

# Package ‘SoilManageR’

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**Type** Package

**Title** Calculate Soil Management Indicators for Agricultural Practice Assessment

**Version** 1.0.1

**Description** Calculate numerical agricultural soil management indicators from on a management timeline of an arable field. Currently, indicators for carbon (C) input into the soil system, soil tillage intensity rating (STIR), number of soil cover and living plant cover days, N fertilization and livestock intensity, and plant diversity are implemented.

The functions can also be used independently of the management timeline to calculate some indicators. The package contains tables with reference information for the functions, as well as a '\*.xlsx' template to collect the management data.

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**Encoding** UTF-8

**LazyData** true

**RoxygenNote** 7.3.1

**Imports** magrittr (>= 2.0.3), dplyr (>= 1.1.4), lubridate (>= 1.9.2), ggplot2 (>= 3.4.4), ggthemes (>= 5.0.0), tidyr (>= 1.3.0), tibble (>= 3.2.1), readxl (>= 1.4.3), Rdpack (>= 2.6)

**Depends** R (>= 2.10)

**Suggests** knitr, rmarkdown, testthat (>= 3.0.0)

**Config/testthat/edition** 3

**VignetteBuilder** knitr

**RdMacros** Rdpack

**URL** <https://gitlab.com/SoilManageR/>

**BugReports** <https://gitlab.com/SoilManageR/SoilManageR/-/issues>

**NeedsCompilation** no

**Author** Olivier Heller [cre, aut] (<<https://orcid.org/0000-0002-5918-4161>>),  
Raphaël Wittwer [ctb] (<<https://orcid.org/0000-0002-2129-7195>>)

**Maintainer** Olivier Heller <[olivier.heller@agroscope.admin.ch](mailto:olivier.heller@agroscope.admin.ch)>

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arrange\_management\_df *arrange management\_df by date, category*

---

### Description

the function arranges the management\_df by date and by category of operations. The order of the operations is harvest, fertilizer\_application, crop\_protection, tillage, sowing, irrigation, other

### Usage

```
arrange_management_df(var_MGMT_data, include.combination = TRUE)
```

### Arguments

var\_MGMT\_data    management\_df to be arranged  
include.combination  
                  logical, if the combinations should considered Default is TRUE

**Value**

a rearranged management\_df

**Examples**

```
#rearrange EXAMPLE data
arrange_management_df(EXAMPLE_data)
```

---

calculate\_indicators *Calculate all soil management indicators*

---

**Description**

Checks the management\_df for consistency with the `check_management_df()` function. Then it calculates the `C_input()`, `tillage_intensity()`, `soil_cover()`, `plant_diversity()`, `N_input()` and `productivity_indicator()`.

**Usage**

```
calculate_indicators(var_MGMT_data)
```

**Arguments**

var\_MGMT\_data a management\_df with a management history

**Value**

data frame with indices per year

**See Also**

- `check_management_df()`
- `C_input()`
- `tillage_intensity()`
- `soil_cover()`
- `N_input()`
- `plant_diversity()`
- `productivity_indicator()`

**Examples**

```
#example input
calculate_indicators(EXAMPLE_data)
```

---

check\_management\_df     *Check management\_df for consistency*

---

### Description

The function checks objects of the class `management_df()` for internal consistency. It formally checks the class and the column names. Additionally, the function checks if dates are consistently increasing and if all organic amendments, tillage and sowing devices and crops are in the relevant look-up-tables. Furthermore, the amount of organic amendments (<100t/ha) and N fertilizer (<100kgN/ha) application rates per event are checked. The depth of tillage operations are compared with the min and max depth from the `STIR_value_LUT`. Finally, the order of tillage, sowing and harvest operations are checked for plausibility (see details for more information).

### Usage

```
check_management_df(var_MGMT_data)
```

### Arguments

`var_MGMT_data`     an object of the `management_df()` class

### Details

The order of tillage, sowing and harvest operations are checked with the following assumptions:

- after "stubble\_cultivation" the following operations are allowed: "stubble\_cultivation", "primary\_tillage", "seedbed\_preparation", "sowing\_main\_crop", "sowing\_cover\_crop"
- after "primary\_tillage" the following operations are allowed: "seedbed\_preparation", "sowing\_main\_crop", "sowing\_cover\_crop"
- after "seedbed\_preparation" the following operations are allowed: "stubble\_cultivation", "seedbed\_preparation", "sowing\_main\_crop", "sowing\_cover\_crop"
- after "sowing\_main\_crop" the following operations are allowed: "sowing\_main\_crop", "harvest\_main\_crop"
- after "sowing\_cover\_crop" the following operations are allowed: "stubble\_cultivation", "primary\_tillage", "seedbed\_preparation", "sowing\_main\_crop", "sowing\_cover\_crop"
- after "harvest\_main\_crop" the following operations are allowed: "harvest\_main\_crop", "straw\_removal", "stubble\_cultivation", "primary\_tillage", "seedbed\_preparation", "sowing\_main\_crop", "sowing\_cover\_crop"
- after "straw\_removal" the following operations are allowed: "harvest\_main\_crop", "straw\_removal", "stubble\_cultivation", "primary\_tillage", "seedbed\_preparation", "sowing\_main\_crop", "sowing\_cover\_crop"

Additionally, there are exceptions for potato crops: "bedder" can be used after a "potato\_planter" and "mulching" can be applied before a "potato\_harvester"

**Value**

a test\_report list (only returned if some tests failed)

**See Also**

- [management\\_df\(\)](#) for creating an management\_df
- [management\\_df\\_from\\_excel\(\)](#) for importing a management\_df from an excel template

**Examples**

```
#example input
check_management_df(EXAMPLE_data)
```

---

CN\_input\_amendments     *Estimate C and N inputs of organic amendments*

---

**Description**

Estimates the carbon (C) and total nitrogen (N) input into the soil system by organic amendments.

**Usage**

```
CN_input_amendments(
  amount,
  amd_type = NA,
  DMC = NA,
  C_content = NA,
  N_content = NA,
  return.comment = FALSE,
  concentration_liquids = 0.5
)
```

**Arguments**

amount	Amount of organic amendment in fresh weight (t/ha)
amd_type	Type of organic manure, there are default values available for "Slurry_dairy_cow", "Manure_dairy_cow", "Slurry_cattle", "Manure_cattle", "Slurry_pig", "Manure_pig", "Compost", "Biorga_Quick_12N" and others (see CN_input_amendments_LUT)
DMC	dry matter content of the organic amendment (gDM/kgFM)
C_content	C content of the dry matter (gC/kgDM)
N_content	N content of the dry matter (gN/kgDM)
return.comment	(optional): logical value if comments are returned or not. Default = FALSE
concentration_liquids	concentration factor for liquid amendments. Default value is .5.

## Details

The C and N inputs by organic amendments is calculated based on the dry matter content (DMC) and the C and N content of the dry matter of the amendment. If the contents are not specified, default values from the Swiss fertilizer recommendations (Sinaj et al. 2017) are assumed. The default values are available the look-up-table CN\_input\_amendments\_LUT For all slurries and liquid amendments (DMC < 150 g/kg), a dilution of 50% is assumed if default DMC values from the CN\_input\_amendments\_LUT are used.

## Value

a tibble with the following parameters:

- C\_input\_org: C input by organic ammendment (kgC/ha)
- N\_input\_org: N input by organic ammendment (kgN/ha)
- comment (optional): Source of information on properties of organic amendment

## References

Sinaj S, Charles R, Baux A, Dupuis B, Hiltbrunner J, Levy Häner L, Pellet D, Blanchet G, Jeangros B (2017). “Grundlagen für die Düngung landwirtschaftlicher Kulturen in der Schweiz (GRUD): Düngung von Ackerkulturen.” *Agrarforschung Schweiz, Spezialpublikation*, **Chapter 8**(6), 1–46. <https://ira.agroscope.ch/en-US/Page/Publikation/Index/36799>.

## See Also

- `C_input()` to calculate C inputs for a management\_df
- `N_input()` to calculate N inputs for a management\_df
- `C_input_crops()` to calculate C inputs by crops
- `C_input_cover_crops()` to calculate C input for cover crops
- `CN_input_amendments_LUT()` for the look-up-table for organic amendments reference values

## Examples

```
#example where amount, dry matter content, C and N content are known.
CN_input_amendments(40, DMC = 300, C_content = 300, N_content = 30)
```

```
#example where only amount and type of amendment are known
CN_input_amendments(20, "Manure_pig")
```

```
#example of a diluted slurry
CN_input_amendments(20, amd_type = "Slurry_dairy_cow", DMC = 50)
```

---

 CN\_input\_amendments\_LUT

*Look-up-table with default values to calculate C and N inputs by organic amendments*

---

## Description

The dataset is a look-up-table that is used to calculate the carbon (C) and nitrogen (N) inputs by organic amendments with the function ‘SoilManager::CN\_input\_amendments()’. The data set is produced from the excel table ‘CN\_input\_amendments\_LUT.xlsx’ file under ‘/inst/extdata/’.

## Usage

CN\_input\_amendments\_LUT

## Format

A tibble with 27 rows and 7 columns:

**Amendment** Name of the amendment

**DMC** Dry matter content of the amendment [gDM/kgFM]

**OM** Organic matter content of the amendment, relative to its fresh weight [gDM/kgFM]

**C\_content** Carbon content of the amendment, relative to its dry matter [gC/kgDM]

**N\_tot** Total N content of the amendment, relative to its dry fresh weight [gN/kgFM]

**N\_content** Nitrogen content of the amendment, relative to its dry matter [gN/kgDM]

**Comment** Comment, e.g. source of the information. These lines are shown as part of the function output

## References

Compilation of Values from the SoilX project. Please check the ‘CN\_input\_amendments\_LUT.xlsx’ file under ‘/inst/extdata/’ for more information

Sinaj S, Charles R, Baux A, Dupuis B, Hiltbrunner J, Levy Häner L, Pellet D, Blanchet G, Jeangros B (2017). “Grundlagen für die Düngung landwirtschaftlicher Kulturen in der Schweiz (GRUD): Düngung von Ackerkulturen.” *Agrarforschung Schweiz, Spezialpublikation*, **Chapter 8**(6), 1–46. <https://ira.agroscope.ch/en-US/Page/Publikation/Index/36799>.

Richner W, Flisch R, Mayer J, Schlegel P, Zähler M, Menzi H (2017). “Grundlagen für die Düngung landwirtschaftlicher Kulturen in der Schweiz (GRUD): Eigenschaften und Anwendung von Düngern.” *Agrarforschung Schweiz, Spezialpublikation*, **Chapter 4**(6), 1–24. <https://ira.agroscope.ch/en-US/publication/41476>.

---

`C_input`*Estimate carbon input*

---

### Description

`C_input()` estimates the carbon (C) input into the soil system per year of a `management_df`.

### Usage

```
C_input(var_MGMT_data, extended.output = FALSE)
```

### Arguments

`var_MGMT_data` a `management_df` that contains the management information

`extended.output`

an optional logical value.

- If FALSE, C input values are aggregated by year.
- If TRUE, a tibble with daily resolution is returned.
- Default value is FALSE

### Details

The function takes a `management_df` as input and returns a C input values per year in the `management_df`.

Alternatively, it can return a tibble with all management operations and their respective C input values.

The functions calculates the C input with the `C_input_crops()`, `C_input_cover_crops()` and `CN_input_amendments()` functions.

### Value

- By default, a tibble with C input values (total and by category) by year is returned.
- If `extended.output = TRUE`, a tibble with all management operations and their respective C inputs is returned.

### See Also

- `calculate_indicators()` to calculate all management indicators for a `management_df`
- `C_input_crops()` to calculate C input for crops
- `C_input_cover_crops()` to calculate C input for cover crops
- `CN_input_amendments()` to calculate C (and N) inputs for organic amendments



**Examples**

```
#example that returns annual C input values
C_input(EXAMPLE_data)

#example that returns a tibble with all operations that have a C input
C_input(EXAMPLE_data, extended.output = TRUE)
```

---

C\_input\_cover\_crops     *Estimate C inputs by cover crops*

---

**Description**

This function estimates the Carbon (C) input into the soil system by cover crops based on the duration of the cover crop stand.

**Usage**

```
C_input_cover_crops(
  abvg_biomass = NA,
  days = 180,
  min_C_abvg = 1253,
  min_days = 180,
  max_C_abvg = 1916,
  max_days = 240,
  Cc_biomass = 450
)
```

**Arguments**

abvg_biomass	(optional): Dry weight of aboveground biomass of the cover crop (tDM/ha)
days	(optional): Number of days that the cover crop was established. If no value is provided, mind_days is assumed (days)
min_C_abvg	(optional): Minimal above ground C that the cover crop produces, given it is established for the min_days number of days. Default value is 1.253 (kgC/ha)
min_days	(optional): Number of days where the interpolation of the biomass starts. The default value is 180 (days)
max_C_abvg	(optional): Maximum biomass that the cover crop can produce. Default value is 1.916 (kgC/ha)
max_days	(optional): Number of days when the maximum biomass of the cover crop is reached. The default value is 240 (days)
Cc_biomass	(optional): Assumed C content of the cover crop biomass. Default value is 450 (kgC/tDM)

## Details

`C_input_cover_crops()` internally calls `C_input_crops()` to calculate the different C fractions. The C in the above ground biomass ( $C_{Product}$ ) is a function of the time a cover crop is established. A minimum and a maximum cover crop biomass are assumed at 180 and 240 days respectively, and linearly interpolated for the period in between.

$$C_{Product} = \begin{cases} 1253 \text{ kgC/ha} , & \text{duration} < 180 \text{ days} \\ 1253 \text{ kgC/ha} + (\text{duration} - 180 \text{ days}) * \frac{663 \text{ kgC/ha}}{60 \text{ days}} , & 180 \text{ days} \leq \text{duration} \leq 240 \text{ days} \\ 1916 \text{ kgC/ha} , & \text{duration} > 240 \text{ days} \end{cases}$$

Assumptions on the C inputs at day 180 and 240 are based on values extracted from Seitz et al. (2022).

The remaining parameters to calculate the C input by cover crops are HI = 1, SER = 3.67, and REF = 0.31, all derived from Seitz et al. (2022).

Note, that with these assumptions the C input of short term cover crops (e.g. few weeks) is overestimated.

The function `C_input_cover_crops()` estimates the C input by applying the assumptions mentioned above. Alternatively, the user can supply an above ground biomass and a CC of the biomass, or other parameters to estimate the C input by cover crops.

## Value

a tibble with the following parameters:

- `C_input_product`: Estimated soil carbon input from product (i.e., the cover crop aboveground biomass) (kgC/ha),
- `C_input_straw`: Estimated soil carbon input by straw or other residues (typically 0 for cover crops) (kgC/ha),
- `C_input_root`: Estimated soil carbon input by roots (kgC/ha),
- `C_input_exudate`: Estimated soil carbon input by roots (kgC/ha),
- `C_input_total`: Total estimated Soil carbon input, sum of `C_input_straw`, `C_input_root`, `C_input_exudate` (kgC/ha),

## References

Seitz D, Fischer LM, Dechow R, Wiesmeier M, Don A (2022). “The potential of cover crops to increase soil organic carbon storage in German croplands.” *Plant and Soil*, **488**(1-2), 157–173. [doi:10.1007/s1110402205438w](https://doi.org/10.1007/s1110402205438w).

## See Also

- `C_input()` to calculate C inputs for a `management_df`
- `C_input_crops()` to calculate C input for crops
- `CN_input_amendments()` to calculate C (and N) inputs for organic amendments
- `C_input_crops_LUT()` for the look-up-table for crop reference values

**Examples**

```
#example when only the duration is known
C_input_cover_crops(days = 205)

#example if the cover crop biomass is known
C_input_cover_crops(abvg_biomass = 2.5, Cc_biomass = 450)

#example with custom assumptions on the above ground biomass development over time
C_input_cover_crops(days = 60, min_C_abvg = 600 , min_days = 50, max_C_abvg = 1916, max_days = 240)
```

---

C\_input\_crops                      *Estimate C inputs by crops*

---

**Description**

Calculates the estimated carbon (C) input into the soil system by harvested main crops.

**Usage**

```
C_input_crops(
  crop,
  crop_product = NA,
  crop_residue = NA,
  harvest_index = NA,
  variable_harvest_index = NA,
  HI_intercept = NA,
  HI_slope = NA,
  shoot_root_ratio = NA,
  root_exudation_factor = NA,
  Cc_product = 450,
  Cc_residue = 450,
  Cc_root = 450,
  straw_removal = NA,
  fixed_belowground_input = NA,
  fixed_C_input_root = NA,
  return_comment = FALSE
)
```

**Arguments**

crop	Crop type. Must match predefined list (see C_input_crops_LUT)
crop_product	(optional) Dry weight of the exported product, i.e. yield. Default value is taken from table (tDM/ha)
crop_residue	(optional) Dry weight of the residues of the main crop (e.g., straw, sugar beet leaves) (tDM/ha)
harvest_index	(optional) Ratio of the product to the total above ground biomass

variable_harvest_index	(optional) Logical value that is TRUE if the variable harvest index assumptions of Fan et al. (2017) are to be applied (TRUE / FALSE)
HI_intercept	(optional) Intercept of the variable harvest index. Values provided by Fan et al. (2017)
HI_slope	(optional) Slope of the variable harvest index. Values provided by Fan et al. (2017) (ha/tDM)
shoot_root_ratio	(optional) Ratio of the total above ground biomass to the root biomass
root_exudation_factor	(optional) Ratio of the root exudated C to the C in the root biomass
Cc_product	(optional) C concentration in the exported product. Default value is 450 (gC/kgDM)
Cc_residue	(optional) C concentration in the residues of the main crop. Default value is 450 (gC/kgDM)
Cc_root	(optional) C concentration in the roots. Default value is 450 (gC/kgDM)
straw_removal	(optional) Logical value that is TRUE if straw is removed at harvest. <ul style="list-style-type: none"> <li>• When NA then SR value from table is take</li> <li>• When TRUE SS is 1</li> <li>• When FALSE SS is 0.</li> <li>• Default value is NA</li> </ul>
fixed_belowground_input	(optional) Logical value that is TRUE if fixed below ground Carbon inputs are to be assumed (e.g. for temporary leys) (TRUE / FALSE)
fixed_C_input_root	(optional) amount of root C that is assumed if fixed_belowground_input is TRUE (kgC/ha)
return.comment	(optional) logical value if comment are returned or not. Default = FALSE (TRUE/FALSE)

### Details

The annual C input by crops were estimated based on crop type and crop yield with the allometric functions of Bolinder et al. (2007):

$$C_{Product} = Product * CC_{Product}$$

$$C_{Straw} = Product * \frac{1 - HI}{HI} * CC_{Straw}$$

$$C_{Root} = \frac{Product}{SRR * HI} * CC_{Root}$$

$$C_{Exudates} = C_{Root} * REF$$

Where  $C$  is the C per fraction (in kgC/ha) and  $CC$  is the C content of given fraction (kgC/tDM).  $Product$  is the dry matter yield of a crop in tDM/ha,  $HI$  is the harvest index (ratio of product total of product and straw),  $SRR$  is the ratio of the shoot biomass (product and straw) to the root

biomass, and *REF* is the root exudation factor (i.e., the ratio of the C exudated by the roots to the C in the root biomass). All fractions are multiplied with a crop and fraction specific *S*-factor that determines the share of the fraction that is returned to the soil.

If not mentioned otherwise parameters were taken from the publications of Bolinder et al. (2007), Keel et al. (2017) or Wüst-Galley et al. (2020). Parameters for potatoes and sugar beets were derived from Bolinder et al. (2015) For temporary leys we assumed yield-independent annual  $C_{Root}$  of 1.5 MgC/ha and a *REF* of 0.5 (Taghizadeh-Toosi et al. 2020). Furthermore, like Wüst-Galley et al. (2020), the belowground C input ( $C_{Root} + C_{Exudates}$ ) of corn maize, silage maize and cereals were fixed to 0.46 MgC/ha, 1.1 MgC/ha and 0.6 MgC/ha respectively, based on the values from Hirte et al. (2018). Additionally, we applied the yield dependent harvest index ( $HI = Intercept + Product * Slope$ ) proposed by Fan et al. (2017) for cereals, faba beans, peas, corn, rapeseed, and soybeans.

Reference yields were derived from the Swiss fertilizer recommendations Sinaj et al. (2017).

All default values can be found in the look-up-table C\_input\_crops\_LUT.

### Value

a tibble with the following parameters:

- C\_input\_product: Estimated soil carbon input from product (e.g. damaged potatoes) (kgC/ha),
- C\_input\_straw: Estimated soil carbon input by straw or other residues (kgC/ha),
- C\_input\_root: Estimated soil carbon input by roots (kgC/ha),
- C\_input\_exudate: Estimated soil carbon input by roots (kgC/ha),
- C\_input\_total: Total estimated Soil carbon input, sum of C\_input\_straw, C\_input\_root, C\_input\_exudate (kgC/ha),
- comment (optional): comment on the derived values

### References

Bolinder MA, Janzen HH, Gregorich EG, Angers DA, VandenBygaart AJ (2007). “An approach for estimating net primary productivity and annual carbon inputs to soil for common agricultural crops in Canada.” *Agriculture, Ecosystems & Environment*, **118**(1-4), 29–42. doi:10.1016/j.agee.2006.05.013.

Bolinder MA, Kätterer T, Poeplau C, Börjesson G, Parent LE (2015). “Net primary productivity and below-ground crop residue inputs for root crops: Potato (*Solanum tuberosum* L.) and sugar beet (*Beta vulgaris* L.)” *Canadian Journal of Soil Science*, **95**(2), 87–93. doi:10.4141/cjss2014091.

Fan J, McConkey B, Janzen H, Townley-Smith L, Wang H (2017). “Harvest index - yield relationship for estimating crop residue in cold continental climates.” *Field Crops Research*, **204**, 153–157. doi:10.1016/j.fcr.2017.01.014.

Hirte J, Leifeld J, Abiven S, Oberholzer H, Mayer J (2018). “Below ground carbon inputs to soil via root biomass and rhizodeposition of field-grown maize and wheat at harvest are independent of net primary productivity.” *Agriculture, Ecosystems & Environment*, **265**, 556–566. doi:10.1016/j.agee.2018.07.010.

Keel SG, Leifeld J, Mayer J, Taghizadeh-Toosi A, Olesen JE (2017). “Large uncertainty in soil carbon modelling related to method of calculation of plant carbon input in agricultural systems.” *European Journal of Soil Science*, **68**(6), 953–963. doi:10.1111/ejss.12454.

Sinaj S, Charles R, Baux A, Dupuis B, Hiltbrunner J, Levy Häner L, Pellet D, Blanchet G, Jeangros B (2017). “Grundlagen für die Düngung landwirtschaftlicher Kulturen in der Schweiz (GRUD): Düngung von Ackerkulturen.” *Agrarforschung Schweiz, Spezialpublikation*, **Chapter 8**(6), 1–46. <https://ira.agroscope.ch/en-US/Page/Publikation/Index/36799>.

Taghizadeh-Toosi A, Cong W, Eriksen J, Mayer J, Olesen J, Keel SG, Glendining M, Kätterer T, Christensen BT (2020). “Visiting dark sides of model simulation of carbon stocks in European temperate agricultural soils: allometric function and model initialization.” *Plant and Soil*, **450**(1-2), 255–272. doi:10.1007/s11104020045009.

Wüst-Galley C, Keel SG, Leifeld J (2020). “A model-based carbon inventory for Switzerland’s mineral agricultural soils using RothC.” *Agroscope Science*, 1–110. doi:10.34776/as105e.

### See Also

- `C_input()` to calculate C inputs for a management\_df
- `C_input_cover_crops()` to calculate C input for cover crops
- `CN_input_amendments()` to calculate C (and N) inputs for organic amendments
- `C_input_crops_LUT()` for the look-up-table for crop reference values

### Examples

```
#example without yield information, default yield is assumed
C_input_crops("wheat, winter")

#example with yield information and straw retention
C_input_crops("barley, spring", crop_product = 4.5, straw.removal = FALSE)

#example with more information
C_input_crops("barley, spring", crop_product = 4.5, harvest_index = 0.4,
              shoot_root_ratio = 2.4, root_exudation_factor = 0.5)

#example with variable harvest index
C_input_crops("barley, spring", crop_product = 4.5, variable_harvest_index = TRUE,
              HI_intercept = 0.35, HI_slope = 0.015, shoot_root_ratio = 2.4,
              root_exudation_factor = 0.5)

#example with fixed below ground input
C_input_crops("maize, silage", crop_product = 18.5,
              fixed_belowground_input = TRUE, fixed_C_input_root = 1500,
              root_exudation_factor = 0.3)
```

---

C_input_crops_LUT	<i>Look-up-table with default values to calculate carbon (C) inputs by crops</i>
-------------------	----------------------------------------------------------------------------------

---

### Description

The data set is a look-up-table that is used to calculate the C inputs by crops with the Bolinder formula, that is implemented in the function 'SoilManageR::C\_input\_crops()'. The data set is produced from the excel table 'C\_input\_crops\_LUT.xlsx' file under '/inst/extdata/'.

### Usage

C\_input\_crops\_LUT

### Format

A tibble with 28 rows and 19 columns:

**Crop** Name of the crop

**RP** Ratio of the C in the product to the total carbon that is allocated by the plant (in a year)

**RS** Ratio of the C in the above ground residues (e.g. straw) to the total carbon that is allocated by the plant (in a year)

**RR** Ratio of the C in the plant roots to the total carbon that is allocated by the plant (in a year)

**RE** Ratio of the C in the root exudates to the total carbon that is allocated by the plant (in a year)

**SP** Proportion of the C in the Product that is transferred to the soil

**SS** Proportion of the C in the above ground residues (e.g. straw) that is transferred to the soil

**SR** Proportion of the C in the roots that is transferred to the soil

**SE** Proportion of the C in root exudates that is transferred to the soil

**crop\_product** Reference yield, derived from the Swiss fertilizer recommendations (GRUD, 2017, Chapters 8 and 9) [tDM/ha]

**harvest\_index** Ratio of the product to the total of the product and the above ground residues. Calculated by  $RP/(RP+RS)$  (assuming all biomass has 45% C)

**variable\_harvest\_index** Logical value, if the variable harvest index assumption of Fan et al. (2017) are to be applied or not.

**HI\_intercept** Intercept of the variable harvest index assumption of Fan et al. (2017) are to be applied.

**HI\_slope** Slope of the variable harvest index assumption of Fan et al. (2017) are to be applied. [ha/tDM]

**shoot\_root\_ratio** Ratio of the product and the above ground residues to the root biomass. Calculated by  $(RP+RS)/RR$  (assuming all biomass has 45% C)

**root\_exudation\_factor** Ratio of the root exudates to the root biomass. Calculated by  $RE/RR$  (assuming all biomass has 45% C)

**fixed\_belowground\_input** Logical value if the fixed below ground C allocation assumption of Taghizadeh-Toosi et al. (2020) is to be applied or not.

**C\_input\_root** Fixed value of root carbon input that is to be assumed. [kgC/ha]

**Source** Source where the information was derived.

## References

Compilation of values from the SoilX project. Please check the ‘C\_input\_crops\_LUT.xlsx’ file under ‘/inst/extdata/’ for more information.

Bolinder MA, Janzen HH, Gregorich EG, Angers DA, VandenBygaart AJ (2007). “An approach for estimating net primary productivity and annual carbon inputs to soil for common agricultural crops in Canada.” *Agriculture, Ecosystems & Environment*, **118**(1-4), 29–42. doi:10.1016/j.agee.2006.05.013.

Bolinder MA, Kätterer T, Poeplau C, Börjesson G, Parent LE (2015). “Net primary productivity and below-ground crop residue inputs for root crops: Potato (*Solanum tuberosum* L.) and sugar beet (*Beta vulgaris* L.)” *Canadian Journal of Soil Science*, **95**(2), 87–93. doi:10.4141/cjss2014091.

Fan J, McConkey B, Janzen H, Townley-Smith L, Wang H (2017). “Harvest index - yield relationship for estimating crop residue in cold continental climates.” *Field Crops Research*, **204**, 153–157. doi:10.1016/j.fcr.2017.01.014.

Hirte J, Leifeld J, Abiven S, Oberholzer H, Mayer J (2018). “Below ground carbon inputs to soil via root biomass and rhizodeposition of field-grown maize and wheat at harvest are independent of net primary productivity.” *Agriculture, Ecosystems & Environment*, **265**, 556–566. doi:10.1016/j.agee.2018.07.010.

Keel SG, Leifeld J, Mayer J, Taghizadeh-Toosi A, Olesen JE (2017). “Large uncertainty in soil carbon modelling related to method of calculation of plant carbon input in agricultural systems.” *European Journal of Soil Science*, **68**(6), 953–963. doi:10.1111/ejss.12454.

Seitz D, Fischer LM, Dechow R, Wiesmeier M, Don A (2022). “The potential of cover crops to increase soil organic carbon storage in German croplands.” *Plant and Soil*, **488**(1-2), 157–173. doi:10.1007/s1110402205438w.

Sinaj S, Charles R, Baux A, Dupuis B, Hiltbrunner J, Levy Häner L, Pellet D, Blanchet G, Jeangros B (2017). “Grundlagen für die Düngung landwirtschaftlicher Kulturen in der Schweiz (GRUD): Düngung von Ackerkulturen.” *Agrarforschung Schweiz, Spezialpublikation*, **Chapter 8**(6), 1–46. <https://ira.agroscope.ch/en-US/Page/Publikation/Index/36799>.

Taghizadeh-Toosi A, Cong W, Eriksen J, Mayer J, Olesen J, Keel SG, Glendining M, Kätterer T, Christensen BT (2020). “Visiting dark sides of model simulation of carbon stocks in European temperate agricultural soils: allometric function and model initialization.” *Plant and Soil*, **450**(1-2), 255–272. doi:10.1007/s11104020045009.

Wüst-Galley C, Keel SG, Leifeld J (2020). “A model-based carbon inventory for Switzerland’s mineral agricultural soils using RothC.” *Agroscience*, 1–110. doi:10.34776/as105e.



EXAMPLE\_data

*Example of a management\_df***Description**

The dataset is derived from a Swiss long term agricultural field experiment. It is intended for demonstration purposes only

**Usage**

EXAMPLE\_data

**Format**

A tibble with 130 rows and 13 columns:

**crop** Name of the main crop. Cover crop related operations are linked to the next main crop in the rotation [String from list]

**date** Date of the management operation [Date]

**year** Year of the management operation [Integer]

**category** Categorization of the management operation [1 level] [String from list]

**operation** Categorization of the management operation [2 level] [String from list]

**device** Categorization of the management operation [3 level] [String from list]

**value** Numerical value linked to management operation (e.g., depth of tillage operation, mass of organic amendment) [Integer]

**unit** Unit of the numerical value (e.g. cm, t/ha) [String from list]

**machine** Further information on the machine used (e.g., type, manufacturer, tool) [String [UTF-8]]

**product** Further information on the applied product (e.g., name, manufacturer, C content) [String [UTF-8]]

**combination** Indicate if a operation was done in combination with others. Use consecutive integer numbers if combined operations occur. Leave empty if not combined

**comments** Comments related to the management operation [String [UTF-8]]

**DMC** Dry matter content of organic amendments [gDM/kgFM]

**C\_content** Carbon content of the amendments, relative to its dry matter [gC/kgDM]

**N\_content** Nitrogen content of organic amendments, relative to its dry matter [gN/kgDM]

**crop\_product** Crop product yield [tDM/ha]

**crop\_residue** Crop residue mass [tDM/ha]

**Cc\_product** Carbon content of the crop product [gC/kgDM\$]

**Cc\_residue** Carbon content of the crop residue [gC/kgDM]

---

filter\_management\_df *Filter management\_df for pattern in comments*

---

### Description

Excludes operations (lines) from management\_df based on a character pattern in the comments column.

### Usage

```
filter_management_df(var_MGMT_data, filter_pattern)
```

### Arguments

var\_MGMT\_data management\_df  
 filter\_pattern string based on which the lines should be excluded

### Value

a filtered management\_df

### Examples

```
# filter EXAMPLE_data and exclude all lines that contain "UFA 330" in comments
filter_management_df(EXAMPLE_data,"UFA 330")
```

---

management\_df *Constructor for management\_df*

---

### Description

This function is a constructor for empty objects of the `management_df()` class, the core of the SoilManageR package.

### Usage

```
management_df(
  crop = NA,
  year = NA,
  date = NA,
  category = NA,
  operation = NA,
  device = NA,
  value = NA,
  unit = NA,
```

```

    machine = NA,
    product = NA,
    combination = NA,
    comments = NA,
    DMC = NA,
    C_content = NA,
    N_content = NA,
    crop_product = NA,
    crop_residue = NA,
    Cc_product = NA,
    Cc_residue = NA
  )

```

### Arguments

crop	Name of the main crop. Must match a pre-existing list
year	Year of the management operation ("YYYY")
date	Date of the management operation ("YYYY-MM-DD")
category	Categorization of the management operation (1 level). Must match a pre-existing list.
operation	Categorization of the management operation (2 level). Must match a pre-existing list.
device	Categorization of the management operation (3 level). Must match a pre-existing list.
value	Numerical value linked to management operation (e.g., depth of tillage operation, mass of organic amendment)
unit	Unit of the numerical value (e.g. cm, t/ha)
machine	Further information on the machine used (e.g., type, manufacturer, tool)
product	Further information on the applied product (e.g., name, manufacturer). Must match pre-existing list for organic amendments.
combination	Indicate if a operation was done in combination with others. Use consecutive integer numbers if combined operations occur. Leave empty if not combined.
comments	Comments related to the management operation
DMC	Dry matter content of organic amendments (gDM/kgFM)
C_content	Carbon content of the amendments, relative to its dry matter (gC/kgDM)
N_content	Nitrogen content of organic amendments, relative to its dry matter (gN/kgDM)
crop_product	Crop product yield (tDM/ha)
crop_residue	Crop residue mass (tDM/ha)
Cc_product	Carbon content of the crop product (gC/kgDM)
Cc_residue	Carbon content of the crop residue (gC/kgDM)

### Value

a `management_df()`

**See Also**

- [management\\_df\\_from\\_excel\(\)](#) for importing a management\_df from an excel template
- [check\\_management\\_df\(\)](#) to check the integrity of a management\_df
- [EXAMPLE\\_data\(\)](#) for an example of a management\_df

**Examples**

```
#creation of an empty management_df
management_df()
```

---

```
management_df_from_excel
      Import management_df from excel file
```

---

**Description**

This function imports management data from an excel template and transforms it into a [management\\_df](#). Additionally, it checks if all columns that are expected for a management\_df are available. The excel template can be found in the SoilManageR Package under inst/extdata/SoilManageR\_mgmt\_data\_template. Optionally, the parameter *year* can be overwritten by the year extracted from *date*.

**Usage**

```
management_df_from_excel(
  path_to_xlsx,
  var_sheet = "Management_template",
  overwrite_year = TRUE
)
```

**Arguments**

path_to_xlsx	path to the excel file with the management data
var_sheet	name of the sheet with the management data template in the excel sheet, default is "Management_template"
overwrite_year	logical: if TRUE (default), the <i>year</i> will be set to the year extracted from the <i>date</i>

**Value**

a management\_df

**See Also**

- [management\\_df\(\)](#) for creating an management\_df
- [check\\_management\\_df\(\)](#) to check the integrity of a management\_df

## Examples

```
#create path
path_to_xlsx_template <- system.file(
  "/extdata/SoilManageR_mgmt_data_template_V2.5.xlsx", package = "SoilManageR")

#load management_df
management_df_from_excel(path_to_xlsx_template)
```

---

N_input	<i>Estimate nitrogen input</i>
---------	--------------------------------

---

## Description

This function estimates the nitrogen (N) input by mineral and organic fertilization into the soil system per year.

## Usage

```
N_input(var_MGMT_data, extended.output = FALSE)
```

## Arguments

`var_MGMT_data` a `management_df` that contains the management information  
`extended.output`  
an optional logical value:

- If FALSE, N input values are aggregated by year
- If TRUE, a tibble with all management operations is returned
- Default value is FALSE

## Details

The function takes a `management_df` as input and returns N input values per year in the `management_df`.

Alternatively, it can return a extensive tibble with all management operations and their N input values.

The functions calculates the N input by organic fertilization with the `CN_input_amendments()` function. Furthermore, it calculates the livestock intensity (LSU/ha) by deviding the animal derived N by 105kgN/LSU.

Be aware that the function currently neglects N that is fixated by plants (e.g. legumes)

## Value

by default, a tibble with N input values (organic N, mineral N and total N) by year is returned. If `extended.output = TRUE`, a tibble with daily resolution is returned.

**See Also**

- `calculate_indicators()` to calculate all management indicators for a `management_df`
- `CN_input_amendments()` for the calculation of N inputs from organic amendments

**Examples**

```
#example that returns annual N input values
N_input(EXAMPLE_data)
```

```
#example that returns a tibble with all management operations and their N input
N_input(EXAMPLE_data, extended.output = TRUE)
```

---

plant\_cover

*Estimate soil cover percentage by plants*

---

**Description**

This function estimates the percentage of soil cover based on the number of days since sowing. The parameters used are derived from Mosimann and Rüttimann (2006).

**Usage**

```
plant_cover(varCrop, varDays = 0)
```

**Arguments**

varCrop	Crop type, must match with crop name in <code>plant_cover_LUT</code>
varDays	Number of days since sowing of the crop

**Details**

The function assumes that plant cover unfolds in four phases with different soil cover rates:

- 0 to 10 % of soil cover
- 10 to 50 % of soil cover
- 50 to 75 % of soil cover
- 75 to 100 % of soil cover

**Value**

percentage of soil cover by plants, value of 0 to 100 %.

**References**

Mosimann T, Rüttimann M (2006). "Berechnungsgrundlagen zum Fruchtfolgefaktor zentrales Mittelland 2005 im Modell Erosion CH (V2.02)." Terragon, Bubendorf. [https://uwe.lu.ch/-/media/UWE/Dokumente/Themen/Bodenschutz/Bodenschutz\\_Landwirtschaft/dokumentationbodenerosionsschluss\\_terragon2006.pdf](https://uwe.lu.ch/-/media/UWE/Dokumente/Themen/Bodenschutz/Bodenschutz_Landwirtschaft/dokumentationbodenerosionsschluss_terragon2006.pdf).

**See Also**

- `soil_cover()` to calculate soil coverage by plants and residue for a management\_df
- `plant_cover_LUT()` for the data used by the `plant_cover()` function

**Examples**

```
plant_cover("wheat, winter", 140)
```

---

plant_cover_LUT	<i>Look-up-table with default values to estimate soil cover by plants</i>
-----------------	---------------------------------------------------------------------------

---

**Description**

The dataset is a look-up-table that is used to estimate the soil cover percentage by plant with the function 'SoilManageR::plant\_cover()'. The data set is produced from the excel table 'plant\_cover\_LUT.xlsx' file under '/inst/extdata/'.

**Usage**

```
plant_cover_LUT
```

**Format**

A tibble with 28 rows and 7 columns:

**Crop** Name of the crop

**Slope\_0\_10** Increase of crop cover per day between 0 and 10% soil cover [%/day]

**Slope\_10\_50** Increase of crop cover per day between 10 and 50% soil cover [%/day]

**Slope\_50\_75** Increase of crop cover per day between 50 and 75% soil cover [%/day]

**Slope\_75\_100** Increase of crop cover per day between 75 and 100% soil cover [%/day]

**days\_30** Number of days it takes to reach 30% soil cover [day]

**Comments** Source where the information was derived

**References**

Mosimann T, Rüttimann M (2006). "Berechnungsgrundlagen zum Fruchtfolgefaktor zentrales Mittelland 2005 im Modell Erosion CH (V2.02)." Terragon, Bubendorf. [https://uwe.lu.ch/-/media/UWE/Dokumente/Themen/Bodenschutz/Bodenschutz\\_Landwirtschaft/dokumentationbodenerosionsschluss\\_terragon2006.pdf](https://uwe.lu.ch/-/media/UWE/Dokumente/Themen/Bodenschutz/Bodenschutz_Landwirtschaft/dokumentationbodenerosionsschluss_terragon2006.pdf).

---

plant_diversity	<i>Calculate plant diversity indicators</i>
-----------------	---------------------------------------------

---

### Description

Derives three indicators for plant diversity of a crop rotation based on management information (mainly sowing events).

### Usage

```
plant_diversity(var_MGMT_data, start_year, end_year)
```

### Arguments

var_MGMT_data	a 'management_df' with a management history
start_year	start year of the cropping sequence of interest
end_year	end year of the cropping sequence of interest

### Details

For the function to work properly the species (or variety) must be mentioned in the "product" column, and all sown species of mixtures must be represented in a single row of the management\_df each.

The function calculates the plant diversity index (*PDI*), the total number of different species, and the Shannon index for all sown species.

The *PDI* is calculated in the following way inspired by Tiemann et al. (2015):

$$PDI = \overline{S_{year}} * S_{rotation}$$

where  $\overline{S_{year}}$  is the average number of sown species per year and  $S_{rotation}$  is the total number of different species sown in the full crop rotation or cropping sequence.

The Shannon Index is calculated with the `shannon_index()` function.

### Value

a tibble with three indicators for plant diversity

### References

Tiemann LK, Grandy AS, Atkinson EE, Marin-Spiotta E, McDaniel MD (2015). "Crop rotational diversity enhances belowground communities and functions in an agroecosystem." *Ecology Letters*, **18**(8), 761-771. doi:10.1111/ele.12453.

### See Also

- `calculate_indicators()` to calculate all management indicators for a management\_df
- `shannon_index()` for more detail on the Shannon index



**Examples**

```
plant_diversity(EXAMPLE_data,2013,2020)
```

---

```
plot.soil_cover_tibble  
      Plotting soil_cover_tibbles
```

---

**Description**

This function plots objects of the class `soil_cover_tibble` in a custom format

**Usage**

```
## S3 method for class 'soil_cover_tibble'  
plot(x, ...)
```

**Arguments**

<code>x</code>	an <code>soil_cover_tibble</code> object
<code>...</code>	arguments to be passed to methods

**Value**

none, it plots the `soil_cover_tibble`

**Examples**

```
data <- soil_cover(EXAMPLE_data, extended.output = TRUE)  
plot(data)
```

---

```
plot_management_df      Plot a management dataframe
```

---

**Description**

Visual representation of a `management_df`.

**Usage**

```
plot_management_df(management_df, title = "Management Timeline")
```

**Arguments**

management\_df a management data frame  
 title the title of the plot

**Details**

The colors in the background represent the soil cover by plants (green), and crop residues (brown). "T" indicates tillage event with a STIR value  $\geq 0$ . "P" indicates a crop protection event. Dotted vertical lines represent sowing events, the sown crop is noted in the lowest quarter at the right side of the line. The values in the middle indicate C inputs into the soil system, either by crops, cover crops or organic amendments. Negative values are withdrawals by residue removal. Note that large management\_df can be heavy to compute and the plots may be messy.

**Value**

a plot

**Examples**

```
# creates a visual representation of the EXAMPLE data
plot_management_df(EXAMPLE_data)
```

---

```
productivity_indicator
```

*Calculate average productivity*

---

**Description**

Estimates estimates the relative yield of a cropping sequence per year. The function takes a management\_df as input and returns a relative\_yield value per year in the management\_df. Alternatively, it can return a tibble with additional information on each crop. The `productivity_indicator()` calculates the relative yields with the `relative_yield()` function.

**Usage**

```
productivity_indicator(var_MGMT_data, extended.output = FALSE)
```

**Arguments**

var\_MGMT\_data a management\_df that contains the management information  
 extended.output an optional logical value.

- If FALSE, relative yields are aggregated by year.
- If TRUE, a tibble with relative yield of each crop is returned.
- Default value is FALSE

**Value**

- By default, a tibble with relative yields by year is returned.
- If `extended.output = TRUE`, a tibble with additional information is returned.

**See Also**

- [relative\\_yield\(\)](#) for calculating relative yields
- [calculate\\_indicators\(\)](#) for calculating all soil management indicators

**Examples**

```
#example that returns annual relative yield values
productivity_indicator(EXAMPLE_data)
```

```
#example that returns a tibble with additional information
productivity_indicator(EXAMPLE_data, extended.output = TRUE)
```

---

relative_yield	<i>Calculate relative yield</i>
----------------	---------------------------------

---

**Description**

This function calculates the relative yield of an observed dry matter yield compared to the reference dry matter yield in the Swiss fertilizing guidelines (Sinaj et al. 2017).

**Usage**

```
relative_yield(var_crop, var_yield)
```

**Arguments**

var_crop	string with name of crop type, must match with the Crops in the C_input_crops_LUT
var_yield	observed dry matter yield (tDM/ha)

**Value**

the numeric value for the relative yield

**References**

Sinaj S, Charles R, Baux A, Dupuis B, Hiltbrunner J, Levy Häner L, Pellet D, Blanchet G, Jeangros B (2017). “Grundlagen für die Düngung landwirtschaftlicher Kulturen in der Schweiz (GRUD): Düngung von Ackerkulturen.” *Agrarforschung Schweiz, Spezialpublikation*, **Chapter 8**(6), 1–46. <https://ira.agroscope.ch/en-US/Page/Publikation/Index/36799>.

**See Also**

- `productivity_indicator()` to calculate relative yields for a `management_df`
- `C_input_crops_LUT()` for reference yield used in the `relative_yield()` function

**Examples**

```
relative_yield("wheat, winter", 4.8)
```

---

shannon\_index

*Calculate Shannon Index for diversity*


---

**Description**

This function calculates the Index of Shannon (1948) for a tibble with different species.

The formula that is used is

$$SI = - \sum_{S=1}^i (p_i * \ln(p_i))$$

where  $p_i$  is the relative abundance of each species ( $S$ ).

**Usage**

```
shannon_index(var_tibble)
```

**Arguments**

`var_tibble` a tibble with two columns (name of species, count per species), the second column must be called "count"

**Value**

double of the Shannon Index

**References**

Shannon CE (1948). "A Mathematical Theory of Communication." *Bell System Technical Journal*, **27**(3), 379-423.

Spellerberg IF, Fedor PJ (2003). "A tribute to Claude Shannon (1916–2001) and a plea for more rigorous use of species richness, species diversity and the 'Shannon–Wiener' Index." *Global ecology and biogeography*, **12**(3), 177–179. doi:10.1046/j.1466822X.2003.00015.x.

**See Also**

`plant_diversity()` to calculate the `shannon_index()` (and other diversity indices) for a `management_df`

**Examples**

```
#create tibble
tibble_example <- tibble::tibble(Plant = c("A", "B", "C", "D", "E"), count = c(10, 5, 8, 20, 10))

#calculate Shannon Index
shannon_index(tibble_example) # = 1.505...
```

soil\_cover

*Estimate soil cover by plants and residues***Description**

Derives the days where soil cover by living plants or residues is  $\geq 30\%$ .

**Usage**

```
soil_cover(var_MGMT_data, extended.output = FALSE)
```

**Arguments**

`var_MGMT_data` a `management_df` that contains the management information  
`extended.output`  
 an optional logical value.

- If FALSE, soil cover days are aggregated by year.
- If TRUE, a `soil_cover_tibble` with daily resolution is returned.
- Default value is FALSE

**Details**

The function takes a `management_df` as input and returns soil cover days per year in the `management_df`. Alternatively, it can return a `soil_cover_tibble` with daily resolution of the estimated soil cover.

The function calculates plant soil cover with the `plant_cover()` function and the soil coverage by residues.

The residue mass is dependent on the residue supply by crops, its decay and its incorporation by tillage operations (Büchi et al. 2016).

Residue supply is estimated with the yield dependent residue C `C_input_straw` provided by the function `C_input_crops()` and a C content of  $450 [mgC/gDM]$ . If residues are removed, the removed residue mass is subtracted.

Residue decay is calculated with the formula of Steiner et al. (1999):

$$M_t = M_{t-1} * (1 - k_{decay})$$

Where  $M_{t-1}$  is the residue mass of the prior day  $[g/m^2]$  and  $k_{decay}$  is the daily decay rate that was assumed to be  $0.028 g/g$ , the average decomposition rate of winter wheat straw (Steiner et al. 1999).

Residue incorporation by tillage was estimated with the operation-specific burial coefficient extracted from the RUSLE2 database (USDA-NRCS 2023) that are provided in the look-up-table STIR\_values\_LUT.

Residue mass is translated into percentage of soil cover by the formula of Steiner et al. (2000):

$$cover_{residues} = (1 - e^{-k(M)}) * 100\%$$

Where  $M$  is the residue mass [ $g/m^2$ ] and  $k$  is a cover coefficient [ $m^2/g$ ].  $k$  was assumed to be 0.0175 (Steiner et al. 2000).

### Value

- By default, a tibble with soil cover days by year is returned.
- If `extended.output = TRUE`, an object of the class `soil_cover_tibble` with daily resolution is returned.

### References

Büchi L, Valsangiacomo A, Burel E, Charles R (2016). “Integrating simulation data from a crop model in the development of an agri-environmental indicator for soil cover in Switzerland.” *European Journal of Agronomy*, **76**, 149–159. doi:10.1016/j.eja.2015.11.004.

Steiner JL, Schomberg HH, Unger PW, Cresap J (1999). “Crop residue decomposition in no-tillage small-grain fields.” *Soil Science Society of America Journal*, **63**(6), 1817–1824. doi:10.2136/sssaj1999.6361817x.

Steiner JL, Schomberg HH, Unger PW, Cresap J (2000). “Biomass and residue cover relationships of fresh and decomposing small grain residue.” *Soil Science Society of America Journal*, **64**(6), 2109–2114. doi:10.2136/sssaj2000.6462109x.

USDA-NRCS (2023). “Revised Universal Soil Loss Equation, Version 2 (RUSLE2), Official NRCS RUSLE2 Program and Database (V 2023-02-24).” USDA-NCRS. [https://fargo.nser1.purdue.edu/rusle2\\_dataweb/RUSLE2\\_Index.htm](https://fargo.nser1.purdue.edu/rusle2_dataweb/RUSLE2_Index.htm).

### See Also

- `calculate_indicators()` to calculate all management indicators for a `management_df`
- `plant_cover()` for more detail on the plant cover function
- `plot_soil_cover_tibble()` for plotting the `soil_cover_tibble`
- STIR\_values\_LUT for tillage operation specific burial coefficients

### Examples

```
#example that returns annual soil cover days by plants and residues
soil_cover(EXAMPLE_data)
```

```
#example that returns a soil_cover_tibble
soil_cover(EXAMPLE_data, extended.output = TRUE)
```

---

STIR *Calculate STIR value*

---

### Description

The function calculates the soil tillage intensity rating (STIR) value of tillage and sowing operations. By default, the `STIR()` function of `SoilManageR` operates on SI units (cm and km/h) and not in imperial units (inch, mph) as the original STIR equation (USDA-NRCS 2023). However, the user can specify that the input is in imperial units. The function can process custom input, if no such input is provided it assumes default values from the `STIR_value_LUT`.

### Usage

```
STIR(
  device = NA,
  speed = NA,
  speed_unit = "km/h",
  type_modifier = NA,
  depth = NA,
  depth_unit = "cm",
  area_disturbed = NA,
  original.STIR.value = FALSE
)
```

### Arguments

<code>device</code>	tillage or sowing implement or operation, must match predefined list, or all necessary inputs ( <code>speed</code> , <code>type_modifier</code> , <code>depth</code> , <code>area_disturbed</code> ) must be provided
<code>speed</code>	speed of the operation (km/h or mph)
<code>speed_unit</code>	unit of the speed input, must be either NA, "km/h" or "mph". Default value is "km/h"
<code>type_modifier</code>	tillage operation type modifier, must be a value between 0 and 1
<code>depth</code>	depth of the soil that is affected by the operation (cm or inch)
<code>depth_unit</code>	unit of the depth input, must be either NA, "cm" or "inch". Default value is "cm"
<code>area_disturbed</code>	share of the surface that is disturbed by the operation (0 to 1)
<code>original.STIR.value</code>	logical value, if TRUE, the original STIR value of the operation in the <code>STIR_value_LUT</code> (instead of the calculated STIR value) is returned. Default value is FALSE

### Details

The concept of the STIR value was developed within the RUSLE2 framework by the USDA-NRCS (2023). The STIR equation is defined as

$$STIR = (0.5 * speed) * (3.25 * type\_modifier) * depth * area\_disturbed$$

where *speed* and *depth* are provided in mph and inches(!). For the purpose of this function we assume that 1 inch = 2.54 cm and 1 mph = 1.609 km/h. The tillage *type\_modifier* is defined to be:

- 1.00 for inversion operation
- 0.80 for mixing and some inversion operations
- 0.70 for mixing operations
- 0.40 for lifting and fracturing operations
- 0.15 for compression operations

In the `STIR_value_LUT` there are more than 400 operations, incl. the original operations from the RUSLE2 software (as of 2023-02-24) and operations defined by the SoilX project.

For further details on the STIR please consider the RUSLE2 website ([https://fargo.nserl.purdue.edu/rusle2\\_dataweb/RUSLE2](https://fargo.nserl.purdue.edu/rusle2_dataweb/RUSLE2)) or the description of the SoilManageR package

### Value

STIR value of the operation

### References

USDA-NRCS (2023). “Revised Universal Soil Loss Equation, Version 2 (RUSLE2), Official NRCS RUSLE2 Program and Database (V 2023-02-24).” USDA-NRCS. [https://fargo.nserl.purdue.edu/rusle2\\_dataweb/RUSLE2\\_Index.htm](https://fargo.nserl.purdue.edu/rusle2_dataweb/RUSLE2_Index.htm).

### See Also

- `tillage_intensity()` to calculate STIR values for `management_df`
- `STIR_values_LUT()` for the reference data used by the `STIR()` function

### Examples

```
#example without additional information
STIR("plough")

#example with additional information
STIR("rotary_harrow", depth = 15)

#custom example
STIR(speed = 10, type_modifier = 0.8, depth = 15, area_disturbed = 0.45)

#example that returns original STIR value
STIR("plough", original.STIR.value = TRUE)

#example that uses imperial units
STIR("plough", depth = 5, depth_unit = "inch", speed = 8, speed_unit = "mph")
```



---

STIR\_values\_LUT      *Look-up-table with default values for tillage operations*

---

### Description

The dataset is a look-up-table that is used to derive STIR values with the function ‘SoilManageR::STIR()’ and residue incorporation by tillage operations with the function ‘SoilManageR::soil\_cover()’. The data set is produced from the excel table ‘STIR\_value\_LUT.xlsx’ file under ‘/inst/extdata/’ and was mostly derived from the official RUSLE2 database (USDA-NRCS 2023).

### Usage

STIR\_values\_LUT

### Format

A tibble with 50 rows and 15 columns:

**Operation** Name of the operation  
**Speed** Average speed of the operation [km/h]  
**Speed\_MIN** Min speed of the operation [km/h]  
**Speed\_Max** Max speed of the operation [km/h]  
**Surf\_Disturbance** Share of the disturbed soil surface [%]  
**Depth** Average depth of the operation [cm]  
**Depth\_MIN** Min depth of the operation [cm]  
**Depth\_MAX** Max depth of the operation [cm]  
**TILLAGE\_TYPE** Type of tillage operation  
**TILLAGE\_TYPE\_Modifier** Numerical value of the tillage type modifier [0-1]  
**STIR** Soil tillage intensity rating value, based on default values  
**Diesel\_use** Diesel use of the operation per area [l/ha]  
**Burial\_Coefficient** Burial of plant residues on the soil surface [0-1]  
**Source** Source of the values in the table  
**Description** Description of the operation

### References

USDA-NRCS (2023). “Revised Universal Soil Loss Equation, Version 2 (RUSLE2), Official NRCS RUSLE2 Program and Database (V 2023-02-24).” USDA-NCRS. [https://fargo.nser1.purdue.edu/rusle2\\_dataweb/RUSLE2\\_Index.htm](https://fargo.nser1.purdue.edu/rusle2_dataweb/RUSLE2_Index.htm).

---

tillage_intensity	<i>Estimate tillage intensity</i>
-------------------	-----------------------------------

---

### Description

Calculates the soil tillage intensity per year. The function takes a `management_df` as input and returns a STIR value per year in the `management_df`. Alternatively, it can return an extensive tibble with each operation and their respective STIR values.

### Usage

```
tillage_intensity(var_MGMT_data, extended.output = FALSE)
```

### Arguments

`var_MGMT_data` a `management_df` that contains the management information

`extended.output`

an optional logical value. Default value is FALSE

- If FALSE, STIR values are aggregated by year.
- If TRUE, a tibble with all management operations is returned.

### Value

by default, a tibble with STIR values by year is returned. If `extended.output = TRUE`, a tibble with daily resolution is returned.

### See Also

- [STIR\(\)](#) for the calculation of a STIR value for operations
- [STIR\\_values\\_LUT\(\)](#) for the reference data used for tillage operations
- [calculate\\_indicators\(\)](#) to calculate all management indicators for a `management_df`

### Examples

```
#example that returns annual STIR values  
tillage_intensity(EXAMPLE_data)
```

```
#example that returns a tibble with all operations that have a STIR value  
tillage_intensity(EXAMPLE_data, extended.output = TRUE)
```

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