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Data Article

Data from extensive comparative measurements of conventional, conservation and organic agricultures in southwestern France

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ABSTRACT

This article present observational and experimental data describing a range of biotic and abiotic parameters that can be related to ecosystem services under contrasted types of crop management: conventional, conservation and organic agricultures. Ninety fields, either cultivated with winter wheat or fava bean, located in Southwestern France, near Toulouse, were monitored for two growing seasons (2014–2016). The dataset encompass data about crop pests (aphids, grain borer, bean beetles, slugs), crop pest natural enemies (hoverflies, parasitoids, predators), soil sensitivity to erosion, crop productivity, pathogenic fungal infection and root colonization by mycorrhiza. This article present detailed protocols applied for each measurement and data collected to describe the context of each field: soil structure, landscape and crop management indicators.

The data presented here can be found in Portail Data INRA repository (DOI: 10.15454/KEW1GK) and were exhaustively used and discussed in the research article Conservation agriculture as a promising trade-off between conventional and organic agriculture in bundling ecosystem services [1].

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Specifications Table

Subject	Agricultural and biological sciences (general)
Specific subject area	Agroecological, agronomic performance, phytopathology, landscape data
Type of data	Table, .xlsx file
How data were acquired	Field observations, surveys
Data format	Raw data
Parameters for data collection	52 winter wheat and 38 fava bean fields in 3 distinct types of crop management: conventional, conservation and organic agricultures
Description of data collection	Monitoring of biocontrol, yields, crop health, mycorrhiza, soil parameters and landscape
Data source location	Institution: INRA Toulouse Region: departments of Tarn, Haute-Garonne and Gers Country: France from 43°N, 0°E to 44°N, 2°E
Data accessibility	Repository name: Portail Data Inra Data identification number: DOI: 10.15454/KEW1GK Direct URL to data: https://doi.org/10.15454/KEW1GK
Related research article	Chabert, A., Sarthou, J.-P. Conservation agriculture as a promising trade-off between conventional and organic agriculture in bundling ecosystem services. <i>Agriculture, Ecosystems and Environment</i> . [1]

Value of the data

This dataset provides an unprecedented broad range of simultaneous measurements of biophysical, ecological and agronomic parameters, for the study of agroecological performances of conservation agriculture in France, with comparison with organic and conventional production systems. It comes from a collaborative work with farmers allowing reliable in-field assessment rather than experimental plots.

This dataset provides a priceless reference for future researcher in agronomy and ecology seeking reference for agroecological performances of early adopters of Conservation Agriculture in France. It also provides in-fields values that are still lacking to support studies on ecosystem services bundles in agroecosystems.

This dataset can be reused for meta-analyses, either by focusing on one specific ecosystem service or agronomic performance or by appreciating bundles of them. Furthermore, methods used were rapid and easy to implement, allowing replication of them in future studies, using this dataset as a reference point or a meaningful complement.

Data

In this data article, we are sharing an extensive recollection of data resulting from two years monitoring of winter wheat, fava bean and mix fava bean-wheat fields distributed among 52 farms.

Data encompass several separate measurements presented in 16 separate excel sheets in the file *Full_dataset.xlsx*. In the sheet '*Cropping_System*', a set of crop management indicators to describe each farm is presented, including tillage, use of chemical inputs, diversity of production and semi-natural habitats. The sheet '*Soil_Parameters*' presents a soil analysis (texture, pH, organic matter) for the wheat field of each farm. A coarse description of the surrounding landscape, within 1.5 km around the wheat field of each farm, can be found in the sheet '*Land-*

scape_1500 m' and the area of semi-natural habitats that can be found on the farm are listed in the sheet 'Semi_Natural_Habitat'.

Several measurements of pests and natural regulations were made: counts of grain aphids on wheat ears, are in the sheet 'Aphids', and counts of pupae of one of their potential predators, the long hoverfly, are in the sheet 'Hoverflies'; counts of wheat stubbles obstructed by grain borer, are in the sheet 'Grain_borer'; number of fava bean grains parasitized by bean beetles and assessment of bean beetle parasitism by *Triaspis thoracicus* are presented on the sheet 'Bean beetles'; Number and species of slugs counted in wheat fields at different seasons (spring and fall) are presented in the sheet 'Slugs' and number of ground predators (including spiders, carabids and rove beetles) counted simultaneously to the slug assessment are presented in the sheet 'Ground Predators'. Other agronomic performances are presented in this dataset, such as speed of water infiltration and soil surface aggregate stability as indicators of soil sensitivity to erosion, in the sheet 'Erodibility', crops yields, respectively in the sheets 'Wheat_Yields' and 'Fava_bean_Yields', and visual assessment of Leaf diseases, in sheets 'Wheat_Diseases' and 'FavaB_Diseases'. The standardized scale used for leaf diseases assessment can be found as supplementary material of this article. Concentrations of several mycotoxins in wheat grains were analyzed and also presented in the sheet 'Wheat_Diseases'. Finally, descriptors of mycorrhiza colonization of roots are presented in the sheet 'Mycorrhiza'.

The second file, *Labels_descr_dataset.xlsx*, gives a comprehensive list of sheet and column labels that appear in *Full_dataset.xlsx* with their description and unit, as well as indication of the fields the data came from (NTW: not treated wheat, OW: organic wheat, W: wheat, F: fava bean, WF: wheat + fava bean mix) and either data referred to the first (2014–2015) or the second (2015–2016) year of experiment (see experimental design below).

On every sheet of the *Full_dataset.xlsx*, a code to identify the farm ('Farm_code') is given on the first column along with date of sampling and identification of the field ('Field_code': NTW, OW, W, F or WF) when relevant.

Data were collected around Toulouse, Southwestern France, from September 2014 to July 2016. Farms were distributed along a 200 km line intersecting Toulouse, from 43°N, 0°E to 44°N, 2°E, crossing three French counties: Gers, Haute Garonne and Tarn. Our agreement with farmers did not allow us to publicly identify their fields with geographic coordinates. However, county of each field can be found in the sheet *Landscape_1500m* of the dataset and a map along with more details about location can be found in Chabert and Sarthou [2].

Experimental design, materials, and methods

Experimental design

A total of 90 fields were monitored: 52 winter wheat fields (14 were label with organic agriculture certification), 38 of which were paired with a fava bean field. Fava bean and wheat fields were always close-by, with a common border in most cases. Field size was 1 ha for winter wheat and 0.5 ha for fava bean. All fields had the same crop cultivars and seed origin. No insecticides, including seed treatment, were applied during the cropping season, and crops were not irrigated. Half of each winter wheat field did not receive fungicide treatment (to standardize disease measurements). All other cropping practices were left to the farmer to decide and were closely monitored (see crop management monitoring below).

Measuring a large number of parameters in the same cropping season on many farms requires extensive labor and time. Measurements were thus chosen to be simple and quick to implement. Data presented here were issued from an experiment designed in cooperation with farmers, in particular for the choice of a meaningful set of measurements. Thus, although that all the measurements were performed by scientific operators to assure homogeneity, they were chosen so that farmers and advisers could reproduce them in the future, mainly for educational purposes.

Crop management monitoring

Information about the field was recorded for tillage, chemical inputs, intercrop management and plant diversity.

Concerning tillage, all mechanical operation in the field were monitored for 3 years (Aug. 2012 – Aug. 2015) and we considered the flowing three types of tillage management: direct seeding ('D', the only mechanical soil disturbance is the opening and closing of the seed line), reduced tillage ('RT', superficial soil tillage without soil inversion) and plowing ('P', use of plow, i.e. soil inversion). To refine tillage description, we also recorded the number of years since last tillage and last plowing in 2015 (*Last_tillage*, *Last_plow*), and an indicator of tillage intensity calculated as the sum of the depth of all operations for the cropping of both crops in 2014–2015 (*Depth_cum*). A coefficient of 2 was applied for depth associated to plowing operations and 3 for the use of rotary power harrow (shallow but very disruptive).

Concerning chemical inputs, we recorded the amount of mineral and organic nitrogen (*Nmin*, *Norg*, kg.ha⁻¹) applied for the cropping of both crops in 2014–2015 and calculated the frequency treatment index for insecticides, herbicides and fungicides taken together (*TFI*), then for herbicides only (*TFI-Herb*) for winter wheat and fava bean respectively. We also indicated if the field was label with French Organic Certification for 3 years of more in 2015 (*Organic*) and if the farming system was specialized in crop production or if a livestock production of any kind exists on the farm (*Farm_type*).

Concerning intercrop management, we recorded whether the soil was bare, covered with crop residues or covered with cover crop during intercrop period before winter crops (*InterCrop*). We completed with the percentage of agricultural area of the farm where cover crops were used during 2013–2014 season (*CoverCrop_%*).

Concerning plant diversity, a Simpson Index was calculated on families of crop cultivated in 2014 ($1/\sum_i(n_i/N)^2$; n_i : number of crop species in family i cultivated on the farm; N : total number of crop species cultivated) and the area they covered (*CropDiv*). We also recorded the mean length of crop rotation (*Rotation*, mean number of years), the percentage of the agricultural area of the farm covered with legume crops (*Legum_percent*) and a Shannon diversity index on semi-natural habitats (woody, herbaceous, fallow, lithic or water habitats) existing on the farm (*SNHDiv*; $-\sum_i(n_i/N)\cdot\log_2(n_i/N)$; n_i : area in square meter of semi-natural habitat type i ; N : total area of semi-natural habitat, in square meter). Semi-natural habitats were identified with farmers from photographs in their 2014 European Union Common Agricultural Program forms.

Soil parameters

Organic carbon content (*C_organic* and *Organic_Matter*), pH (*pH_water*) and proportion of each size class (5 fractions without decarbonation: *Clay*, *Silt_fine*, *Silt_coarse*, *Sand_fine* and *Sand_coarse*) were measured from a homogenous mix of five soil cores (30 cm deep) collected from the treated half of each winter wheat field, taking care to avoid the 10m-wide border of the field. Soil analyses were performed by an approved laboratory (<http://www.galys-laboratoire.fr/>).

Landscape context

The landscape context was determined with a rapid assessment of land use type following Chabert et al. [3] from aerial photographs (© IGN - BD Ortho® 2014 edition) and expressed as percentages of the area within a 1.5 km radius from the center of the wheat field. We considered six land use types (*Wood*, *Cult*, *Fallow*, *Human*, *Hedg*, *Water*): woodlands, cultivated fields (crops or temporary grasslands, to avoid the difficulty to distinguish them on photographs, see [3]), fallow lands (including natural grassland), human-modified areas (e.g. buildings, roads, quarries), hedges and water surfaces (e.g. lakes, ponds, rivers).

Grain aphids, *Sitobion avenae*

Abundance of *Sitobion avenae* in each winter wheat field, was estimated during population growth peak, at winter wheat flowering (June 3–6, 2015). Thirty wheat ears were randomly collected in each field, taking care to avoid the 10 m-wide border of the field, and stored in hermetic containers. Containers were brought back to the lab and stored in a temperate room away from direct light. Within two days, containers were emptied over a counting grid and each wheat ear was carefully brushed to retrieve all aphids. Aphids were counted for the 30 ears together, i.e. one value per field. In some fields parasitism by parasitoids occurred and some aphids were dead and mummified. We counted mummified aphids in a separate count. Ears were also re-counted to ensure homogeneity of the counting.

Long hoverfly pupae, *Sphaerophoria scripta*

To assess the abundance of the aphidophagous larvae of the long hoverfly *Sphaerophoria scripta* (i.e. estimate of regulation of *Sitobion avenae* by *Sphaerophoria scripta*, see Chabert and Sarthou [2]) in each winter wheat field, long hoverfly pupae were counted on wheat ears at wheat maturity. Sampling was done immediately before harvest (June 26 – July 2, 2015), after *S. scripta* metamorphosed on the beards of wheat ears, leaving the empty shell of its pupal stage. In each field, wheat ears from 20 random plots were sampled using a hoop with a radius of 19.25 cm, taking care to avoid the 10m-wide border of the field. Pupae or pupal shells on the beards were counted by placing ears on a light surface. In some rare cases, another hoverfly pupae (*Episyrphus balteatus*) or coccinellidae larvae were observed. They were counted separately. Wheat ears from 6 to 12 plots (depending on field heterogeneity) were then pooled and stored in paper bags to be use for measurements of yields components.

Longhorn grain borer, *Calamobius filum*

Abundance of *Calamobius filum* (Coleoptera, Cerambycidae) was assessed after harvest (between July 3–July 23, 2015) by counting wheat stubbles clogged with shredded fiber by *C. filum* larva. The assessment was based on that particular behavior of the larva, which bore down the stem shortly before harvest and overwinter in the stubble, after clogging the opening to protect itself from the weather. Fiber clogs made by *C. filum* are easy to see on freshly cut stubbles and cannot be mistaken for some other natural clogs. Additionally, never more than one larva occupies a single stem, making fiber clogs count a rapid assessment of *C. filum* abundance in the field. Using the same sampling hoops that for hoverflies and yields, number of stubbles obstructed by fiber and total number of stubbles were counted at 20 random plots in each fields, taking care to avoid the 10m-wide border of the field.

Broad bean beetle, *Bruchus rufimanus*, and their parasitoid, *Triaspis thoracicus*

Broad bean beetles pressure on fava bean and their parasitism by a specialized parasitoid was estimated through observations on the grains. Immediately before harvest (June 26–July 2, 2015), 20 fava bean plants were randomly selected, taking care to avoid the 10m-wide border of the field. All beans were collected manually and pooled into emergence containers, i.e. 1L plastic jars, approximately 30 cm-long and pierced with 8 holes (3 cm in diameter) that were closed with 0.5 mm sieve. Emergence containers were stored outside protected from the sun, strong wind and rain. Beans were examined 5 months later to ensure that all beetles and parasitoids had emerged. To avoid misinterpretation due to possible insect evasion at the opening of

the container, insects were not kept and estimation were rather made on the number of emergence holes left on beans. Due to the significant size difference of *B. rufimanus* and its parasitoid *T. thoracicus*, emergence holes left by either bean beetle (neat round 4–5 mm diameter holes) or parasitoids (1.5–2.0 mm diameter holes) were different enough to enable estimation of bean beetle and parasitoid abundances based on number of small or big holes. Because some grains had more than one hole, number of undamaged grain and total of grains were also recorded to allow calculation of percentage of parasitized grains for instance.

Slugs community

Rather than an exhaustive slug community measurement, we focused on the actively feeding slug community and used a non-capture, non-lethal bait method using wheat bran. Measurements were conducted during wheat emergence (November 19–23, 2014) and at activity resumption after winter (April 14–20, 2015) the first year, and twice during wheat emergence (October 28–November 08, 2015 and November 26–December 05, 2015) the second year due to very dry conditions during the first period. Approximately 30 cl of organic wheat bran was left on the soil and spread over an area of 20 cm in diameter. The bait was left in the open on the soil for 36 h without any trapping system. Such baits were placed at least 15 m apart from each other on three random plots in each winter wheat field, avoiding the 15 m-wide border of the field. Plots were inspected for slugs at night between 10:30pm and 4:00am, which was identified as the period of peak feeding activity of the pest slugs. All slugs within a 50 cm square area around each bran bait were identified and counted in field. Taxonomic group or species that were possible to identify in fields were *Deroceras reticulatum*, *Arion hortensis*, *Milax gagates*, *Lehmmania valenciana*, *Limax maximus*, *Arion* gr. *ater*, *Arion* gr. *hortensis*, *Arion* gr. *fasciatus* and *Arion* gr. *subfuscus*. No sampling of specimens was performed.

Generalist predators

We estimated the number of opportunistic ground predators using simplified pitfall traps constructed from 14 cm-long cones with a 6 cm circular opening (a hard plastic beach ashtray with the cover removed). Traps were set in three sampling plots in winter wheat fields for 36 h, simultaneously with the slugs' community measurements (two periods: April 14–20, 2015 and October 28–November 08, 2015). Traps were filled with soapy water and salt to prevent escape and preserve trapped insects. They were set 5 m away from wheat bran baits for slugs and 15 m apart from each other and from the border of the field. Traps were collected by night and pooled within a single sample per field, stored in 70° ethanol. Ground beetles (Coleoptera, Carabidae), spiders (Araneae) and rove beetles (Coleoptera, Staphylinidae) were sorted and counted in the lab. No identification to genus or species were done, but special care was taken to identify and remove from counting potential individuals of genera *Zabrus* and *Amara*, most common phytophagous species of ground beetles in fields in this area. None were actually found for this dataset. Other invertebrates that may have been trapped were counted and coarsely identify as a comment in the dataset.

Soil erodibility

Soil erodibility was assessed through structural stability of soil aggregates and water infiltration rate. The later was measured as the time needed for the soil to absorb 125 cl of water poured rapidly into a 14 cm diameter metal cylinder sunk approximately 3 cm into the ground. Measurements were performed in April 2016 at three random plots within the wheat field, taking care to avoid the 10 m-wide border of the field. To ensure similar soil moisture when measuring infiltration, a first dose of 125 cl of water was poured into the cylinder and allowed to

infiltrate the soil before the second dose of 125 cl of water was poured and timed. In cases where infiltration was very low, the experiment was stopped after 3 min and height of remaining water was measured to calculate the volume of infiltrated water. In this dataset, raw values of actual volume infiltrated and corresponding time of infiltration are given for the first (*Vol_1, Time_1*) and second pouring (*Vol_2, Time_2*). Structural stability of soil aggregates was assessed based on a method for measuring water turbidity using a Secchi disk [4]. A small version (45 mm diameter) of the standard Secchi disk was plunged into the metal cylinder immediately after the second pouring of water and the depth of clear water from the water surface was immediately measured. This method relies on the assumption that measured turbidity is attributable to the quantity of fine particles that are likely to be detached from the soil due to rain and runoff. In cases where water infiltration was too rapid to allow measurement, additional water was poured to completely fill the cylinder. In the dataset, turbidity is given as the raw value of depth of clear water in the cylinder (*Turbidity*).

Crop yields

Winter wheat and fava bean yields were estimated by collecting grains immediately before harvest, simultaneously with Long hoverfly pupae and Broad bean beetle parasitoid sampling in 2015. To allow expression of yields in quintals per hectare for both crops, fava bean plant density was estimated by counting plants in three random plots of 1 m² and 20 plants were randomly sampled for weighting grains. For wheat, sampling effort was not homogenous among all fields because of very scarce development of wheat in some fields (6 to 15 for the samplings for hoverflies were kept for yields). Yield values are expressed per hectare, taking into account the number of hoop area sampled, yet to keep track of the sampling effort the number of samplings is recorded in the dataset (*Sampling_nber*). The harvested wheat ears were threshed using a square sieve (10 mm) threshing machine and grains were cleaned using a densimetric column separator (type INRA 240). Fava beans were manually shelled. For both crops, samples were then dried at 80°C for 48 h and weighed immediately (weight at 0% humidity). For wheat, a subsample was weighed and the number of grains determined with a grain counter to calculate the weight of one thousand kernels. Same protocols were applied in 2016 for both crops.

Fungal diseases

We estimated fungal leaf disease infection on both crop with a standardized six-level scale (See Supplementary Materials) evaluating leaves coverage by symptoms of diseases. After thorough inspection of plants in two diagonal transects, fields were scored from 0 to 5, corresponding to the predominant score of observed plants. One score was given for each field, all leaf diseases combined (mainly Septoriosiis, rusts and Helminthosporiosis for wheat; Anthracnose and Botrytis for fava bean). For informational purposes, the proportion of symptoms attributable to each disease was coarsely estimated and noted down. Grain samples from wheat yield measurements were also analyzed at INRA laboratory UR1264 MYCSA with high performance liquid chromatography and mass spectrometry (HPLC-MS) for concentrations (ng.g⁻¹) of Zearalenone and 5 type B trichothecene mycotoxins: Deoxynivalenol, 15-Acetyl-deoxynivalenol, 3-Acetyl-deoxynivalenol, Nivalenol and Fusarenone X.

Mycorrhiza

Winter wheat roots colonization by mycorrhiza was assessed during 2015–2016 growth season. Twenty wheat plants were collected in May 2016 at 5 random plots in the field, taking care to avoid the 10m-wide border of the field. Whole plant and its roots were collected. Roots were

carefully separated in the lab and immediately frozen (-20 °C) for conservation. Samples were defrosted in water at ambient temperature, twelve roots were randomly chosen and sliced into 1 cm fragments. Root fragments were colored following Vierheilig et al. [5] method and observed under microscope to determine parameters of mycorrhizal colonization (adapted from Trouvelot et al. [6]): frequency of mycorrhiza (*Mycor_freq*) and arbuscules (*Arb_freq*) in the root system, intensity of the mycorrhizal colonization (*Mycor_inten*) and mean number of arbuscules (*Arb_nb*) in the root system, intensity of the mycorrhizal colonization (*Mycor_inten_frag*) and arbuscular structures (*Arb_inten_frag*) in the root fragments. With following calculation:

$$\text{Mycor_freq (\%)} = (\text{number of fragments with mycorrhiza} / \text{total number of fragment}) * 100$$

$$\text{Arb_freq (\%)} = (\text{number of fragments with arbuscule} / \text{total number of fragment}) * 100$$

$$\text{Mycor_inten (\%)} = (95 * n_5 + 70 * n_4 + 30 * n_3 + 5 * n_2 + n_1) / (\text{number total of fragment})$$

where n_5 = number of fragments rated 5; n_4 = number of fragments 4 etc. (see Trouvelot et al.

[6])

$$\text{Arb_nb} = \text{total number of arbuscule} / \text{total number of fragment}$$

$$\text{Mycor_inten_frag (\%)} = \text{Mycor_inten} * (\text{number total of fragments}) / (\text{number with mycorrhiza})$$

$$\text{Arb_inten_frag} = \text{total number of arbuscule} / \text{number of fragment with arbuscule}$$

Declaration of Competing Interest

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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Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.dib.2020.105827.

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