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► **To cite this version:**

Marie-Sophie Dedieu, Thomas Poméon, Baptiste Girault, Philippe Martin, Christian Bockstaller. A dataset of crop succession indicators for 2015–2021. *Data in Brief*, 2024, 57, pp.110907. <10.1016/j.dib.2024.110907>. <hal-04697182>

HAL Id: hal-04697182

<https://hal.inrae.fr/hal-04697182v1>

Submitted on 4 Jul 2025

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Data Article

A dataset of crop succession indicators for 2015–2021



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ARTICLE INFO

Article history:

Received 16 May 2024

Revised 19 July 2024

Accepted 29 August 2024

Available online 4 September 2024

Dataset link: [Indicateurs sur les successions culturelles 2015–2021 \(Original data\)](#)

Keywords:

Crop sequences

Crop diversity

Arable land

Agri-environmental indicators

Land parcel identification system

ABSTRACT

The current agroecological transition of agriculture pushes to a diversification of cropping systems, which requires quantified data describing crop successions. “Crop successions indicators 2015–2021” dataset provides a set of twenty synthesis indicators to characterize crop diversity, crop seasonality, particular components of crop successions and duration of crop rotations. Indicators are computed for a seven-year period from 2015 to 2021. Data source are raw crop sequences open access dataset. Indicators are available for municipalities, departments, regions and the whole mainland France, for arable land. A group of experts in agronomy has been associated to this work, in order to define relevant themes, relevant indicators and relevant indicator definitions. This dataset could be useful to characterize agricultural practices on a given territory, for researchers, local actors as decentralized state services, water agencies, territorial collectivities, chambers of agriculture, or agricultural cooperatives. Proposed indicators could be useful for policy makers to monitor the evolution of cultivation practices, in order to design, implement or evaluate measures targeting cultivation practices.

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Specifications Table

Subject	Agronomy and Crop Science
Specific subject area	Indicators to characterize crop successions and crop rotations at the municipality, department, and region levels for mainland France on arable land.
Data format	.csv file (a dataset with numbers) .xlsx file (two datasets with labels, units, and definitions of the variables) Filtered Note: raw data are filtered to remove uncomplete sequences, and to select sequences with crops cultivated on arable land (in particular, exclusion of sequences with perennial crops, permanent grasslands, or only with fallow land).
Type of data	Table
Data collection	Treatments of crop sequences dataset with Onyxia SSP Cloud Datalab, R Studio service: addition of information on crop classification, data filtering, computing indicators at the sequence level, and geographical gathering.
Data source location	Country scale: mainland France. Raw data source used: Girault, Baptiste; Martin, Philippe, 2023, "Séquences de culture, France, 2015-2021", Recherche Data Gouv, V1 available here: https://doi.org/10.57745/PMD42J
Data accessibility	Repository name: recherche.data.gouv Data identification number: https://doi.org/10.57745/SHXHP4 Direct URL to data: https://doi.org/10.57745/SHXHP4 Instructions for accessing these data: open access.
Related research article	None.

1. Value of The Data

- Crop succession is an agronomical lever to break the cycle of weeds and pathogens, and for soil fertility management.
- Lengthening and diversifying crop rotations are encouraged by public authorities.
- This dataset could be useful to characterize agricultural practices on a given territory or for the whole mainland France, for researchers, local actors, as decentralized state services, water agencies, territorial collectivities, chambers of agriculture or agricultural cooperatives.
- Proposed indicators could be useful for policy makers, to monitor the evolution of cultivation practices, in order to design, implement or evaluate measures targeting cultivation practices, for instance some agri-environmental measures, or criteria to reach good agricultural and environmental conditions of the common agricultural policy.
- Results at the municipality scale can be gathered at other geographical scales depending on the user needs, as watershed or agricultural districts.

2. Background

The challenges of characterising crop rotations in agriculture are not new and are the subject of various studies and datasets around the world. In the United States, the Economic Research Service of the Department of Agriculture produces crop sequences datasets, over eight-year periods, using satellite imagery [1]. Crop sequences information can be useful for crop type prediction [2]. The Government of Canada has also been producing data on crop rotations and their sustainability, at plot level, since 2009 [3].

At the European Union level, the need for better knowledge of farming practices, and in particular crop rotations, considered as a key of agroecological transition, has been the subject of recent work [4]. As area declarations made for Common Agricultural Policy support are not homogeneous between Member States, data from the Land Use Cover Area frame statistical Survey (LUCAS) have been mobilised in order to define eight types of crop sequences.

In France, as a major lever of agro-ecological practices, lengthening and diversification of crop rotations are encouraged by public authorities. This is particularly the case in the French Strategic Plan of the common agricultural policy 2023–2027 [5]. Requirements on crop rotations were included in payment conditionality constraints [6], even if they have been recently withdrawn at the European level [7]. This context underlines the need of quantified data describing crop successions or crop sequences, to supplement data from public agricultural statistics, often produced on the basis of samples. The reference survey, called agricultural practices, is carried out approximately every 5 years and is only representative at regional level. Crop succession is defined by the nature of the crops and their order of succession in the same parcel, whereas crop rotation refers to cyclical crop successions.

Since 2021, crop sequences computed from the annual French Land Parcel Identification System have been on open access [8]. However, these data remain potentially difficult to handle to produce synthesis information, as they contain over 14 million sequences, over 300 crop codes, distributed within departmental heavy geographical files. To provide new information on crop rotation practices, we propose a set of synthetic data with relevant indicators as a service of the Rural Development Observatory (ODR). ODR is a unit of the French National Research Institute for Agriculture, Food and Environment, which develops resources and data on public policies and agricultural systems.

3. Data Description

The dataset [9] is structured with information by geographical entity as rows (nearly 35 000 rows) and the various indicators as columns (185 columns). The finest geographical level proposed is the municipal level. An extract of the dataset extract is shown in Fig. 1.

Crop succession indicators belongs to four themes. All of them are computed on a seven-year period from 2015 to 2021. They are available for municipalities, departments, regions and the whole mainland France. A weighted mean by area is proposed for most indicators. Additional information about the area concerned by the different values or intervals of values are also available.

LIB_GEO	REGION	LIB_REG	INSEE_DEP	LIB_DEP	INSEE_COM	LIB_COM	N_CULT	SURF_1CULT	SURF_2CULT
31_Haute-Garonne	76	Occitanie	31	Haute-Garonne	00	Ensemble département	3.642165	6522.41	33514.59
31001_Agassac	76	Occitanie	31	Haute-Garonne	31001	Agassac	3.775670	3.11	40.40
31002_Aignes	76	Occitanie	31	Haute-Garonne	31002	Aignes	3.937455	0.00	122.43
31003_Aigrefeuille	76	Occitanie	31	Haute-Garonne	31003	Aigrefeuille	3.281243	0.00	73.56
31004_Ayguesvives	76	Occitanie	31	Haute-Garonne	31004	Ayguesvives	3.764192	0.00	62.39
31005_Alanc	76	Occitanie	31	Haute-Garonne	31005	Alanc	3.475539	1.13	42.97
31006_Albiac	76	Occitanie	31	Haute-Garonne	31006	Albiac	3.798797	0.00	29.44
31007_Ambax	76	Occitanie	31	Haute-Garonne	31007	Ambax	3.386069	7.25	62.76
31008_Ananc	76	Occitanie	31	Haute-Garonne	31008	Ananc	3.831715	2.90	97.12

Fig. 1. Dataset extract for some indicators and municipalities in the department 31, region 76: mean number of crops (N_CULT), area with one crop (SURF_1CULT) or two crops (SURF_2CULT), in hectares.

General information is included in the data set.

General information

Location information

- LIB_GEO: Name of the geographical level.
- REGION: Region codes.
- LIB_REG: Region name.
- INSEE_DEP: Department codes.
- LIB_DEP: Department names.
- INSEE_COM: Municipality code.
- LIB_COM: Municipality name.

Description of sequences and sequence types

- X_NB_PARCELLES: Number of sequences for X scope. X can be all of the sequences or a crop type selection.
- X_SURFACE: Sequences area for X scope. X can be all of the sequences or a crop type selection.

The first theme is about crop diversity with a set of seven main indicators.

Theme 1. Diversity of crops within successions

Number of crops (species)

- N_CULT: Area weighted mean number of crops per sequence.
- SURF_iCULT: Area of sequences with i crops.

Reverse Simpson index, for crops ($1/\sum p_i^2$, with p_i proportion of crop i)

- INV_SIM: Area weighted mean Reverse Simpson Index per sequence.
- SURF_INV_SIM_i: Area of sequences within a Reverse Simpson Index specified interval.

Maximum of occurrence of a same crop within a succession

- N_MAX: Area weighted mean maximum occurrence of a same crop within a succession. For each sequence, we count the number of occurrences of each crop. The maximum is kept. Then, the mean is calculated for the aggregations.
- SURF_FREQMAXi: Area of sequences with i value as a maximum occurrence of the same crop.

Number of botanical families per sequence

- N_FAM: Area weighted mean number of botanical families per sequence.
- SURF_iFAM: Area of sequences with i botanical families.

Reverse Simpson index, for botanical families ($1/\sum p_j^2$, with p_j proportion of botanical family j)

- INV_SIM_F: Area weighted mean Reverse Simpson Index for botanical families per sequence.
- SURF_INV_SIM_F_i: Area of sequences within a Reverse Simpson Index specified interval for botanical families.

Maize monoculture

- SURF_MONO_MAÏS: Area of sequences with 7 maizes.
- SURF_QUASIMONO_MAÏS: Area of sequences with 6 or 7 maizes.

Diversity of crop combinations, regardless of crop order or crop repetitions

- NB_MOTIF_PCT50: Number of combinations representing 50 % of the arable area.
 - NB_MOTIF_PCT: Number of combinations representing 80 % of the arable area.
-

The second theme is related to crop seasonality with a set of five main indicators.

Theme 2. Seasonality of crops within successions

Number of autumn crops (winter rape exclusively)

- N_AU: Area weighted mean number of autumn crops per sequence.
- SURF_iAU: Area of sequences with i autumn crops.

Number of winter crops

- N_HI: Area weighted mean number of winter crops per sequence.
- SURF_iHI: Area of sequences with i winter crops.

Number of spring crops

- N_PTPTS: Area weighted mean number of spring crops per sequence.
- SURF_iPTPTS: Area of sequences with i spring crops.

Number of summer crops

- N_ET: Area weighted mean number of summer crops per sequence.
- SURF_iETE: Area of sequences with i summer crops.

Indicator of equilibrium between autumn-winter crops and spring-summer crops

- SURF_AUTHI_xsur7: Area of sequences with x autumn or winter crops upon 7. Only calculated for sequences with 7 qualified crops.
- SURF_SAIS: Area of sequences for which all of the crops have a season qualification. Temporary grasses, forage legumes and fallow land are not concerned.

The third theme is about three components of crop successions.

Theme 3. Focus on particular components of successions

Number of leguminous crops

- N_LEG: Area weighted mean number of leguminous crops (as a botanical family).
- SURF_iLEG: Area of sequences with i leguminous crops.

Number of temporary grasses

- N_PT: Area weighted mean number of temporary grasses per sequence.
- SURF_iPT: Area of sequences with i of temporary grasses.
- N_PT_CONS: Area weighted mean number of consecutive temporary grasses per sequence.
- SURF_iPT_CONS: Area of sequences with i consecutive temporary grasses.

Number of long intercrop periods (A long intercrop period occurs between two spring or summer crops, between a winter crop followed by a spring or summer crop, or between an autumn crop followed by a spring or a summer crop.)

- N_IL: Area weighted mean number of long intercrop periods.
 - SURF_iIL: Area of sequences with i long intercrop periods.
-

The last theme refers to crop rotation duration, with five main indicators, calculated only if at least two identical crops are counted in a sequence. If there are more than one return time within a sequence, the mean return time by sequence is calculated.

Theme 4. About crop rotation duration

Wheat return time

- BR_BLE: Area weighted mean wheat return time.
- SURF_DRi_BLE: Area of sequences with a wheat return time of i .
- SURF_DR_BLE: Area of sequences with almost two wheats, on which a return time is computed.

Potato return time

- DR_PDT: Area weighted mean potato return time.
- SURF_DRi_PDT: Area of sequences with a potato return time of i .
- SURF_DR_PDT: Area of sequences with almost two potatoes, on which a return time is computed.

Rapeseed return time

- DR_CZX: Area weighted mean rapeseed return time.
- SURF_DRi_CZX: Area of sequences with a rapeseed return time of i .
- SURF_DR_CZX: Area of sequences with almost two rapeseeds, on which a return time is computed.

Sequence with at least two identical crops successively

- SURF_CULTCONS: Area of sequences with two identical crops successively.

Short return time sequences

- SURF_DR_COURT: Area of sequences with a short return time (defined when the number of crops is three or less than three, or when there are two identical crops successively). Temporary grasslands, forage legumes or fallow land not taken into account.
-

Associated metadata are in *indicateurs_successions_2015_2021_metadata.xlsx*:

- VARIABLE: Variable name.
- LIBELLE: Variable wording.
- UNIT: Variable units.
- DEFINITION_PRECISIONS: Definition of the variable, precisions. Users can find here useful information for data understanding.

Information related to crop classification used is in *NOMENCLATURE_CULTURES_RPG.xlsx*:

- CULTCOD: Crop code.
- CULTLIB: Crop name.
- NOMEN_PAC: Common agricultural crop groups.
- TYPE_PAC: Common agricultural policy area type.
- FAMBOT: Crop botanical family.
- SAISON: Crop season classification.
- CODREV: New crop codes given at the specie level (for instance to gather grain maize and maize harvested in green).

4. Experimental Design, Materials and Methods

A group of eleven experts in agronomy has been associated to this work, in order to define relevant themes, relevant indicators and relevant indicator definitions.

Indicators characterizing diversity of crops within successions (first theme) have been selected as diversified rotations are a lever to reduce the use of pesticides [10], and a lever to activate

natural regulation of pests and diseases [11]. Reverse Simpson Index is included in this first theme as it is easily interpretable and it has already been proposed for crop rotations indicators [12]. For instance, if there are seven different crops in a seven-year sequence, Reverse Simpson Index equals 7 while, if there is only one crop in the seven-year sequence, it equals 1. The focus on maize monoculture is justified as it represents the great majority of areas with only one crop during the period (81 %). These areas are often conducted in high input systems associated with harmful environmental impacts [13].

Indicators belonging to the second theme, seasonality of crops within successions, are particularly related to weed management or water requirements issues. Within the third theme, indicators about leguminous crops are interesting regarding their potential to reduce the use of mineral nitrogen fertilizer and their other agronomical interests [14]. Temporary grasses are known for their advantages for carbon soil storage [15], and other ecosystem services as soil conservation, soil water retention, or biological control of pests [16]. Number of long intercrop periods indicator is also available, as a potential of cover cropping areas, or bare soil areas.

The last theme gathers indicators related with return time of a same crop within a succession. Return time indicators have already been used to characterize crop rotations [17]. If there are more than two crops of interest (wheat, rapeseed, potatoes) within a sequence, return time is defined as the average observed return time.

Dataset to characterize crop successions (*indicateurs_successions_2015_2021.csv*) is computed from raw crop sequences dataset related to the 2015–2021 period [8,18], as a reuse of an open access dataset. Data processing consists in four steps.

- (1) Addition of geographical information and crop classification. Each sequence is located in a municipality by its last parcel id in order to delete heavy geometries.
- (2) Data filtering, to remove uncomplete sequences, and to target sequences related to arable land is applied.
- (3) Computation of indicators is done at the sequence level.
- (4) Geographical gathering, from individual sequence data to results at different administrative levels (Fig. 2).

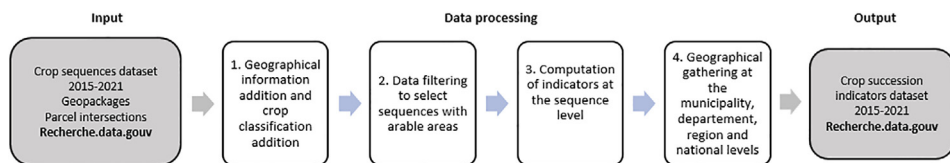


Fig. 2. Data processing.

Data processing has been realised with the Onyxia SSP Cloud open platform for state data scientists and state statisticians, with R Studio service [19].

A new edition of the raw dataset, 2015–2022, is now available [20]. Depending on feedback from potential users of the data, the ideal would be, resources permitting, to produce an updated set of indicators over a longer period of 8 years (2015–2022) or over a comparable period of 7 years (2016–2021). The information contained in the metadata is as explicit as possible (definition of indicators, crop classification used), so that a user can repeat the calculations made.

Limitations

The French Land Parcel Identification System (LPIS), used to build sequence dataset, does not include agricultural land from farms which are not subject to Common Agricultural Policy payments. That's represents less than 5 % of total agricultural land, mainly dedicated to vineyards, orchards and market gardening.

The scope of the dataset is limited to arable land. Complementary work could be carried out on permanent pasture or perennial crops, or with the new edition of the raw dataset 2015–2022.

This dataset does not include any information about cover crops, only main crops are considered. Moreover, the sequence dataset does not include any information at the farm level, as this information is not included in the LPIS public version.

Each indicator refers to a seven-year period, and has to be interpreted according to this duration. Return times of wheat, potato and rapeseed are only computed when there is a minimum of two crops of interest in the sequence. We encourage users to consult the metadata file detailing the definition of each indicator and the crop classification file. Filtering criteria are also explained in this file.

Ethics Statement

This work does not involve human subjects, animal experiments, or any data collected from social media platforms.

This manuscript adheres to ethics in publishing standards.

Data Availability

[Indicateurs sur les successions culturales 2015–2021 \(Original data\)](#) (Recherche data gov).

CRedit Author Statement

Marie-Sophie Dedieu: Conceptualization, Software, Validation, Data curation, Writing – original draft; **Thomas Poméon:** Writing – review & editing, Supervision, Conceptualization; **Baptiste Girault:** Resources, Conceptualization, Writing – review & editing; **Philippe Martin:** Resources, Conceptualization, Writing – review & editing; **Christian Bockstaller:** Conceptualization, Writing – review & editing.

Acknowledgments

The author acknowledges participants in the working group dedicated to this work (Guillaume Adeux, Rémy Ballot, Nicolas Guilpart, Mae Guinet, Olivier Lision, Benjamin Nowak, Antoine Méssean, Nicolas Munier-Jolain, Olivier Therond). This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

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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