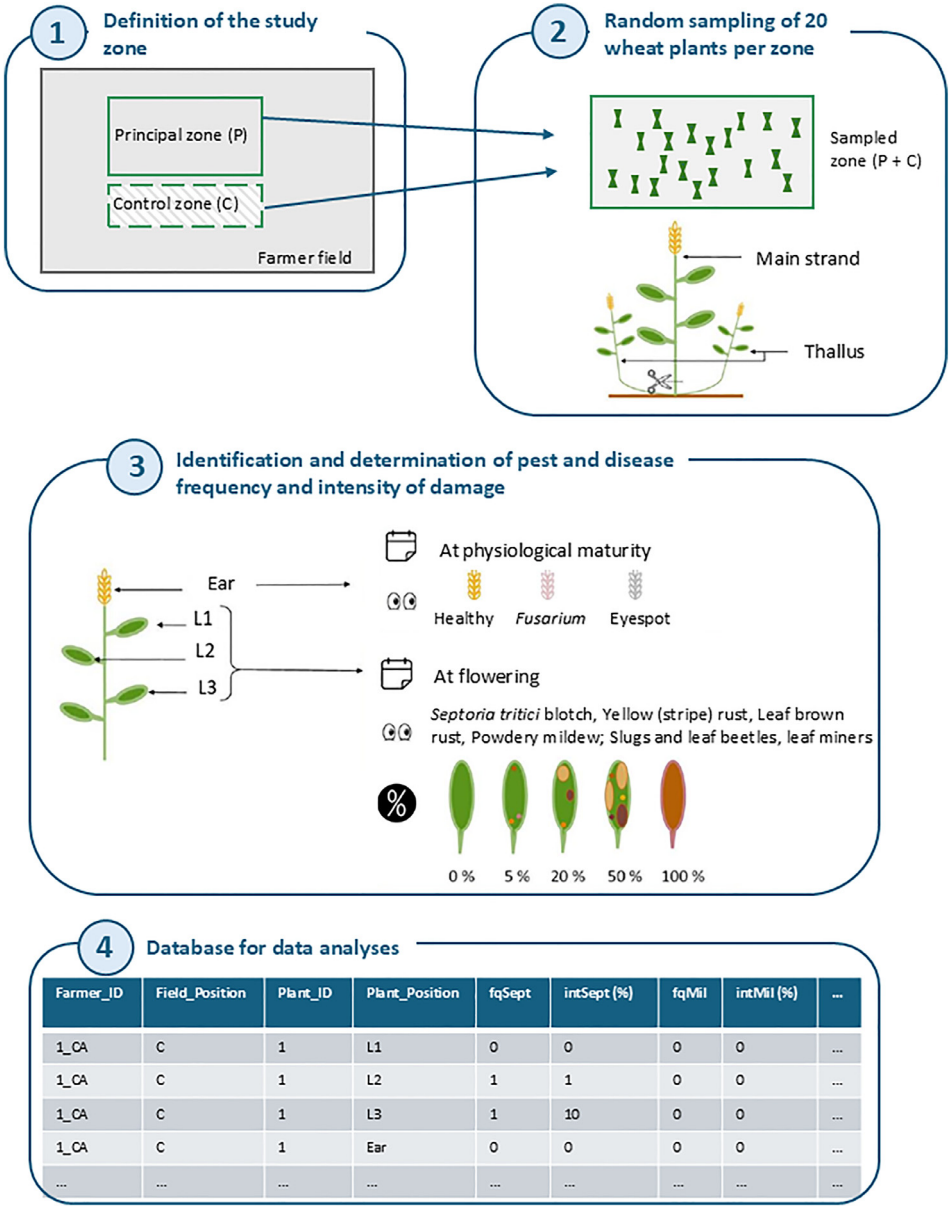
The abundance of bacteria (*AbundBact*) and fungi (*AbundFungi*) was measured following the protocol NF EN ISO 16,072, similar to Djemiel et al. [17]. Total DNA was extracted in the same way as for measuring *MMB*. The DNA was then purified to eliminate any pollutants. A specific DNA sequence was then amplified by qPCR (Polymerase Chain reaction). This PCR made it possible to determine the initial quantity of targeted DNA (16S rDNA for bacteria and 18S rDNA for fungi) from the DNA produced during PCR amplification. Bacteria and fungi abundance was expressed in copy numbers. The abundance ratio of fungi and bacteria was also calculated (*FBRatio*). Similarly, the diversity of bacteria (*DivBact*) and fungi (*DivFungi*) were measured. After extraction and purification of the total DNA, the 16S and 18S specific DNA sequences were amplified by PCR. The amplicons obtained were sequenced using a massive sequencing technique. This sequencing resulted in several tens of thousands of targeted gene sequences. Data was processed by bioinformatics to filter, sort, classify, group, and link sequences from databases. Results are expressed as a number of Operational Taxonomic Units (OTUs).

4.5.9. Plant health

4.5.9.4. Pest and disease. Plant disease and pests were monitored in Year 2 on twenty-four plots in the P and C zones. For each monitored disease or pest attack, their frequency of occurrence on leaves or ear were counted, and for each occurrence of disease or pest attacks, the disease or pest intensity of damage was assessed. To ensure to avoid any experimenter bias, all the plant disease and pest monitoring were performed by the same observer. Disease analyses included *Septoria tritici* blotch, Yellow (stripe) rust and leaf brown rust, powdery mildew, eyespot, and *Fusarium* spp.. Pest analyses included slugs, leaf beetles and leaf miners attacks.

In each zone, twenty plants were randomly selected (Fig. 5). Only the three youngest fully developed leaves (L1, L2 and L3) were observed for foliar diseases, and ears were observed when diseases were observable at plant maturity. On each plant organ (L1, L2, L3 and ear), the presence of disease or pest attack was counted and summed to obtain a disease frequency at the zone scale. A frequency of 60 for a given foliar disease or pest attack indicated that all leaves were affected, while a frequency of 0 meant that no leave was affected *(fqSept, fqMil, fqlminers*). Brown and yellow rust were gathered and defined as “Rust”, since on-field, it was not always simple to distinguish the difference between a leave affected by brown or yellow rust (*fqRust).* Likewise, *slug plus leaf beetle damage* were gathered, since their damage on leaves were hardly distinguishable *(fqslugs_lbeetles).* For ear-observable diseases, a frequency of 20 meant that all ears were affected by disease (*fqFusa, fqEyespot*). The total frequency of diseases counted was summarised in *fqTotDis*, while the total frequency of damage was summarised in *fqPests*.

Eyespot and *Fusarium* damage intensity were not recorded, since when an ear was affected, we considered it was automatically affected with an intensity of 100 %. For each affected leave the intensity of damage (by diseases: *Septoria*, powdery mildew, rust, or pests: slugs and leaf beetles and leaf miners) was recorded as indicated in Fig. 5 (*intSept, intMil, intRust, intslugs_lbeetles, intlminers*). The average intensity of disease (*intAvDis*) or pests (*intPests*) per zone was calculated considering *Septoria*, powdery mildew and rust for diseases, and slugs/leaf beetles and leaf miners for pests.



Farmer_ID	Field_Position	Plant_ID	Plant_Position	fqSept	intSept (%)	fqMil	intMil (%)	...
1_CA	C	1	L1	0	0	0	0	...
1_CA	C	1	L2	1	1	0	0	...
1_CA	C	1	L3	1	10	0	0	...
1_CA	C	1	Ear	0	0	0	0	...
...	...	...	...	...	...	...	...	...

Fig. 5. In-field protocol for plant pest and disease analysis adapted from [18].

4.5.9.5. Growth. The average wheat height just before harvest was measured on three positions (A, B, C) of the P zone with three sub-repetitions at each location (*Height*).

4.5.10. Grain quality

4.5.10.6. Nutritional and sanitary quality. Farmers were asked to keep aside 5 and 10 kg of grain wheat from the P zone at harvest. Grains were collected in early August 2022 (for year 1 monitored plots) as well as in August 2023 (for year 2 monitored plots) and stored at ambient temperature before analyses a few weeks later in 2022 and in 2023.

A first series of analyses was conducted in a certified laboratory (https://www.phytocontrol.com/). Total N concentration in grain (*g.TN*) was measured following NF EN ISO 16,634–1 by combustion according to the Dumas principle. As for soils, Fe, Mn and Zn concentrations (*g.Fe, g.Mn* and *g.Zn*) were determined by inductively coupled plasma mass spectrometry (ICP-MS) adapted from EN NF 15,763. K and P concentrations (*g.K* and *g.P*) were measured by ICP-MS following a COFRAC (French Committee for Certification) certified method. Eventually, vitamin B9 (*B9*) was determined by High-Performance Liquid Chromatography (HPLC) and immunoaffinity column, with a limit of quantification of 10 μg/kg.

The Valorex company (https://www.valorex.com/) analysed the contents of starch (*Starch*), cellulose (*Cellulose*), and protein (*Prot*) using Near-Infrared spectroscopy (MPA II, Brucker device). Valorex also measured antioxidants (*Antiox*) and polyphenols (*Polyph*) concentrations in year 1 while the James Hutton Institute (Scotland) measured *Antiox* and *Polyph* in year 2. Both partners used the same FRAP (Ferric Reducing Antioxidant Power Assay) methodology for antioxidant analyses and the Folin-Ciocalteu (FC) method for polyphenol analyses as described in Bionutrient Institute [19].

The concentration of the amino acid Ergothionein (*Ergo*) was measured at the University of Pennsylvania according to the protocol described in Beelman et al. [20] using a Sciex 4000 Q Trap mass spectrometer coupled with a Waters ACQUITY UPLC separation system.

Sanitary quality indicators were also analysed by the certified laboratory *Phytocontrol* (https://www.phytocontrol.com/). Three types of mycotoxins were analysed: (1) Deoxinivalenol (*DON*), (2) HT2 (*HT2*), and (3) Zearalenone (*ZEA*). All were analysed by liquid chromatography coupled with a mass spectrometer (LC-MS/MS) following a COFRAC method, with a limit of quantification of 50 μg/kg. In addition, residues of glyphosate and Aminomethylphosphonic Acid (AMPA) in grain were analysed by LC-MS/MS, using a QuEChERS method (*i.e.* "quick, easy, cheap, effective, rugged, and safe") which corresponds to solid phase extraction method for detection of biocide residues in food. These pesticide residue analyses were performed on forty samples corresponding to grain samples of farmers who used glyphosate just before the wheat growth campaign (year 1 or 2). We did not analyse glyphosate residues in grains of farmers who did not apply glyphosate in the year preceding the monitored campaigns.

4.5.10.7. Yield and technological quality. During the summer sampling of years 1 and 2, at wheat physiological maturity, ear samples were taken from points A, B, and C on each P zone. Three replicates per point were taken on each plot using the ring method. Rings with a diameter of 50 cm were laid out randomly around each sampling point, and the ears whose stems originated in the ring were cut and placed in kraft bags (Photo 2). Ears were then dried in a greenhouse for at least a week after collection. Once dried, the bags of ears were stripped, and the number of ears per bag was counted *(Grain_ear_n)*. Ears were then threshed using a fixed-station thresher (model LD 350, Wintersteiger), and the threshed grains were again dried at 70 °C for 48 h to ensure a homogeneous and minimal moisture content. Once dried, grain samples were weighed to obtain the value of experimental yield (*ExpYield_n*). Then, from each sample, 500 grains were taken and counted with a grain counter (Numigral model) and weighed to determine the thousand kernel grain (*TKW*). Samples from the same sampling point were then pooled to determine the specific weight (*ExpSW_n*). SW was measured using a Dickey-John GAC500 XT instrument. Each SW measurement was repeated three times for the same sample and averaged to obtain a value per plot. Farmers also provided the SW value obtained after harvest (*FarmerSW_n*) as well as the yield obtained for their whole plot (both values obtained either from their combine harvester or by the grain collector) (*FarmerYield_n*).

4.5.11. Flour and bread

Bread-making tests were run on a sub-sample of plots (10 plots in year 1 and 10 in year 2) on the wheat harvested by farmers in summer 2022 and 2023. Grain was stored at ambient temperature, and bread-making tests were run in early fall 2022 and 2023 by the flour mill “Moulins Girardeau” (https://www.minoterie-girardeau.com/en/about/). Grains were milled on a test mill with steel grinding wheels. A subsample of flour was incinerated at 900 °C for 1:30 h and the

Photo 2. Ear sampling with ring methodology in June 2023. ©Clara Lefèvre.

quantity of ashes was measured (*f.Ashes*). With the remaining flour, the mill yield (*MillYield*) and Hagberg falling time were measured (*f.Hagberg*), as well as the percentage of flour hydration (*f.Hydration*). Bread-making tests were then run and several variables were measured on dough, such as the elasticity index (*b.IE*), the toughness:extensibility ratio (*b.P_L*) and the baking force (*b.W*). Finally, bread technological parameters were measured, *i.e.* its length (*b.Length*), volume (*b.Volume*), and the baking score (*Baking_Score*). All analyses were run following the BIPEA[1] criteria and protocols.

4.5.12. Field socio-economic and environmental performances

The ratio between *minN_n* and *ExpYield_n* was calculated, providing information on the efficiency of mineral N (*minN_eff_n*).

Field socio-economic and environmental performances were computed using Systerre® methodology. Systerre® is a performance assessment tool developed by the French Agricultural Institute "Arvalis-Institut du végétal" which calculates scientifically-based performance indicators of cropping systems from an exhaustive description of their cultivation practices including machinery and input use and outputs including grain yield and biomass production [21–24]. Different assumptions were made to perform the model:

- The machinery pool is the same for any farmer (*e.g.* one same no-till drill for CONV farmers, one same combined seed drill for CONV farmers, etc.),
- All farmers brought their inputs at the same price,
- All farmers sold their wheat at the same price,
- Plots were not irrigated

[1] BIPEA is a European NPO ISO 9001 certified by the Lloyd's Register Quality Assurance. It provides proficiency testing programs and reference materials for laboratories concerned with control and quality. Their services cover different fields: cereals, grains, feed, food, beverages, air, waters, soils and cosmetics. It is ISO/IEC 17043 accredited by COFRAC for the organisation of proficiency testing programs. Also see: https://www.bipea.org/milling/

These enabled us to monitor only the effects of practices on farm performances, without taking into account the farmer's economic strategy. Amongst Systerre® outputs, we considered six specific indicators that provide information on:

(i) Field economic performance, with:
- the production cost (*ProductionCost*) to produce 1 ton of winter wheat in each P zone accounting for inputs and mechanisation costs,
- the input expenses (*InputExpenses*), *i.e.* the ratio between *ProductionCost* and yield (*farmerYield_n*), and
- The semi-net margin (*SNMargin*) is calculated as follows:

$$Semi\_net\ margin = gross\ income - operating\ costs - mechanisation\ costs$$

$$With\ gross\ income\ =\ Yield * Selling\ price\ *\ harvested\ area\ (1\ ha)$$

And Operating expenses = Input expenses * Quantities supplied (inputs = fertilisers, seeds, crop protection products, etc.) * area treated (1 ha)

(ii) Field social performance:
- working time (*WorkingTime*) was calculated as the work rate on the plot in hours per ha, only taking into account in-field spent time, thus not including time spent on administrative management, crop observation, etc.

(iii) environmental performance:
- Gas consumption by machinery (*GasConsumption*) during field operations. Additional consumption (maintenance, etc.) is not included. And,
- greenhouse gases total emissions (*GHGtotEmiss*) in CO_2eq/ha accounting for all emissions from fuel, inputs, from fabrication to use (calculated after life cycle assessment).

Limitations

We noticed a high intraplot variability between the three replicates for in-field assessed data. In addition, on unchanged plots from year 1 to year 2, we noticed an interannual unexpected variability for some soil data supposed to be stable over time (*e.g.* soil texture, VESS), highlighting the high intraplot intrinsic variability. Although more replicates and a larger size of sampled farms would likely have supported better variability management, a compromise had to be found with time, workforce, and financial resources to ensure the study feasibility.

Finally, data on cropping practices refers to information provided by farmers. The reliability and accuracy of this data are based on the trust relationship between our research team and farmers.

Ethics Statement

The authors have read and followed the ethical requirements for publication in *Data in Brief* and confirm that the current work does not involve human subjects or animal experiments. The authors confirm that data provided by farmers are shared after informed consent is obtained from the study participants and after anonymisation of all participant data.

Data Availability

Data of on-farm assessment of cropping practices in a "one health" perspective, Winter wheat, France (Original data) (Dataverse)

CRediT Author Statement

Lefèvre Clara: Conceptualization, Methodology, Software, Formal analysis, Writing – original draft; **Husson Olivier:** Supervision, Writing – review & editing, Validation; **Dumora Bruno:** Methodology, Writing – review & editing; **Grudé Océane:** Methodology, Writing – review & editing; **Lugassy Léa:** Funding acquisition, Supervision; **Sarthou Jean-Pierre:** Supervision, Writing – review & editing, Validation.

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Declaration of competing interests

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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