D6.3 Biophysical model connection modules

agricore

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Executive Summary

AGRICORE is a research project funded by the European Commission under the RUR-04-2018 call, part of the H2020 programme, which proposes an innovative way to apply agent-based modelling to improve the capacity of policymakers to evaluate the impact of agricultural-related measurements under and outside the framework of the Common Agricultural Policy (CAP).

Within the modular architecture of AGRICORE, which is presented in deliverable D6.1 of the Project, the connection of the agent-based simulation module (D6) with a series of external biophysical models (D15) is envisaged.

This connection will allow the incorporation of these models into the optimisation-simulation flow of each agent:

- On the one hand, the agro-management decisions taken by the agents can be passed as an argument and simulated in the biophysical model to represent the realisation of an agricultural campaign, with each agent receiving back its effective yield and the possible effects on its agricultural land, among other information.
- On the other hand, the biophysical models may be used as experimental models for optimisation, generating a series of alternative technological profiles among which the agents must decide which to implement.

To incorporate either of the two functionalities mentioned above, it is necessary to have connectors that allow the exchange of information between the agents and the biophysical models, as well as the launch of the execution of the biophysical models via command line, without the need to use the specific graphical interface of each model.

This document explains the implementation of such connectors (translators) to allow the interconnection of the AGRICORE tool with the WOFOST, DNDC and STICS biophysical models.

Abbreviations

Abbreviation	Full name
ABM	Agent Based Model
AGRICORE	Agent-based support tool for the development of agriculture policies
BIOMA	BIOphysical Model Applications
BMC	Biophysical Model Connector
CANEGROW	sugar CANE GROWth model
CROPSYST	CROPping SYSTems simulation model
DNDC	DeNitrification-DeComposition model
DWH	Data WareHouse
EU	European Union
gRPC	general-purpose Remote Procedure Call
I/O	Input/Output
SEAMLESS	System for Environmental and Agricultural Modelling; Linking European Science and Society
STICS	Simulateur mulTIdisciplinaire pour les Cultures Standard
WARM	WAste Reduction Model
WOFOST	the WOrld FOod STudies simulation model

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1 Introduction

The objective of the deliverable *D6.3 Biophysical model connection modules* is to depict a software solution allowing to parse the ABM Simulation Module queries to an external biophysical model, such as the status of the land plot with a combination of agro management decisions that would be applied on them, and return the effect of these decisions on the future state of the land plot/livestock herd as well as the immediate resulting productivity to the ABM Simulation Module, as it was introduced in revised architecture for AGRICORE described in deliverable D6.1.

The biophysical model connection module will allow to incorporate into the ABM simulation the biophysical dynamics of the ecosystem, in which the agents being simulated are located, which in turn will allow to incorporate into the decision process of holding managers the (limited) knowledge they have about how their land and herds behave in the face of different combinations of crops and/or applied production factors, and to simulate the temporal evolution of the dynamics of the ecosystem, as a result of the aggregate effect of the decisions of all the holdings located in it (agro-management decisions) and of external factors (climatic disturbances, pests, etc.).

2 Requirements of the AGRICORE-linked Biophysical Models

Initially, it was planned to link AGRICORE to BioMA (Biophysical Model Applications), which is a public domain software framework designed and implemented for developing, parameterising and running modelling solutions based on biophysical models in the domains of agriculture and environment. The BioMA framework is a development of the work carried out under the 6th EU Framework Programme SEAMLESS project, and it is widely used within the EU. It consists of a rich library of biophysical models, including CROPSYST, WOFOST, WARM, CANEGROW or STICS. In the revised AGRICORE architecture described in deliverable D6.1, the BIOMA connection module has been replaced by a generic Biophysical Model Connector due to the impossibility to get access to the latest version of BIOMA (source code) and being unable to establish contact with their developers. Currently, this module aims to enable the connection to three different growth models, i.e. STICS, WOFOST, and DNDC (more specifically, DNDC v.CAN). The selection of these specific models resulted from several assumptions. First of all, only multi-crops models were considered which are able to simulate crop sequences in most production systems. Because AGRICORE agent-based modelling aims to be conducted on a regional scale, the used biophysical models had to include parametrized plant species and varieties belonging to various climatic zones. An additional requirement of the revised AGRICORE architecture was the ability to run the external models from the command line. Furthermore, the selected models were dedicated to simulating the externalities of agricultural production systems and studying the genotype and environment interactions. Selected models came from different approaches of modelling the potential and actual crop yield (they belong to the various model families), and each of them put the main focus on a specific process determining plant development. There are considerable differences in the complexity and composition of the selected models. The Denitrification-Decomposition (DNDC) model is a process-oriented model focused mainly on carbon and nitrogen biogeochemistry in agroecosystems. The crop growth and decomposition sub-models of DNDC are able to predict soil temperature, moisture, pH, redox potential and substrate concentration profiles, while the nitrification, denitrification and fermentation sub-models, aim to predict emissions of carbon dioxide, methane, ammonia, nitric oxide nitrous oxide and dinitrogen from the plant-soil systems. STICS model simulates crop growth and additionally calculates soil water and nitrogen balances from daily climatic data. It predicts agricultural variables (yield, input consumption) and environmental variables (water and nitrogen losses). A very important feature of STICS model is its adaptability to various crops, both annual and perennial. WOFOST model explains crop growth based mainly on photosynthesis, respiration and how these processes are influenced by environmental conditions. It calculates attainable crop production, biomass, water use, given knowledge about soil, crop, weather and crop management.

As each external biophysical model has its requirements for the input data needed for its initialization, the Biophysical Model Connector module can be initialized with different input datasets depending on the availability of the information in the external databases. For each of the three selected models, the set of input/output data has been identified and the minimal, optimal and maximal sets were defined. In Table 1 the optimal set of the input data is provided for the selected 3 models, whereas the complete information on the input/output datasets is attached to this deliverable as separate files.

Table 1: The optimal input datasets for STICS, DNDC and WOFOST models.

	STICS			DNDC			WOFOST		
	VARIABLE	DESCRIPTION	UNIT	VARIABLE	DESCRIPTION	UNIT	VARIABLE	DESCRIPTION	UNIT
Site	altisimul	altitude of simulated site	(m)	__Site_name	name of the site (a string)	(-)	SOFILE	name of soil file	(-)
	altistation	altitude of the input metorological station	(m)	__Simulated_years	number of total simulated years (an integer)	(-)			
	latitude	latitude of the site	(degree)	__Latitude	latitude (decimal unit) of the site	(decimal degree)			
	patm	atmospheric pressure	(mbar)						
	zr	reference height of meteorological data measurement	(m)						
Weather	weather file *.XXX where the XXX are the 3 last digits of the year	name of the weather file	(-)	__Air_CO2_concentration	atmospheric background CO_2 concentration which affects plant photosynthesis	(ppm)	WCCYEARNR	the WCC-variable 'WCCYEARNR' that gives the year	(y)
	1st column	name of weather file	(-)	__Climate_files	number of climate files included in the simulations and the name of the file with the link to the corresponding directory	(-)	LONG	longitude of the station	(decimal degree)
	2nd column	year	(y)	1st column	Julian day;	(-)	LAT	latitude of the station	(decimal degree)
	3rd column	month	(m)	2nd column	daily maximum air temperatures;	(ºC)	ALT	altitude of the station	(m)
	4th column	day in month	(d)	3rd column	daily minimum air temperatures;	(ºC)	A	the A coefficient for the Ängström formula	(-)
	5th column	Julian day	(day of the year)	4th column	daily precipitation sum	(cm)	B	the B coefficients for the Ängström formula	(-)
	6th column	minimum temperature	(°C)	5th column	wind speed daily average	(m/s)	1st column	station number	(-)

	STICS			DNDC			WOFOST		
	VARIABLE	DESCRIPTION	UNIT	VARIABLE	DESCRIPTION	UNIT	VARIABLE	DESCRIPTION	UNIT
	7th column	maximum temperature	(°C)	6th column	radiation daily sum	(MJ/m²/day)	2nd column	year	(y)
	8th column	global radiation	(MJ·m^{-2}·j^{-1})	7th column	humidity daily average	(%)	3rd column	day number	(day of year)
	9th column	Penman PET	(mm·j^{-1})				4th column	irradiation	(kJ·m^{-2}·d^{-1})
	10th column	rainfall	(mm·j^{-1})				5th column	minimum temperature	(°C)
	11th column	wind	(m·s^{-1})				6th column	maximum temperature	(°C)
	12th column	vapour pressure	(mbars)				7th column	early morning vapor pressure	(kPa)
							8th column	mean wind speed at 2 m above ground	(m·s^{-1})
							9th column	precipitation	(mm·d^{-1})
Soil	argi	clay content after decarbonation	(%)	__Land_use_ID	select a current land use (Options are: **1** - upland crop field, **2** - rice paddy field, **3** - moist grassland/pasture, **4** - dry grassland/Pasture, **5** - wetland **6** - tree plantation)	(-)	soil file *.new	name of the .new soil file	(-)
	calc	total carbonate content	(%)	__Soil_texture_ID	select a soil type based on either its texture or clay fraction (There are 12 soil types: **1** - sand, **2** - loamy sand, **3** - sandy loam, **4** - silt loam, **5** - loam, **6** - sandy clay loam, **7** - silty clay loam,	(-)	SMTAB	volumetric soil moisture content as function of pF	([log (cm); cm^3 cm^{-3}])

	STICS			DNDC			WOFOST		
	VARIABLE	DESCRIPTION	UNIT	VARIABLE	DESCRIPTION	UNIT	VARIABLE	DESCRIPTION	UNIT
					8 - clay loam, **9** - sandy clay, **10** - silty clay, **11** - clay, **12** - organic soil				
	DAF	bulk density of fine earth fraction in each soil layer	($g \cdot cm^{-3}$)	__Bulk_density	bulk density (g/cubic cm) of top soil (0-10 cm).	(g/cm^3)	SMW	soil moisture content at wilting point	($cm^3\ cm^{-3}$)
	hccf	gravimetric water content at field capacity of each soil layer (/fine earth)	(% w)	__pH	pH of top soil	(-)	SMFCF	soil moisture content at field capacity	($cm^3\ cm^{-3}$)
	hminf	gravimetric water content at wilting point of each soil layer (/fine earth)	(% w)	__Clay_fraction	clay fraction of soil by weight	(-)	SM0	soil moisture content at saturation	($cm^3\ cm^{-3}$)
	Norg	soil organic N content in the first soil layer (supposed constant down to the depth profhum), equal to total nitrogen (Kjeldahl method)	(% dry soil)	__Field_capacity	water-filled porosity (WFPS) at soil field capacity	(-)	CRAIRC	critical soil air content for aeration	($cm^3\ cm^{-3}$)
	pH	Initial soil pH (water solution)	(pH)	__Wilting_point	water-filled porosity (WFPS) at soil wilting point	(-)	CONTAB	10-log hydraulic conductivity as function of pF	([log (cm); log (cm/day)])
	typsol	soil type	(SD)	__Hydro_conductivity	hydrological saturation conductivity	(m/hr)	K0	hydraulic conductivity of saturated soil	($cm\ d^{-1}$)
				__Top_layer_SOC	Content of total soil organic carbon (SOC), including litter residue, microbes, humads, and passive humus at surface layer (0-5 cm).	(kg C/kg)	SOPE	maximum percolation rate root zone	($cm\ d^{-1}$)
							KSUB	maximum percolation rate subsoil	($cm\ d^{-1}$)
							SPADS	1st topsoil seepage parameter deep seedbed	(-)

	STICS			DNDC			WOFOST		
	VARIABLE	DESCRIPTION	UNIT	VARIABLE	DESCRIPTION	UNIT	VARIABLE	DESCRIPTION	UNIT
							SPODS	2nd topsoil seepage parameter deep seedbed	(-)
							SPASS	1st topsoil seepage parameter shallow seedbed	(-)
							SPOSS	2nd topsoil seepage parameter shallow seedbed	(-)
							DEFLIM	required moisture deficit deep seedbed	(-)
Crop	Crop file *_plt.xml	Name of the crop *_plt.xml file: baresoil_plt.xml – bare soil, corn_plt.xml – maize, DurumWheat_ACALOU_plt.xml – durum wheat, DurumWheat_ALLUR_plt.xml – durum wheat, DurumWheat_AMARILLO_plt.xml – durum wheat, DurumWheat_ARCALIS_plt.xml – durum wheat, DurumWheat_ARTIMON_plt.xml – durum wheat, DurumWheat_BIENSUR_plt.xml – durum wheat, DurumWheat_LLOYD_plt.xml – durum wheat, DurumWheat_MONTSEGUR_plt.xml – durum wheat, DurumWheat_NEFER_plt.xml – durum wheat,	(-)	_____Crop_ID	one of the crop types parameterized in DNDC. The choices are: 0 Fallow 1 Corn 2 Winter_wheat 3 Soybean 4 Legume_hay 5 Non_legume_hay 6 Spring_wheat 7 Sugarcane 8 Barley 9 Oats 10 Alfalfa 11 Annual_grass 12 Perennial_grass 13 Sorghum 14 Cotton 15 Rye	(-)	crop file *.cab	name of the .cab crop file BAR301.CAB – spring barley (EU) FBE0801.CAB - Faba bean (Vicia faba) (EU) MAG201.CAB – Maize (DE & LU) MAG202.CAB – Maize (Southern DE & Northern FR) MAG203.CAB – Maize (Central FR & Northern IT)	(-)

	STICS			DNDC			WOFOST		
	VARIABLE	DESCRIPTION	UNIT	VARIABLE	DESCRIPTION	UNIT	VARIABLE	DESCRIPTION	UNIT
		DurumWheat_NEODUR_plt.xml – durum wheat, DurumWheat_ORJAUNE_plt.xml – durum wheat, grass_plt.xml – forage grass, mustard_CoverCrop_plt.xml – mustard, pea_plt.xml – pea, proto_alfalfa_plt.xml proto_banana_plt.xml – banana, proto_barley_InterCrop_plt.xml – barley, proto_barley_plt.xml – barley, proto_fescue_plt.xml – fescue, proto_flax_plt.xml – flax, proto_lettuce_plt.xml – lettuce, proto_pea_InterCrop_plt.xml - pea proto_potato_plt.xml – potato, proto_sorghum_plt.xml – sorghum, proto_soybean_plt.xml – soybean, proto_strawberry_plt.xml - strawberry proto_sugarcane_plt.xml - sugarcane proto_sunflower_plt.xml – sunflower, proto_tomato_plt.xml – tomato, proto_winterbarley_plt.xml – winter barley, rapeseed_plt.xml - rapeseed ryegrass_CoverCrop_plt.xml – ryegrass, sugarbeet_plt.xml – sugarbeet, vine_CABFRA_plt.xml – vine, vine_CHARCCH_plt.xml – vine, vine_CHARCC_plt.xml – vine, vine_CHARDOB_plt.xml – vine, vine_CHENIN_plt.xml – vine,			16 Vegetables 17 Papaya 18 Potato 19 Beet 20 Paddy_rice 21 Banana 22 Celery 23 Peanut 24 Upland_rice 25 Rapeseeds 26 Tobacco 27 Millet 28 Sunflower 29 Beans 30 DeepWater_rice 31 Onion 32 Palm 33 Strawberry 34 Lettuce 35 Artichoke 36 Flowers 37 Sprout 38 Berries 39 Truck_crops 40 Fruit_trees 41 Citrus 42 Grape 43 Silage_corn 44 Hops 45 Tomato 46 Rainfed_rice 47 Cover_crop 48 Safflower 49 Flax 50 Sedge 51 Cassava 52 Cattail 53 CA_broccoli 54 Evergreens			MAG204.CAB – Maize (Southern FR, Northern IT, ES & PT) MAG205.CAB – Maize (GR, Southern IT, Southern ES) POT701.CAB – potato (DE, FR, NL, BE, LU, UK, IE, DK) POT702.CAB – potato (Southern FR) POT703.CAB – potato (Northern and Central IT) POT704.CAB – potato (Southern IT, GR, ES, PR) RAP1001.CAB – winter oilseed rape (EU without Southern FR, Southern IT, Southern ES) RAP1002.CAB – winter oilseed rape (Southern FR, Southern IT)	

	STICS			DNDC			WOFOST		
	VARIABLE	DESCRIPTION	UNIT	VARIABLE	DESCRIPTION	UNIT	VARIABLE	DESCRIPTION	UNIT
		vine_GRENAC_plt.xml – vine, vine_MERLOT_plt.xml – vine, vine_PINCCH_plt.xml – vine, vine_PINCC_plt.xml – vine, vine_PINOTB_plt.xml – vine, vine_SYRAH_plt.xml – vine, vine_UGNIB_plt.xml – vine, wheat_plt.xml – wheat			55 Cabbage 56 Green_onion 57 Mustard 58 Tule 59 Moss 60 Radish 61 Shrub 62 Boreal_sedge 63 Almond 64 Nut_tree 65 Melon 66 Pasture_hay 67 Small_grain_hay 68 carrots 69 peppers 70 Asparagus 71 Cauliflower 72 Artichokes 73 Sweet_Potato 74 Beans_green 75 COT 76 Olives 77 Plums 78 Cherries 79 Peach 80 Pears 81 Apples 82 Dates 83 Avocados 84 Apricots 85 Figs 86 Prunes 87 Lemons 88 Fpeas 89 Ley 90 Lentil			RAP1003.CAB – winter oilseed rape (Southern ES) RAP1004.CAB - oilseed rape (ES) RIC501.CAB – rice (FR, IT, GR, ES, PR) SOY0901.CAB – soybean (Northern FR) SOY0902.CAB – soybean (Central FR) SOY0903.CAB – soybean (Northern ES) SOY0904.CAB – soybean (Southern FR) SOY0905.CAB – soybean (IT) SOY0906.CAB – soybean (ES & GR) SUG0601.CAB – sugar beet (DE, Northern and Central FR, NL, BE, LU, UK, IE, DK) SUG0602.CA	
				_____Planting_month	a number from 1 to 12 for the month of planting	(-)			

	STICS			DNDC			WOFOST		
	VARIABLE	DESCRIPTION	UNIT	VARIABLE	DESCRIPTION	UNIT	VARIABLE	DESCRIPTION	UNIT
				_____Planting_day	a number from 1 to 31 for the day of planting	(-)		B – sugar beet (Southern FR, Northern and Central IT, ES, PT) SUG0603.CA B – sugar beet (Southern ES and Southern IT) SUG0604.CA B – sugar beet (GR) SUN1101.CA B – sunflower (FR, IT, ES, GR) WWH101.CA B – winter wheat (Northern IE, Scotland, northern UK, DK) WWH102.CA B – winter wheat (IE, central and southern UK, NL, northern DE) WWH103.CA B – winter wheat (southern NL, DE, BE, LU) WWH104.CA B – winter wheat	
				_____Harvest_month	a number from 1 to 12 for the month of harvesting	(-)			
				_____Harvest_day	a number from 1 to 31 for the day of harvesting	(-)			

	STICS			DNDC			WOFOST		
	VARIABLE	DESCRIPTION	UNIT	VARIABLE	DESCRIPTION	UNIT	VARIABLE	DESCRIPTION	UNIT
								(central DE, northern FR) WWH105.CAB – winter wheat (FR, northern & central IT, northern ES, northern PT) WWH106.CAB – winter wheat (southern IT, central & eastern ES, southern PT) WWH107.CAB – winter wheat (southern ES & Central and Southern GR)	
Agrotechnical practices	codcueille	option of harvest type (1 =single harvest (cutting), 2 = multiple harvests (picking))	(code 1/2)	___Till_applications	number of tilling applications in the year	(-)	Irigation can be added indirectly – by adding the amount of water to the daily sum of the rainfall in the weather file Fertilization can also be included indirectly – by adding the amount of NPK to the NBASE, PBASE, and KBASE variables (basic supply of nitrogen, phosphorus and potassium by the unfertilized soil)		
	codefracappN	option to activate splitting applications of N fertiliser (1 = absolute value, 2 = % of total value)	(code 1/2)	_____Till#	sequential number of each application.	(-)			
	doseI	irrigation amount	(mm·d^{-1})	_____Till_month	month of the tilling application	(-)			
	engrais	fertilizer type (1=ammonium nitrate, 2=UAN solution, 3=urea, 4=anhydrous ammonia, 5=ammonium sulfate, 6=ammonium phosphate, 7=calcium nitrate, 8= fixed efficiency fertiliser)	(*)	_____Till_day	day of the tilling application	(-)			

	STICS			DNDC			WOFOST		
	VARIABLE	DESCRIPTION	UNIT	VARIABLE	DESCRIPTION	UNIT	VARIABLE	DESCRIPTION	UNIT
	fracN	proportion of fertiliser N applied at each application	(%)	_____Till_method	define tilling depth by selecting one of the default methods as **1** - no-till (i.e., only mulching) (0 cm), **2** - ploughing slightly (5 cm), **3** - ploughing with disk or chisel (10 cm), **4** - ploughing with moldboard (20 cm), **5** - deep ploughing (30 cm).	(-)			
	iplt0	date of sowing	(julian.d)	___Fertilizer_applications	number of applications in the year	(-)			
	irec	date of harvest	(julian.d)	_____Fertilizing#	sequential number of each application	(-)			
	julapI	date(s) of irrigation	(julian.d)	_____Fertilizing_month	month of the fertilization application	(-)			
	julapN	date(s) of fertilizer application	(julian.d)	_____Fertilizing_day	day of the fertilization application	(-)			
	juleclair	day of fruits removal	(julian.d)	_____Nitrate	nitrate fertilizer amount	(kg N/ha)			
	julfauche	date(s) of each cut for forage crops	(julian.d)	_____Ammonium_bicarbonate	ammonium bicarbonate fertilizer amount	(kg N/ha)			
	jultrav	date(s) of soil tillage	(julian.d)	_____Urea	urea fertilizer amount	(kg N/ha)			
	nbcueille	number of fruit harvestings (1= one at the end, 2 = many during the cycle)	(code 1/2)	_____Anhydrous_ammonia	anhydrous ammonia fertilizer amount	(kg N/ha)			
	nbjtrav	number of tillage operations	(SD)	_____Ammonium	ammonium $(NH_4)NO_3$ fertilizer amount	(kg N/ha)			
	Qtot_N	amount of total mineral N fertilizer applications	($kg \cdot ha^{-1}$)	_____Sulphate	sulphate $(NH_4)_2SO_4$ fertilizer amount	(kg N/ha)			
	variete	cultivar number corresponding to the cultivar name in the plant file	SD	_____Phosphate	phosphate $(NH_4)_2HPO_4$ fertilizer amount	(kg N/ha)			
				___Irrigation_applications	number of applications in the year	(-)			

	STICS			DNDC			WOFOST		
	VARIABLE	DESCRIPTION	UNIT	VARIABLE	DESCRIPTION	UNIT	VARIABLE	DESCRIPTION	UNIT
				_____Irrigation#	sequential number of each application	(-)			
				_____Irri_month	month of the fertilization application	(-)			
				_____Irri_day	day of the fertilization application	(-)			
				_____Water_amount	amount of water used	(cm)			
				_____Irri_method	sequential irrigation method used, flood, sprinkler and drip are options subject to different evaporation or leaching water losses and hence have different water use efficiencies **1** - furrow **2** - sprinkler **3** - drip (0cm) **4** - drip (15cm)	(-)			
Run file (USM.xml) in STICS/Timer file in WOFOST	datedebut	day of the beginning of the simulation	(julian.d)	Not applicable			ISYR	first year for which crop growth is simulated.	(y)
	datefin	day of the end of simulation	(julian.d)				IDSOW	day of sowing (day of year). Used if ISTCHO = 1.	(day of year)
	culturean	number of calendar years involved in the crop cycle (1 = 1 year e.g. for spring crops, 0 = two years, e.g. for winter crops)	(code 1/0)						
Site File	Not applicable			Not applicable			NBASE	basic supply of nitrogen by the unfertilized soil (N, kg•ha-1). Range: 0 - 100	kg ha^{-1}

	STICS			DNDC			WOFOST		
	VARIABLE	DESCRIPTION	UNIT	VARIABLE	DESCRIPTION	UNIT	VARIABLE	DESCRIPTION	UNIT
							PBASE	basic supply of phosphorus by the unfertilized soil (P, kg•ha-1). Range: 0 - 10.	kg ha^{-1}
							KBASE	basic supply of potassium by the unfertilized soil (K, kg•ha-1). Range: 0 - 100.	kg ha^{-1}

3 Architecture of the AGRICORE's Biophysical Models Connectors

To ensure the connectivity between ABM Simulation Module and the external biophysical models, which usually have their own structure and format of the input/output files, the input/output translators for biophysical models had to be developed. They are used to translate the ABM gRPC request with input parameters to the formats and structures specific for each of the used biophysical models. After the bio-simulation is executed properly, the output information from the biophysical model is delivered also as a gRPC response to the ABM simulation engine. The schematic flowchart describing the internal architecture of the Biophysical models connector and their communication with ABM Simulation Module is presented in Figure 1. Additionally, the flow of the data from the Data Warehouse to the ABM simulation engine is shown to understand what data is passed via gRPC request to Biophysical models connectors module.

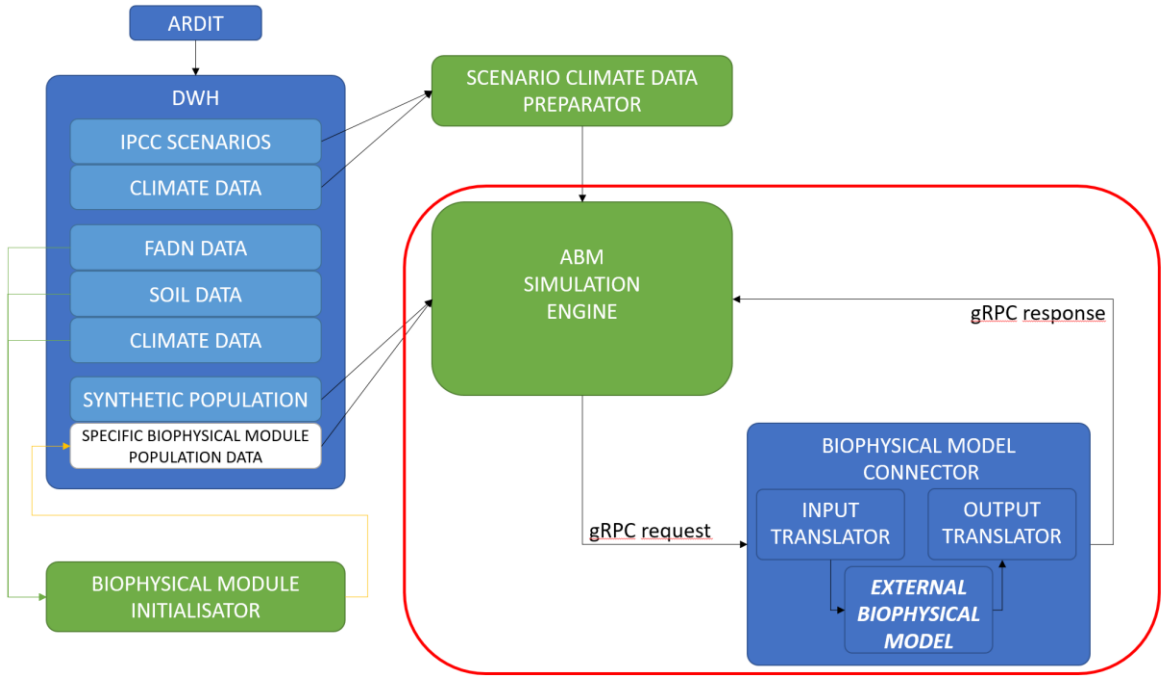


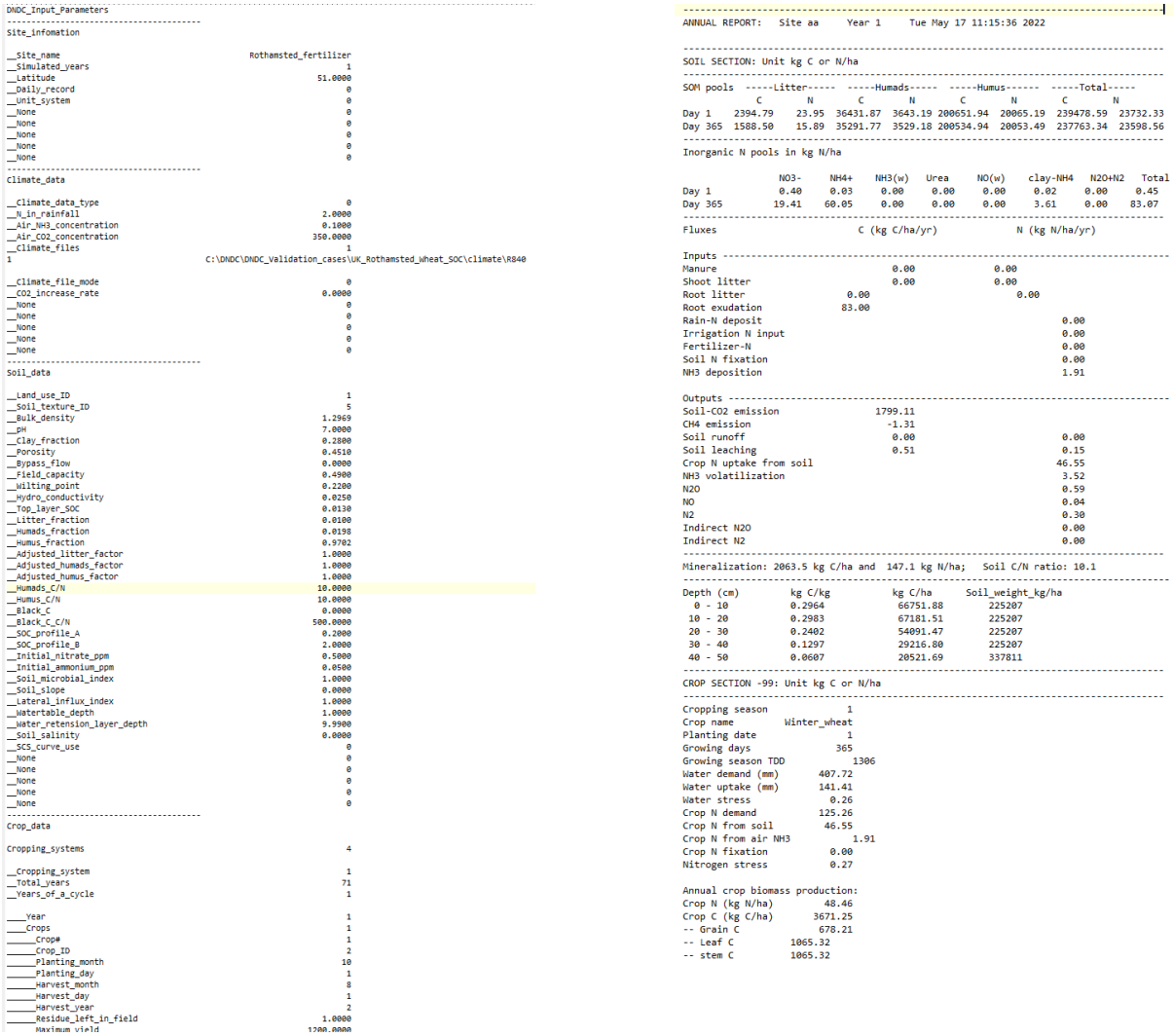
Figure 1: The flowchart of Biophysical models connectors architecture.

The translators of the request from ABM Simulation Module had to take into account the specificity of the structure of the input/out data files for each of the used external biophysical models. The selected models differ in the required number of input files necessary to initialize the simulations and output files with the results of simulations.

3.1 DNDC Model I/O

The DNDC model input file is in plain text format and contains the list of variables and their values, in individual lines. This file contains input values concerning: site information, soil and plant description, applications of soil tillage, fertilizers, irrigation, plant cutting and grazing as well as basic climate parameters such as N in rainfall, air NH_3 concentration, air CO_2 concentration and CO_2 increase rate. Only, the climate yearly time series data of daily values are contained in separate files and the names of these files, with the links to the corresponding directories, are included in a separate line of this input file. DNDC model is dedicated to simulating the

development and growth of annual and perennial crops. When working with perennial crops users have to specify it in the data input file. The results of the simulation are provided in annual report files. The units are strictly defined for all the input variables and cannot be changed. In Figure 2 an example of the input and output DNDC files is presented.



```
DNDC_Input_Parameters
-------------------------------------
Site_infomation

__Site_name                                  Rothamsted_fertilizer
__Simulated_years                                            1
__Latitude                                               51.0000
__Daily_record                                               0
__Unit_system                                                0
__None                                                       0
__None                                                       0
__None                                                       0
__None                                                       0
__None                                                       0
-------------------------------------
Climate_data

__Climate_data_type                                          0
__N_in_rainfall                                          2.0000
__Air_NH3_concentration                                  0.1000
__Air_CO2_concentration                                350.0000
__Climate_files                                              1
1                                    C:\DNDC\DNDC_Validation_cases\UK_Rothamsted_Wheat_SOC\climate\R840

__Climate_file_mode                                          0
__CO2_increase_rate                                      0.0000
__None                                                       0
__None                                                       0
__None                                                       0
__None                                                       0
__None                                                       0
-------------------------------------
Soil_data

__Land_use_ID                                                1
__Soil_texture_ID                                            5
__Bulk_density                                           1.2969
__pH                                                     7.0000
__Clay_fraction                                          0.2800
__Porosity                                               0.4510
__Bypass_flow                                            0.0000
__Field_capacity                                         0.4900
__Wilting_point                                          0.2200
__Hydro_conductivity                                     0.0250
__Top_layer_SOC                                          0.0130
__Litter_fraction                                        0.0100
__Humads_fraction                                        0.0198
__Humus_fraction                                         0.9702
__Adjusted_litter_factor                                 1.0000
__Adjusted_humads_factor                                 1.0000
__Adjusted_humus_factor                                  1.0000
__Humads_C/N                                            10.0000
__Humus_C/N                                             10.0000
__Black_C                                                0.0000
__Black_C_C/N                                          500.0000
__SOC_profile_A                                          0.2000
__SOC_profile_B                                          2.0000
__Initial_nitrate_ppm                                    0.5000
__Initial_ammonium_ppm                                   0.0500
__Soil_microbial_index                                   1.0000
__Soil_slope                                             0.0000
__Lateral_influx_index                                   1.0000
__Watertable_depth                                       1.0000
__Water_retension_layer_depth                            9.9900
__Soil_salinity                                          0.0000
__SCS_curve_use                                              0
__None                                                       0
__None                                                       0
__None                                                       0
__None                                                       0
__None                                                       0
-------------------------------------
Crop_data

Cropping_systems                                             4

__Cropping_system                                            1
__Total_years                                               71
__Years_of_a_cycle                                           1

____Year                                                     1
____Crops                                                    1
______Crop#                                                  1
______Crop_ID                                                2
______Planting_month                                        10
______Planting_day                                           1
______Harvest_month                                          8
______Harvest_day                                            1
______Harvest_year                                           2
______Residue_left_in_field                              1.0000
      Maximum_yield                                      1200.0000
```

```
-------------------------------------------------------------------------------
ANNUAL REPORT:   Site aa     Year 1     Tue May 17 11:15:36 2022

-------------------------------------------------------------------------------
SOIL SECTION: Unit kg C or N/ha
-------------------------------------------------------------------------------
SOM pools  -----Litter-----  -----Humads-----  -----Humus------  -----Total-----
              C        N         C        N         C        N         C        N
Day 1     2394.79    23.95  36431.87  3643.19 200651.94  20065.19  239478.59  23732.33
Day 365   1588.50    15.89  35291.77  3529.18 200534.94  20053.49  237763.34  23598.56
-------------------------------------------------------------------------------
Inorganic N pools in kg N/ha

                NO3-     NH4+    NH3(w)   Urea     NO(w)    clay-NH4   N2O+N2   Total
Day 1           0.40     0.03     0.00    0.00     0.00     0.02     0.00     0.45
Day 365        19.41    60.05     0.00    0.00     0.00     3.61     0.00    83.07
-------------------------------------------------------------------------------
Fluxes                        C (kg C/ha/yr)              N (kg N/ha/yr)

Inputs -----------------------------------------------------------------------
Manure                                  0.00                0.00
Shoot litter                            0.00                0.00
Root litter                     0.00                                0.00
Root exudation                 83.00
Rain-N deposit                                                              0.00
Irrigation N input                                                          0.00
Fertilizer-N                                                                0.00
Soil N fixation                                                             0.00
NH3 deposition                                                              1.91

Outputs ----------------------------------------------------------------------
Soil-CO2 emission                     1799.11
CH4 emission                            -1.31
Soil runoff                             0.00                            0.00
Soil leaching                           0.51                            0.15
Crop N uptake from soil                                                46.55
NH3 volatilization                                                      3.52
N2O                                                                     0.59
NO                                                                      0.04
N2                                                                      0.30
Indirect N2O                                                            0.00
Indirect N2                                                             0.00
-------------------------------------------------------------------------------
Mineralization: 2063.5 kg C/ha and  147.1 kg N/ha;   Soil C/N ratio: 10.1
-------------------------------------------------------------------------------
Depth (cm)        kg C/kg          kg C/ha      Soil_weight_kg/ha
  0 - 10          0.2964            66751.88        225207
 10 - 20          0.2983            67181.51        225207
 20 - 30          0.2402            54091.47        225207
 30 - 40          0.1297            29216.80        225207
 40 - 50          0.0607            20521.69        337811
-------------------------------------------------------------------------------
CROP SECTION -99: Unit kg C or N/ha
-------------------------------------------------------------------------------
Cropping season             1
Crop name         Winter_wheat
Planting date               1
Growing days              365
Growing season TDD         1306
Water demand (mm)       407.72
Water uptake (mm)       141.41
Water stress              0.26
Crop N demand           125.26
Crop N from soil         46.55
Crop N from air NH3       1.91
Crop N fixation           0.00
Nitrogen stress           0.27

Annual crop biomass production:
Crop N (kg N/ha)         48.46
Crop C (kg C/ha)       3671.25
-- Grain C             678.21
-- Leaf C            1065.32
-- stem C            1065.32
```

Figure 2: The structure of the input (left panel) and output (right panel) for the DNDC model.

3.2 STICS Model I/O

To initiate a simulations in STICS it is necessary to define simulation units, which correspond to a climate, a soil, a crop and a crop management. These parameter files are stored in a working directory called workspace in the interface. The input parameters are subdivided into two categories: global parameters (giving access to general parameters and crop parameters files) and local parameters (giving access to specific parameters files). The global parameters are grouped into different categories creating a structure and containing:

- parameters corresponding to options (with the different possible values).
- parameters for which a value has to be given (a specific value is entered in the box).

Two additional types of crop parameters are contained in a separate file:

- parameters corresponding to options (they can be chosen from possible values); for a chosen option there is a specific list of parameters. For example, if the 'annual' option is chosen, some specific parameters will be displayed in 'emergence and starting' for defining the germination or latency parameters and the type of plant growth; however, if the 'perennial' option is chosen, those parameters are no longer displayed.
- parameters for which a value has to be given (the value can be entered in the box in GUI).

The local parameters of STICS model include five sets of files which refer to:

- initialization of the system at simulation start.
- soils parameterization.
- crop management parameterization.
- climate data and weather station parameterization.

The list of available input parameters of STICS model is presented in Table 1. The results of the simulations are saved in output files, whose number and structure can be defined in a configuration file. There are the following types of output files:

- balance files: which describe the different stages of the simulated crop and balances.
- history file: is a log file that gives you the parameter values used and warning or error messages concerning the simulation.
- daily output files: containing the variables chosen within the state variables simulated by the model.
- report file: a file that gives a synthesis of the state variables chosen on a line corresponding to a date and/or stage.
- profile file: provides a state variable of temperature or soil moisture along with the depth of the soil for a set of chosen dates.

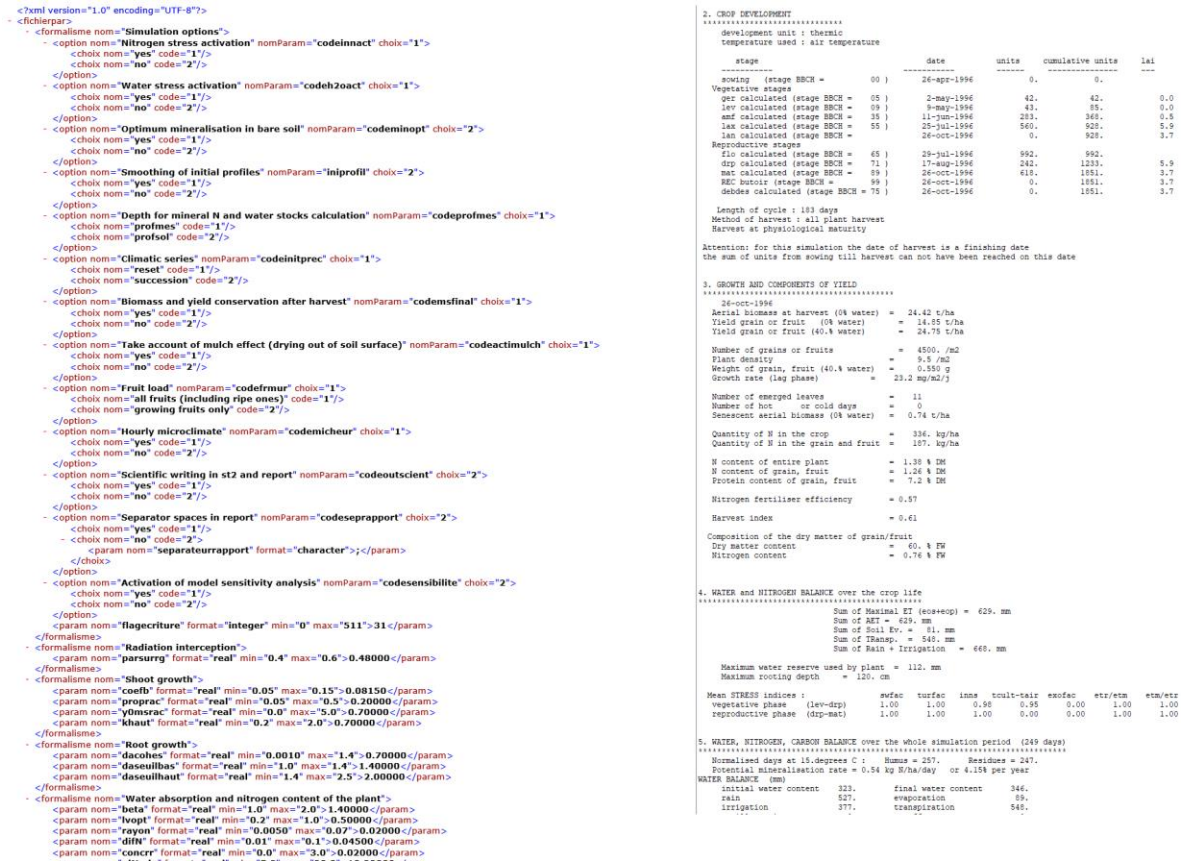


Figure 3: The examples of the input xlm (left panel) and output text (right panel) files for the STICS model.

3.3 WOFOST Model I/O

WOFOST is a dynamic simulation model for the quantitative analysis of the growth and production of annual field crops. There is no option for perennial crops included. With this model, it is possible to calculate potential production, and two levels of limited production: water-limited and nutrient-limited production. The potential production option allows obtaining yield in a simulation environment non-constrained by water or nutrient limitations, while the other pre-defined models available, as water-limited and nutrient-limited, allow calculating the production in a constrained simulation environment. Only in these pre-defined models, the simulation environment allows for establishing some agro-management decisions that are triggered by some simulation events, either dates or internal crop states. The decisions concern: irrigation regarding both the amount of water in mm and the date of treatment, the effectiveness and fertiliser dose amount of nitrogen, phosphorous, and potassium in kilograms per hectare. However, to run such a simulation using agro-management decisions, it is necessary to use the simulation engine rather than running a pre-defined model. This allows skipping some constraints of the model, which does not take into account the effect of these decisions on crop production directly. The particularity of using agro-management decisions is that each action can be triggered by events either dates or states related to simulation variables.

The input files containing the specific crop, soil, and weather parameters are written in separate data files with precisely defined units. There are also input run files that are used for the configuration of specific types of simulations. The first of them is the timer file with weather and crop calendar-related data; next, there is the site file with default values for soil and the rerun file which defines the series of consecutive WOFOST runs; and finally, there is the run option file with

general information. There are four different output file types in WOFOST: detailed output of the simulation, summary output for potential growth, summary output for water-limited growth, and summary output (which is created only when the simulation is made for more than two weather years).

```
** $Id: wwh101.cab 1.3 1997/09/25 14:07:03 LEM release $
** File WWH101.CAB
** CROP DATA FILE for use with WOFOST Version 5.4, June 1992
**
** WHEAT, WINTER 101
** Regions : Northern Ireland, Scotland, northern UK (R71), Denmark
** start date 1 January
** mean date of flowering 10 Jun, mature 15 Aug

** Derived from SUCROS87 data set for wheat.
** Calibrated for use in WOFOST model at the Centre for Agrobiological
** Research (CABO-DLO) for the simulation of crop growth and yield on the
** basis of daily weather data.
** Purpose of application: Crop growth monitoring with agrometeorological
** model in the EC.
** Developed in the framework of JRC Agriculture Project Action 3.

CRPNAM='Winter wheat 101, N-U.K., Denmark'

** emergence
TBASEM   = -10.0    ! lower threshold temp. for emergence [cel]
TEFFMX   =  30.0    ! max. eff. temp. for emergence [cel]
TSUMEM   =   0.     ! temperature sum from sowing to emergence [cel d]

** phenology
IDSL     =   0      ! indicates whether pre-anthesis development depends
                    ! on temp. (=0), daylength (=1) , or both (=2)
DLO      = -99.0    ! optimum daylength for development [hr]
DLC      = -99.0    ! critical daylength (lower threshold) [hr]
TSUM1    =1000.     ! temperature sum from emergence to anthesis [cel d]
TSUM2    = 950.     ! temperature sum from anthesis to maturity [cel d]
DTSMTB   =   0.00,    0.00,     ! daily increase in temp. sum
             30.00,   30.00,     ! as function of av. temp. [cel; cel d]
             45.00,   30.00
DVSI = 0.           ! initial DVS
DVSEND   =   2.00   ! development stage at harvest (= 2.0 at maturity [-])

** initial
TDWI     = 210.00   ! initial total crop dry weight [kg ha-1]
LAIEM    =   0.1365 ! leaf area index at emergence [ha ha-1]
RGRLAI   =   0.00817 ! maximum relative increase in LAI [ha ha-1 d-1]

** green area
SLATB    =   0.00,    0.00212,   ! specific leaf area
             0.50,    0.00212,   ! as a function of DVS [-; ha kg-1]
             2.00,    0.00212
SPA      =   0.000  ! specific pod area [ha kg-1]
SSATB =  0.0, 0.0,  ! specific stem area [ha kg-1]
         2.0, 0.0   ! as function of DVS
SPAN     =  31.3  ! life span of leaves growing at 35 Celsius [d]
TBASE    =   0.0    ! lower threshold temp. for ageing of leaves [cel]

** assimilation
KDIFTB = 0.0, 0.60, ! extinction coefficient for diffuse visible light [-]
         2.0, 0.60  ! as function of DVS
```

```
**WOFOST version 7.1.7, release September 2013
RUNNAM -> WCC
OUTPUT -> file: output\wcc.out
RERUNS -> no reruns

WEATHER-> name: Netherlands, Wageningen
          file: meteo\cabowe\nl11.   start year: 1980
RAIN   -> belonging to weather station
CROP   -> name: Spring barley 301, EC
          file: cropd\bar301.cab
SOIL   -> name: EC1-coarse
          file: soild\ec1.new
START  -> fixed sowing date
    start waterbalance = -99     sowing date =   1     emergence date =  45

POTENTIAL CROP PRODUCTION
=========================

YEAR  DAY IDSEM DVS  TSUM   WLV    WST    WSO    TAGP   LAI  TRA   GASS   MRES    DMI

                     degrd kg/ha  kg/ha  kg/ha   kg/ha m2/m2   mm/d CH2O CH2O  kg/ha/d
 1980  45   0  0.00    0.    24.     0.     0.    24.  0.05 0.00    0.0    0.0    0.0
 1980  46   1  0.00    2.    24.     0.     0.    24.  0.05 0.01    0.6    0.3    0.2
 1980  47   2  0.01    7.    24.     0.     0.    24.  0.05 0.00    1.4    0.3    0.8
 1980  48   3  0.02   13.    24.     0.     0.    24.  0.05 0.00    1.7    0.3    1.0
 1980  49   4  0.02   17.    25.     0.     0.    25.  0.05 0.01    2.1    0.3    1.3
 1980  50   5  0.03   22.    25.     0.     0.    25.  0.05 0.01    2.4    0.2    1.6
 1980  51   6  0.03   25.    26.     0.     0.    26.  0.05 0.01    2.6    0.3    1.7
 1980  52   7  0.04   29.    27.     0.     0.    27.  0.05 0.02    3.7    0.3    2.4
 1980  53   8  0.04   35.    28.     0.     0.    28.  0.06 0.02    3.6    0.3    2.3
 1980  54   9  0.05   41.    29.     0.     0.    29.  0.06 0.01    0.3    0.3    0.0
 1980  55  10  0.06   45.    29.     0.     0.    29.  0.06 0.01    0.7    0.3    0.3
 1980  56  11  0.06   50.    29.     0.     0.    29.  0.06 0.00    0.0    0.0    0.0
 1980  57  12  0.07   54.    29.     0.     0.    29.  0.06 0.01    0.0    0.0    0.0
 1980  58  13  0.07   57.    29.     0.     0.    29.  0.06 0.01    0.0    0.0    0.0
 1980  59  14  0.07   59.    29.     0.     0.    29.  0.06 0.01    0.0    0.0    0.0
 1980  60  15  0.08   62.    29.     0.     0.    29.  0.06 0.01    0.2    0.2    0.0
 1980  61  16  0.09   69.    29.     0.     0.    29.  0.06 0.01    0.2    0.2    0.0
 1980  62  17  0.09   74.    29.     0.     0.    29.  0.06 0.01    0.3    0.3    0.0
 1980  63  18  0.10   77.    29.     0.     0.    29.  0.06 0.01    0.4    0.3    0.1
 1980  64  19  0.10   79.    29.     0.     0.    29.  0.06 0.01    0.0    0.0    0.0
 1980  65  20  0.10   82.    29.     0.     0.    29.  0.06 0.01    0.0    0.0    0.0
 1980  66  21  0.11   86.    29.     0.     0.    29.  0.06 0.01    0.0    0.0    0.0
 1980  67  22  0.11   90.    29.     0.     0.    29.  0.06 0.02    0.1    0.1    0.0
 1980  68  23  0.12   97.    29.     0.     0.    29.  0.06 0.01    0.0    0.0    0.0
 1980  69  24  0.13  101.    29.     0.     0.    29.  0.06 0.01    0.0    0.0    0.0
 1980  70  25  0.13  102.    29.     0.     0.    29.  0.06 0.01    1.0    0.4    0.5
 1980  71  26  0.13  108.    29.     0.     0.    29.  0.06 0.00    0.7    0.3    0.3
 1980  72  27  0.14  114.    29.     0.     0.    29.  0.06 0.00    1.1    0.3    0.6
 1980  73  28  0.15  119.    29.     0.     0.    29.  0.06 0.02    3.2    0.4    2.0
 1980  74  29  0.16  126.    30.     0.     0.    30.  0.06 0.02    2.3    0.3    1.5
 1980  75  30  0.16  131.    31.     0.     0.    31.  0.06 0.01    1.5    0.3    0.9
 1980  76  31  0.17  133.    31.     0.     0.    31.  0.06 0.01    2.3    0.3    1.4
```

Figure 4: The examples of the structure of input (left panel) and output (right panel) files for the WOFOST model.

4 Implementation of the input/output translators

4.1 Interface definition

The biophysical connection module was implemented as a server awaiting requests providing data indispensable for running the biophysical models and returning the response related to the yield and other plant production details. The communication between the biophysical module and other modules of the Agricore suite is realized using the gRPC protocol. As a result, Protocol Buffers are used for the interface definition. The third version of the Protocol Buffers language specification was used for interface definition.

The Protocol Buffers code defining the interfaces is presented below in CodeBlock 1.

```
Syntax = "proto3";

  service BiophysicalModels {
    rpc BiophysDndcRun (DndcRequest) returns (DndcReply) {}
    rpc BiophysDndcCheckRequest (DndcRequest) returns (DndcReply) {}
  }

  message DndcRequest {
    //The  iophysical model to be used
    enum TmodelType {
      FAKE_ENTRY_MODEL_TYPE = 0;
      DNDC = 1;
      WOFOST = 2;
      STICS = 3;
    };

    //Input parameters detailedness mode
    enum TmodelMode {
      FAKE_ENTRY_MODEL_MODE = 0;
      MINIMAL = 1;
      OPTIMAL = 2;
      DETAILED = 3;
    }

    enum TtillMethod {
      NO_TILLAGE = 0;
      MULCHING_ONLY = 1;
      PLOUGHING_SLIGHTLY_5_CM = 2;
      PLOUGHING_W_DISK_OR_CHISEL_10_CM = 3;
      PLOUGHING_W_MOLDBOARD_20_CM = 4;
      PLOUGHING_DEEP_30_CM = 5;
      LITTER_BURYING_TILL = 6;
      CROP_TERMINATING_TILL = 7;
    }

    enum TirrigationMethod {
      FURROW = 0;
      SPRINKLER = 1;
      DRIP_0_CM = 2;
      DRIP_15_CM = 3;
    }

    enum TlandUse {
      FAKE_LAND_USE = 0;
      UPLAND_CROP = 1;
      RICE_PADDY = 2;
      MOIST_GRASSLAND = 3;
      DRY_GRASSLAND = 4;
      WETLAND = 5;
      TREE = 6;
    }

    enum TsoilTextureClass {
      FAKE_SOIL_TEXTURE = 0;
      SAND = 1;
      LOAMY_SAND = 2;
      SANDY_LOAM = 3;
      SILTY_LOAM = 4;
      LOAM = 5;
      SANDY_CLAY_LOAM = 6;
      SILTY_CLAY_LOAM = 7;
      CLAYLEY_LOAM = 8;
      SANDY_CLAY = 9;
      SILTY_CLAY = 10;
      CLAY = 11;
      ORGANIC_SOIL = 12;
```

```
}


enum TCropName {
  FALLOW = 0;
  CORN = 1;
  WINTER_WHEAT = 2;
  SOYBEAN = 3;
  LEGUME_HAY = 4;
  NON_LEGUME_HAY = 5;
  SPRING_WHEAT = 6;
  SUGARCANE = 7;
  BARLEY = 8;
  OATS = 9;
  ALFALFA = 10;
  ANNUAL_GRASS = 11;
  PERENNIAL_GRASS = 12;
  SORGHUM = 13;
  COTTON = 14;
  RYE = 15;
  VEGETABLES = 16;
  PAPAYA = 17;
  POTATO = 18;
  BEET = 19;
  PADDY_RICE = 20;
  BANANA = 21;
  CELERY = 22;
  PEANUT = 23;
  UPLAND_RICE = 24;
  RAPESEEDS = 25;
  TOBACCO = 26;
  MILLET = 27;
  SUNFLOWER = 28;
  BEANS = 29;
  DEEPWATER_RICE = 30;
  ONION = 31;
  PALM = 32;
  STRAWBERRY = 33;
  LETTUCE = 34;
  ARTICHOKE = 35;
  FLOWERS = 36;
  SPROUT = 37;
  BERRIES = 38;
  TRUCK_CROPS = 39;
  FRUIT_TREES = 40;
  CITRUS = 41;
  GRAPE = 42;
  SILAGE_CORN = 43;
  HOPS = 44;
  TOMATO = 45;
  RAINFED_RICE = 46;
  COVER_CROP = 47;
  SAFFLOWER = 48;
  FLAX = 49;
  SEDGE = 50;
  CASSAVA = 51;
  CATTAIL = 52;
  CA_BROCCOLI = 53;
  EVERGREENS = 54;
  CABBAGE = 55;
  GREEN_ONION = 56;
  MUSTARD = 57;
  TULE = 58;
  MOSS = 59;
  RADISH = 60;
  SHRUB = 61;
```

```
    BOREAL_SEDGE = 62;
    ALMOND = 63;
    NUT_TREE = 64;
    MELON = 65;
    PASTURE_HAY = 66;
    SMALL_GRAIN_HAY = 67;
    CARROTS = 68;
    PEPPERS = 69;
    ASPARAGUS = 70;
    CAULIFLOWER = 71;
    ARTICHOKES = 72;
    SWEET_POTATO = 73;
    BEANS_GREEN = 74;
    COT = 75;
    OLIVES = 76;
    PLUMS = 77;
    CHERRIES = 78;
    PEACH = 79;
    PEARS = 80;
    APPLES = 81;
    DATES = 82;
    AVOCADOS = 83;
    APRICOTS = 84;
    FIGS = 85;
    PRUNES = 86;
    LEMONS = 87;
    FPEAS = 88;
    LEY = 89;
    LENTIL = 90;
  }

  //Weather data for a given year
  message TWeatherYearlyData {
    int32 Year = 1;
    repeated TWeatherDailyData WeatherDailyData = 2;
  }

  //Weather data daily record definition
  message TWeatherDailyData {
    int32 JulianDay = 1;
    float AirTMax = 2;
    float AirTMin = 3;
    float TotalPrecipitation = 4;
    optional float AverageWindSpeed = 5;
    optional float TotalRadiation = 6;
    optional float AverageAirHumidity = 7;
  }

  //Till application
  message TTillApplication {
    int32 TillId = 1;
    int32 TillMonth = 2;
    int32 TillDay = 3;
    TTillMethod TillMethod = 4;
  }

  //Fertilizer application
  message TFertilizerApplication {
    int32 FertilizingId = 1;
    int32 FertilizingMonth = 2;
    int32 FertilizingDay = 3;
    float FertNitrate = 4;
    float FertAmmoniumBicarbonate = 5;
    float FertUrea = 6;
    float FertAnhydrousAmmonia = 7;
    float FertAmmonium = 8;
```

```
    float FertSulphate = 9;
    float FertPhosphate = 10;
  }

  //Irrigation application
  message TIrrigationApplication {
    int32 IrrigationId = 1;
    int32 IrrigationMonth = 2;
    int32 IrrigationDay = 3;
    float IrrigationWaterAmount = 4;
    TIrrigationMethod IrrigationMethod = 5;
  }

  //Crop data
  message TCropData {
    TCropName CropName = 1;
    int32 PlantingMonth = 2;
    int32 PlantingDay = 3;
    int32 HarvestMonth = 4;
    int32 HarvestDay = 5;
    int32 TillApplicationNo = 6;
    repeated TTillApplication TillApplication = 7;
    int32 FertilizerApplicationNo = 8;
    repeated TFertilizerApplication FertilizerApplication = 9;
    int32 IrrigationApplicationNo = 10;
    repeated TIrrigationApplication IrrigationApplication = 11;
  }

  TModelType ModelType = 1;
  TModelMode ModelMode = 2;
  //Site
  int32 SimulatedYears = 3;
  float Latitude = 4;
  //Climate
  float AirCo2Concentration = 5;
  repeated TWeatherYearlyData WeatherYearlyData = 6;
  //Soil
  TLandUse LandUse = 7;
  TSoilTextureClass SoilTextureClass = 8;
  float BulkDensity = 9;
  float pH = 10;
  float ClayFraction = 11;
  float FieldCapacityTheta = 13;
  float WiltingPointTheta = 14;
  float SaturatedConductivity = 15;
  float TopLayerSOC = 16;
  //Crop
  int32 CroppingSystemsNo = 17;
  repeated TCropData CropData = 18;
}

message DndcReply {
  enum TReturnCode {
    FAKE_RETURN_CODE = 0;
    OK = 1;
    ERR_REQUEST = 2;
    ERR_RUNTIME = 3;
  }

  message TModelReply {
    int32 YearNo = 1;
    string CropName = 2;
    float TotalCPool = 3;
    float TotalNPool = 4;
    float InorganicNInTotalPool = 5;
    float CMineralization = 6;
```

```
    float NMineralization = 7;
    float CIn0_10Layer = 8;
    float CIn10_20Layer = 9;
    float CIn20_30Layer = 10;
    float CIn30_40Layer = 11;
    float CIn40_50Layer = 12;
    float SoilCO2Emmision = 13;
    float SoilNH4Emmision = 14;
    float CropNUptake = 15;
    float N20 = 16;
    float N2 = 17;
    float WaterDemand = 18;
    float WaterUptake = 19;
    float CropNDemand = 20;
    float CropNFromSoil = 21;
    float CropNFromAirNH3 = 22;
    float CropNFixation = 23;
    float NitrogenStress = 24;
    float CropN = 25;
    float CropC = 26;
    float CropGrainC = 27;
    float CropLeafC = 28;
    float CropStemC = 29;
    float CropRootC = 30;
    float CropNPP = 31;
    float CropNEE = 32;
    float Stubble = 33;
    float FruitCut = 34;
    float LeafCut = 35;
    float StemCut = 36;
    float RootCut = 37;
    float LifestockFeedDemand = 38;
    float GrazedBiomass = 39;
    float FinalSoilProfileWater = 40;
    float FinalSoilP = 41;
    float PFluxOfLeaching = 42;
  }

  TReturnCode ReturnCode = 1;
  string RunInfo = 2;
  repeated TModelReply ModelReply = 3;
}
```

CodeBlock 1: Interfaces Definition using Protocols Buffer Language

4.1.1 Interface constraints and assumptions

Despite the provided definition of the request, which is only a formal specification of the structure (fields and their types) of the request, additional requisites must be fulfilled, which can't be specified within the Protocol Buffers specification. And have to be taken into account in the client code, which forms the request to be sent to the biophysical models' interface module.

The list of the constraints:

1. Some request fields are defined as the enumeration structures (ENUM). In some cases, the first field of ENUM has the name beginning with the phrase "FAKE_..." (e.g. FAKE_ENTRY_MODEL_TYPE, or FAKE_ENTRY_MODEL_MODE). Usage of these values in the request is prohibited. They had to be placed in the request definition due to the Protocol Buffers requirements to start ENUMs with 0, but this value is not acceptable due to the particular biophysical model requirements.
2. The repeated field WeatherDailyData (repeated TWeatherDailyData WeatherDailyData) in the message TWeatherYearlyData is providing the meteorological data for subsequent days of the given year:
    a. the daily records have to appear in chronological order (the field JulianDay has to be sorted ascending),
    b. the records have to be provided for all days within the considered year,
    c. the field JulianDay enumerates days within the year starting from 1 for the 1st of January.
3. When variables indicating the tillage (TillApplicationNo), irrigation (IrrigationApplicationNo), and fertilizer (FertilizerApplicationNo) application events have the value 0 - then the accompanying list defining particular events (TillApplication, IrrigationApplication and/or FertilizerApplication) have to be empty lists.
4. Value constraints to be fulfilled:
    a. $0.5 < \text{BulkDensity} < 1.8$,
    b. $3 < \text{pH} < 10$,
    c. WiltingPointTheta < FieldCapacityTheta.

4.1.2 Interface correctness check service

The correctness of the request is checked prior to running the biophysical model. In case of a failing check, the response returns the ReturnCode::ERR_REQUEST. The additional endpoint was also provided (BiophysDndcCheckRequest) allowing checking the correctness of the request.

4.2 Input/output translators software development

The code was implemented using Python programming language. Some new Python language features were used in the code so at least version 3.10 of the Python interpreter is needed to run the code of the biophysical models interconnection module.

The server-side executable was implemented which provides two endpoints for running the biophysical model (BiophysDndcRun) and testing the correctness of the request (BiophysDndcCheckRequest).

4.2.1 General architecture

The general flowchart describing the functioning of the server is provided below. The server allows servicing multiple simultaneously connecting clients. Each of the clients sends the request to the server which will cause the biophysical model execution to prepare response data for the particular client. The runtime environment of the biophysical models is organized in such a way that the simultaneously running biophysical models are isolated and do not infer each other.

As the biophysical model run time might be quite long, especially to be used for optimisation purposes, a repository was conceived to store already calculated cases. After the biophysical model calculation, the solved case is saved on the disk storage together with the checksum of the model's configuration. The server reads this storage upon the startup and the new case runs only if the new-case configuration checksum differs from these already known case checksums. The appropriate results from the cases repository are returned immediately otherwise.

The server maintains the in-memory database of the cases checksum adding information about new calculated cases. The SHA256 checksum is used for this purpose to ensure the correct case configuration discrimination.

When the new case is to be run, the server prepares biophysical model configurations file(s) based on the content of the request, spawns the biophysical model, and finally parses the model output file(s) to form the response.

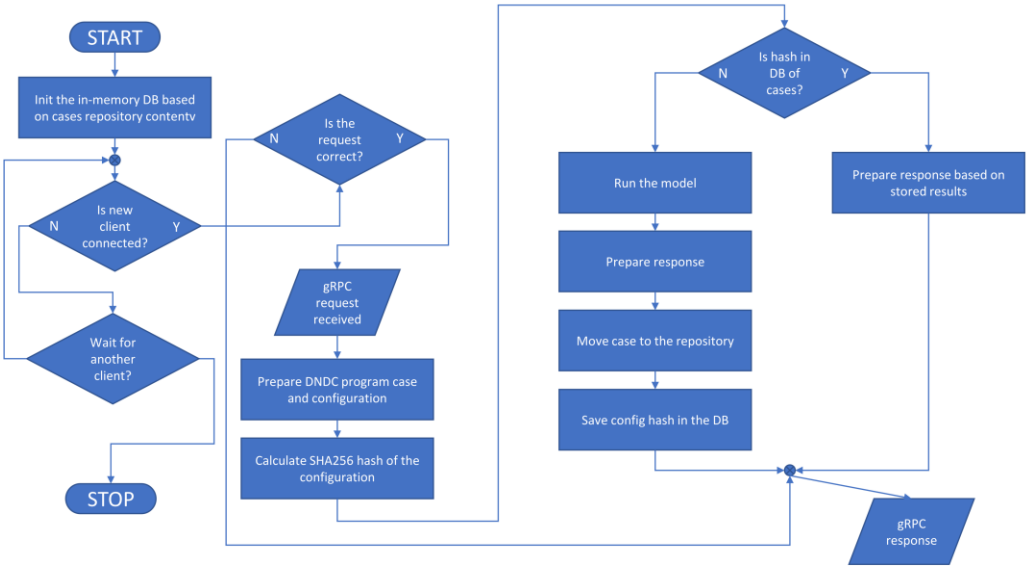


Figure 5: The flowchart of the server code implementing the interface to the biophysical modeling software.

4.2.2 DNDC model interface implementation

The general requirement for the preparation of the gRPC interface to the biophysical model is the ability of the biophysical model executable to be run in the CLI batch mode without the GUI interface. The standard distribution of the DNDC model does not have such property. To overcome this problem the fork DNDCv.CAN 9.5.3 of the original DNDC 9.5 was used instead which can be run from the command line. The DNDCv.CAN implements the same biophysical modelling framework extending it on a few minor, not important from the view of the AGRICORE

suite features. The binary of the DNDCv.CAN can be downloaded from the GitHUB service (https://github.com/BrianBGrant/DNDCv.CAN).

4.2.3 Docker microservice implementation

The server was implemented as a docker microservice. The Docker container creation configuration file defining essential software runtime dependencies for the biophysical model and the server itself is provided below in CodeBlock 2. The container is based on the Windows 10 OS due to the operating system requirements of the biophysical modelling software (DNDC, WOFOST).

4.3 Functionality tests

4.3.1 Unit testing

The set of the automated unit tests was performed to validate the correctness of the developed pieces of the source code implementing the biophysical models' interaction interface.

4.3.2 Functional tests

The exploratory functional tests were performed for a few scenarios in a non-automated manner using the client python-based (dndc_client.py) implementation forming the gRPC request based on the request data stored in the form of the JSON files.

```
FROM mcr.microsoft.com/windows:20H2
SHELL ["powershell", "-Command", "$ErrorActionPreference = 'Stop';
$ProgressPreference = 'SilentlyContinue';"]
ENV PYTHONIOENCODING UTF-8
ENV PYTHON_VERSION 3.10.5

RUN $url = ('https://www.python.org/ftp/python/{0}/python-{1}-amd64.exe' -f
($env:PYTHON_VERSION -replace '[a-z]+[0-9]*$', ''), $env:PYTHON_VERSION); \
    Write-Host ('Downloading {0} ...' -f $url); \
    [Net.ServicePointManager]::SecurityProtocol =
[Net.SecurityProtocolType]::Tls12; \
    Invoke-WebRequest -Uri $url -OutFile 'python.exe'; \
    \
    Write-Host 'Installing ...'; \
# https://docs.python.org/3/using/windows.html#installing-without-ui
    $exitCode = (Start-Process python.exe -Wait -NoNewWindow -PassThru \
        -ArgumentList @( \
            '/quiet', \
            'InstallAllUsers=1', \
            'TargetDir=C:\Python', \
            'PrependPath=1', \
            'Shortcuts=0', \
            'Include_doc=0', \
            'Include_pip=0', \
            'Include_test=0' \
        ) \
    ).ExitCode; \
    if ($exitCode -ne 0) { \
        Write-Host ('Running python installer failed with exit code: {0}' -f
$exitCode); \
        Get-ChildItem $env:TEMP | Sort-Object -Descending -Property
LastWriteTime | Select-Object -First 1 | Get-Content; \
        exit $exitCode; \
    } \
    \
# the installer updated PATH, so we should refresh our local value
    $env:PATH = [Environment]::GetEnvironmentVariable('PATH',
[EnvironmentVariableTarget]::Machine); \
    \
    Write-Host 'Verifying install ...'; \
    Write-Host '  python --version'; python --version; \
    \
    Write-Host 'Removing ...'; \
    Remove-Item python.exe -Force; \
    Remove-Item $env:TEMP/Python*.log -Force; \
    \
    Write-Host 'Complete.'

# if this is called "PIP_VERSION", pip explodes with "ValueError: invalid truth
value '<VERSION>'"
ENV PYTHON_PIP_VERSION 22.0.4
# https://github.com/docker-library/python/issues/365
ENV PYTHON_SETUPTOOLS_VERSION 58.1.0
# https://github.com/pypa/get-pip
ENV PYTHON_GET_PIP_URL https://github.com/pypa/get-
pip/raw/6ce3639da143c5d79b44f94b04080abf2531fd6e/public/get-pip.py
ENV PYTHON_GET_PIP_SHA256
ba3ab8267d91fd41c58dbce08f76db99f747f716d85ce1865813842bb035524d

RUN Write-Host ('Downloading get-pip.py ({0}) ...' -f $env:PYTHON_GET_PIP_URL);
\
    [Net.ServicePointManager]::SecurityProtocol =
[Net.SecurityProtocolType]::Tls12; \
    Invoke-WebRequest -Uri $env:PYTHON_GET_PIP_URL -OutFile 'get-pip.py'; \
    Write-Host ('Verifying sha256 ({0}) ...' -f $env:PYTHON_GET_PIP_SHA256); \
```

```
    if ((Get-FileHash 'get-pip.py' -Algorithm sha256).Hash -ne
$env:PYTHON_GET_PIP_SHA256) { \
        Write-Host 'FAILED!'; \
        exit 1; \
    }; \
    \
    $env:PYTHONDONTWRITEBYTECODE = '1'; \
    \
    Write-Host ('Installing pip=={0} ...' -f $env:PYTHON_PIP_VERSION); \
    python get-pip.py \
        --disable-pip-version-check \
        --no-cache-dir \
        --no-compile \
        ('pip=={0}' -f $env:PYTHON_PIP_VERSION) \
        ('setuptools=={0}' -f $env:PYTHON_SETUPTOOLS_VERSION) \
    ; \
    Remove-Item get-pip.py -Force; \
    \
    Write-Host 'Verifying pip install ...'; \
    pip --version; \
    \
    Write-Host 'Complete.'

RUN pip install grpcio
RUN pip install protobuf
RUN pip install pandas
RUN pip install checksumdir

#32-bit Visual C++ 2015 Redistributable needed by DNDC
USER ContainerAdministrator
ADD https://aka.ms/vs/17/release/vc_redist.x86.exe /vc_redist.x86.exe
RUN c:\vc_redist.x86.exe /install /quiet /norestart
RUN del c:\vc_redist.x86.exe

EXPOSE 50051

COPY ./install_repository/DNDC c:/DNDC
COPY ./install_repository/dll_dependencies c:/dll_dependencies
COPY ./install_repository/far c:/far
COPY ./install_repository/DNDC/run_dndc_cmd_opt.bat c:/DNDC
COPY ./lib c:/server/lib
COPY dndc_server.py c:/server
COPY dndc_config_templates.py c:/server
COPY bm_int_dndc_pb2.py c:/server
COPY bm_int_dndc_pb2_grpc.py c:/server
CMD ["python.exe","c:/server/dndc_server.py"]
```

CodeBlock 2: Docker container creation configuration file

5 Conclusions

The module implementing interface allowing for calling the biophysical modeling software was prepared and tested.

During the module development, the feature of the DNDCvCAN binary was discovered which could be potentially an issue and have to be adequately addressed. The DNDCv.CAN although can be run in a batch mode without the GUI, but if any runtime error occurs during DNDCv.CAN execution the program raises the GUI message box showing the error message. As the GUI interaction can't be controlled, it will cause freezing of the further execution of the DNDCv.CAN, and as a result, the server python code is infinitely waiting for the finishing of the biophysical model run. As the developed module is preparing the DNDC configuration files correctly and the request is validated in advance this shouldn't happen. But to be sure about the DNDCv.CAN execution we will try to access the source code of the DNDCv.CAN and modify it so the potential errors were reported in the controllable by batch execution way.

References

For preparing this report, the following deliverables have been taken into consideration:

Deliverable Number	Deliverable Title	Lead beneficiary	Type	Dissemination Level	Due date
D6.1	AGRICORE architecture and interfaces	IDE	Report	Public	M23
D6.2	External Interface Module	IDE	Report	Public	M31
D6.6	Software Quality Assurance measures for AGRICORE	AAT	Report	Public	M15

DNDC DETAILED INPUT/OUTPUT

	VARIABLE	DESCRIPTION	UNIT	In Optimal?	In Minimal?
		INPUTS			
Site	__Site_name	name of the site (a string)	(-)	+	+
	__Simulated_years	number of total simulated years (an integer)	(-)	+	+
	__Latitude	latitude (decimal unit) of the site	(decimal degree)	+	+
	__Daily_record	allow DNDC to record daily results (0=no; 1=yes)	(-)	default=0	default=0
	__Unit_system	system of the units	(-)	default=0	default=0
Climate	__Climate_data_type	The climate data file can be constructed with eight different formats based on the original data source (**1** - Column 1: Julian day; 2: daily average air temperatures; 3: daily precipitation; **2** - Column 1: Julian day; 2: daily maximum air temperatures; 3: daily minimum air temperatures; 4: daily precipitation; **3** - Column 1: Julian day; 2: daily maximum air temperatures; 3: daily minimum air temperatures; 4: daily precipitation; 5: radiation; **4** - Column 1: Julian day; 2: daily maximum air temperatures; 3: daily minimum air temperatures; 4: daily precipitation; 5: daily average wind speed; **5** - Column 1: Julian day; 2: daily maximum air temperatures; 3: daily minimum air temperatures; 4: daily precipitation; 5: wind speed; 6: radiation; 7: humidity; **6** - Column 1: Julian day; 2: daily maximum air temperatures; 3: daily minimum air temperatures; 4: daily precipitation; 5: wind speed; 6: humidity; **7** - Column 1: Julian day; 2: daily maximum air temperatures; 3: daily minimum air temperatures; 4: daily precipitation; 5: humidity; **8** - Column 1: Julian day; 2: daily maximum air temperatures; 3: daily minimum air temperatures; 4: daily precipitation; 5: wind speed; 6: humidity	(-)	default=5 (Column 1: Julian day; 2: daily maximum air temperatures; 3: daily minimum air temperatures; 4: daily precipitation; 5: wind speed; 6: radiation; 7: humidity)	default=2 (Column 1: Julian day; 2: daily maximum air temperatures; 3: daily minimum air temperatures; 4: daily precipitation)
	__N_in_rainfall	Annual average N (dissolved nitrate and ammonium) concentration in rainfall	(mg N/l or ppm)	default=0.5000	default=0.5000
	__Air_NH3_concentration	Average background concentration of NH_3 in the air, which affects NH_3 dry deposition on plants.	(ug N/m^3)	default=0.0600	default=0.0600
	__Air_CO2_concentration	atmospheric background CO_2 concentration which affects plant photosynthesis	(ppm)	+	default=400.0000
	__Climate_files	number of climate files included in the simulations and the name of the file with the link to the corresponding directory	(-)	+	+
	1st column	Julian day;	(-)	+	+
	2nd column	daily maximum air temperatures;	(ºC)	+	+
	3rd column	daily minimum air temperatures;	(ºC)	+	+
	4th column	daily precipitation sum	(cm)	+	+
	5th column	wind speed daily average	(m/s)	+	no need to provide
	6th column	radiation daily sum	(MJ/m^2/day)	+	no need to provide
	7nh column	humidity daily average	(%)	+	no need to provide
	__Climate_file_mode	mode of the climate files	(-)	default=0	default=0
	__CO2_increase_rate	for multi-year simulations, the atmospheric CO_2 concentration can be changed by setting this annual change rate.	(ppm/yr)	default=0	default=0
	__CO2_File_Mode	mode of the CO_2 file	(-)	default=0	default=0
	__CO2_FileName	filename and directory of the CO_2 file	(-)	no need to provide	no need to provide
Soil	__Land_use_ID	select a current land use (Options are: **1** - upland crop field, **2** - rice paddy field, **3** - moist grassland/pasture, **4** - dry grassland/Pasture, **5** - wetland **6** - tree plantation)	(-)	+	+
	__Soil_texture_ID	select a soil type based on either its texture or clay fraction (There are 12 soil types: **1** - sand, **2** - loamy sand, **3** - sandy loam, **4** - silt loam, **5** - loam, **6** - sandy clay loam, **7** - silty clay loam, **8** - clay loam, **9** - sandy clay, **10** - silty clay, **11** - clay, **12** - organic soil	(-)	+	+
	__Bulk_density	bulk density (g/cubic cm) of top soil (0-10 cm).	(g/cm^3)	+	default value from Soil_parameters.txt
	__pH	pH of top soil	(-)	+	default value from Soil_parameters.txt
	__Clay_fraction	clay fraction of soil by weight	(-)	+	default value from Soil_parameters.txt
	__Porosity	soil porosity, a fraction	(-)	default value from Soil_parameters.txt	default value from Soil_parameters.txt
	__Bypass_flow	if the soil has macro-pores, the by-pass flow rate can be fined as a fraction	(-)	default=0.0000	default=0.0000
	__Field_capacity	water-filled porosity (WFPS) at soil field capacity	(-)	+	default value from Soil_parameters.txt
	__Wilting_point	water-filled porosity (WFPS) at soil wilting point	(-)	+	default value from Soil_parameters.txt
	__Hydro_conductivity	hydrological saturation conductivity	(m/hr)	+	default value from Soil_parameters.txt
	__Top_layer_SOC	Content of total soil organic carbon (SOC), including litter residue, microbes, humads, and passive humus at surface layer (0-5 cm).	(kg C/kg)	+	default=0.0275
	__Litter_fraction	fraction of litter pool	(-)	default=0.0100	default=0.0100
	__Humads_fraction	fraction of humads (active humus) pool	(-)	default=0.0219	default=0.0219
	__Humus_fraction	fraction of passive humus pool	(-)	default=0.9681	default=0.9681
	__Adjusted_litter_factor	factor to systematically change the litter decomposition rates to deal with unusual situations	(-)	default=1.000	default=1.000
	__Adjusted_humads_factor	factor to systematically change the humads decomposition rates to deal with unusual situations	(-)	default=1.000	default=1.000
	__Adjusted_humus_factor	factor to systematically change the passive humus decomposition rates to deal with unusual situations	(-)	default=1.000	default=1.000
	__Humads_C/N	C/N ratio for humads (active humus) pool	(-)	default=10.000	default=10.000
	__Humus_C/N	C/N ratio for passive humus pool	(-)	default=10.000	default=10.000
	__Black_C	fraction of inorganic carbon (such as chark) pool	(-)	default=0.000	default=0.000
	__Black_C_C/N	C/N ratio for inorganic carbon (such as chark) pool	(-)	default=0.000	default=0.000
	__SOC_profile_A	a depth, above which the SOC content is uniform	(m)	default=0.200	default=0.200

	__SOC_profile_B	A rate, which determines how fast the SOC content decreases below the top soil. The higher the rate, the faster the SOC content decreases. A fraction value (i.e., <1.0) means SOC content increases along with increase in the soil depth (such as for peat soil).	(-)	default=2.000	default=2.000
	__Initial_nitrate_ppm	the default initial nitrate content at surface layer	(mg N/kg) (ppm)	default=0.5000	default=0.5000
	__Initial_ammonium_ppm	the default initial ammonium content at surface layer	(mg N/kg) (ppm)	default=0.0500	default=0.0500
	__Soil_microbial_index	an index ranging from 0.0 to 1.0 for indicating impact of soil toxic materials on soil microbial activity	(-)	default=1.000	default=1.000
	__Soil_slope	slope of the soil surface in percentage. The slope for a level soil is 0	(-)	default=0.000	default=0.000
	__Lateral_influx_index	index for lateral influx	(-)	default=1.000	default=1.000
	__Drainage_Efficiency	efficiency of the drainage	(-)	default=0.000	default=0.000
	__WaterTable_Depth	depth of water retention layer in m, which could be formed by soil compaction (common for intensively grazed pasture) or clay pan	(m)	default=2.000	default=2.000
	__Soil_salinity	soil salinity index. If the index > 0, the soil salinity will affect crop growth and soil microbial activity	(-)	default=0.0000	default=0.0000
	__SCS_curve_use	activates the Soil Conservation Service (SCS) curve number method and the Modified Universal Soil Loss Equation (MUSLE) approach to simulate soil surface runoff and soil erosion (**0** – no; **1** – yes)	(-)	default=1	default=1
	____SCS_curve_number	define soil hydrological curve number regulating soil surface runoff flow	(-)	default=73.0000	default=73.0000
	____Land_surface_roughness	define soil surface roughness for calculating runoff flow	(-)	default=0.1900	default=0.1900
	____Channel_surface_roughness	define channel surface roughness for calculating channel flow	(-)	default=0.1900	default=0.1900
	____Channel_slope	define channel slope	(m/m)	default=0.0000	default=0.0000
	____Channel_length	define channel length	(km)	default=0.0000	default=0.0000
	____Land_management_factor	define an index for adjusting land management on runoff flow	(-)	default=0.0000	default=0.0000
	__Deep_WaterPoolBD	flow rate to drains that is directly proportional to effective depth	(m)	default=3.0000	default=3.0000
	__Soil_Profile_Type	select the type of soil profile: **0** - homogeneous soil profile (default) **1** - heterogeneous soil profile	(-)	default=0	default=0
	__Profile_File_Name	name and location of the file with soil profile properties definition	(-)	no need to provide	no need to provide
Crop	Cropping_systems	the number of different cropping systems consecutively applied during the entire simulated time span	(-)	default=1	default=1
	__Cropping_system	sequential number of the cropping system going to be defined.	(-)	default=1	default=1
	__Total_years	the number of total years modeled in this simulation	(-)	default=1	default=1
	__Years_of_a_cycle	the number of years a cycle of this cropping system lasts for	(-)		
	____Year	sequential number of the year in a cycle for current input process	(-)	default=1	default=1
	____Crops	the number of the cropping systems	(-)	default=1	default=1
	______Crop#	crop sequential number	(-)	default=1	default=1
	______Crop_ID	one of the crop types parameterized in DNDC. The choices are: 0 Fallow 1 Corn 2 Winter_wheat 3 Soybean 4 Legume_hay 5 Non_legume_hay 6 Spring_wheat 7 Sugarcane 8 Barley 9 Oats 10 Alfalfa 11 Annual_grass 12 Perennial_grass 13 Sorghum 14 Cotton 15 Rye 16 Vegetables 17 Papaya 18 Potato 19 Beet 20 Paddy_rice 21 Banana 22 Celery 23 Peanut 24 Upland_rice 25 Rapeseeds 26 Tobacco 27 Millet 28 Sunflower 29 Beans 30 DeepWater_rice 31 Onion 32 Palm 33 Strawberry 34 Lettuce 35 Artichoke 36 Flowers 37 Sprout 38 Berries 39 Truck_crops 40 Fruit_trees 41 Citrus 42 Grape 43 Silage_corn 44 Hops 45 Tomato 46 Rainfed_rice 47 Cover_crop 48 Safflower 49 Flax 50 Sedge 51 Cassava 52 Cattail 53 CA_broccoli 54 Evergreens 55 Cabbage 56 Green_onion 57 Mustard 58 Tule 59 Moss 60 Radish 61 Shrub 62 Boreal_sedge 63 Almond 64 Nut_tree 65 Melon 66 Pasture_hay	(-)	+	+

		67 Small_grain_hay 68 carrots 69 peppers 70 Asparagus 71 Cauliflower 72 Artichokes 73 Sweet_Potato 74 Beans_green 75 COT 76 Olives 77 Plums 78 Cherries 79 Peach 80 Pears 81 Apples 82 Dates 83 Avocados 84 Apricots 85 Figs 86 Prunes 87 Lemons 88 Fpeas 89 Ley 90 Lentil			
	_____Planting_month	a number from 1 to 12 for the month of planting	(-)	+	+
	_____Planting_day	a number from 1 to 31 for the day of planting	(-)	+	+
	_____Harvest_month	a number from 1 to 12 for the month of harvesting	(-)	+	+
	_____Harvest_day	a number from 1 to 31 for the day of harvesting	(-)	+	+
	_____Harvest_year	a number defining the subsequent year of harvesting	(-)	default=1	default=1
	_____Residue_left_in_field	a fraction of the above-ground crop residue left as stubble in the field after harvest	(-)	default=0.5000	default=0.5000
	_____Maximum_yield	the maximum biomass productions for grain, leaves+stems and roots under optimum growing conditions	(kg C/ha) (1 kg dry matter contains 0.4 kg C)	default value from Crop_parameters.xlsx	default value from Crop_parameters.xlsx
	_____Leaf_fraction	the leaf fraction of total biomass at maturity	(-)	default value from Crop_parameters.xlsx	default value from Crop_parameters.xlsx
	_____Stem_fraction	the stem fraction of total biomass at maturity	(-)	default value from Crop_parameters.xlsx	default value from Crop_parameters.xlsx
	_____Root_fraction	the root fraction of total biomass at maturity	(-)	default value from Crop_parameters.xlsx	default value from Crop_parameters.xlsx
	_____Grain_fraction	the grain fraction of total biomass at maturity	(-)	default value from Crop_parameters.xlsx	default value from Crop_parameters.xlsx
	_____Leaf_C/N	ratio of C/N leaves	(-)	default value from Crop_parameters.xlsx	default value from Crop_parameters.xlsx
	_____Stem_C/N	ratio of C/N stems	(-)	default value from Crop_parameters.xlsx	default value from Crop_parameters.xlsx
	_____Root_C/N	ratio of C/N for roots	(-)	default value from Crop_parameters.xlsx	default value from Crop_parameters.xlsx
	_____Grain_C/N	ratio of C/N for grain	(-)	default value from Crop_parameters.xlsx	default value from Crop_parameters.xlsx
	_____Accumulative_temperature	thermal degree days, accumulative air temperature from seeding till maturity of the crop.	(°C)	default value from Crop_parameters.xlsx	default value from Crop_parameters.xlsx
	_____Optimum_temperature	the optimum temperature for the crop growth.	(°C)	default value from Crop_parameters.xlsx	default value from Crop_parameters.xlsx
	_____Water_requirement	amount of water needed for the crop to produce a unit of dry matter of biomass	(g water/g dry matter)	default value from Crop_parameters.xlsx	default value from Crop_parameters.xlsx
	_____N_fixation_index	N fixation index. The default number is 1 for non-legume crops. For legume crops, the N fixation index is equal to the ratio (total N content in the plant)/(plant N taken from soil)	(-)	default value from Crop_parameters.xlsx	default value from Crop_parameters.xlsx
	_____Root_Depth	depth of the roots	(m)	default=2.0000	default=2.0000
	_____If_cover_crop	as a cover crop, its biomass will be totally left in the field without any fraction harvested by the end of the crop season **0** - no **1** - yes	(-)	default=0	default=0
	_____If_perennial_crop	define the crop as a perennial crop **0** - no **1** - yes	(-)	default value from Crop_parameters.xlsx	default value from Crop_parameters.xlsx
	_____If_transplanted	define whether the crop is transplanted **0** - no **1** - yes	(-)	default=0	default=0
	_____Tree_maturity_age	maturity age of the tree	(y)	default=0.0000	default=0.0000
	_____Tree_current_age	current age of the tree	(y)	default=0.0000	default=0.0000
	_____Tree_max_leaf	maximum number of leaves	(-)	default=0.0000	default=0.0000
	_____Tree_min_leaf	minimum number of leaves	(-)	default=0.0000	default=0.0000
	_____Root_Shape	The shape of the density distribution from the surface to maximum root length **1** - more emphasis on surface roots, **8** - more even distribution of root density	(-)	default=5.0000	default=5.0000
	_____Grain_Fill	plant Growth Stage (0-1) at which grain filling occurs	(-)	default=0.5000	default=0.5000
	_____LAI_Maximum	maximum LAI value for a particular crop type, has relevance for calculation potential evapotranspiration rates	(-)	default=4.0000	default=4.0000
	_____FrostKill_Temperature	temperature of the frostkill	(°C)	default=-2.0000	default=-2.0000
	_____ALF_CHRMX	hardening rate of alfalfa	(°C d^{-1})	default=0.1840	default=0.1840
	_____ALF_CDRMX	dehardening rate of alfalfa default 0.82	(°C d^{-1})	default=0.8200	default=0.8200
	_____ALF_CTMX	maximum cold tolerance of alfalfa cultivar default -15.0	(°C)	default=-15.0000	default=-15.0000
	_____ALF_PDFMX	plant population death rate default 0.108	(°C d^{-1})	default=0.1080	default=0.1080
Agrotechnical practices	____Till_applications	number of tilling applications in the year	(-)	+	default=0
	_____Till#	sequential number of each application.	(-)	+	no need to define
	_____Till_month	month of the tilling application	(-)	+	no need to define
	_____Till_day	day of the tilling application	(-)	+	no need to define
	_____Till_method	define tilling depth by selecting one of the default methods as **1** - no-till (i.e., only mulching) (0 cm), **2** - ploughing slightly (5 cm), **3** - ploughing with disk or chisel (10 cm), **4** - ploughing with moldboard (20 cm), **5** - deep ploughing (30 cm).	(-)	+	no need to define
	____Fertilizer_applications	number of applications in the year	(-)	+	default=0
	_____Fertilizing#	sequential number of each application	(-)	+	no need to define
	_____Fertilizing_month	month of the fertilization application	(-)	+	no need to define
	_____Fertilizing_day	day of the fertilization application	(-)	+	no need to define
	_____Fertilizing_method	method of the fertilization: **0** - manual **1** - auto-fertilization **2** - precision fertilization **3** - fertigation	(-)	default=0	no need to define
	_____Fertilizing_depth	select surface application with a default depth 0.2 cm, or injection with a default depth 15 cm	(cm)	default=0.2000	no need to define
	_____Nitrate	nitrate fertilizer amount	(kg N/ha)	+	no need to define
	_____Ammonium_bicarbonate	ammonium bicarbonate fertilizer amount	(kg N/ha)	+	no need to define
	_____Urea	urea fertilizer amount	(kg N/ha)	+	no need to define
	_____Anhydrous_ammonia	anhydrous ammonia fertilizer amount	(kg N/ha)	+	no need to define
	_____Ammonium	ammonium $(NH_4)NO_3$ fertilizer amount	(kg N/ha)	+	no need to define
	_____Sulphate	sulphate $(NH_2)_2SO_4$ fertilizer amount	(kg N/ha)	+	no need to define
	_____Phosphate	phosphate $(NH_4)_2HPO_4$ fertilizer amount	(kg N/ha)	+	no need to define

	_____Slow_release_rate	the total days during which the fertilizer-N will be uniformly released must be specified	(d)	default=1.0000	no need to define
	_____Nitrification_inhibitor_efficiency	the efficiency of the nitrification inhibitor	(-)	default=0.0000	no need to define
	_____Nitrification_inhibitor_duration	the effective duration (days) of the nitrification inhibitor	(d)	default=0.0000	no need to define
	_____Urease_inhibitor_efficiency	the efficiency of the urease inhibitor must be specified	(-)	default=0.0000	no need to define
	_____Urease_inhibitor_duration	the effective duration (days) of the urease inhibitor must be specified	(d)	default=0.0000	no need to define
	____Fertilization_option	Options for fertilization	(-)	default=0	default=0
	____Manure_applications	number of manure applications in the year	(-)	default=0	default=0
	____Film_applications	number of film applications in the year	(-)	default=0	default=0
	____Method	method of film application	(-)	default=0	default=0
	____Flood_applications	number of flooding applications in the year	(-)	default=0	default=0
	____Water_control	0 - irrigation 1 - rainfed 2 - observed water table fluctuation data 3 - empirical parameters		default=0	default=0
	____Flood_water_N	inorganic N received with the flooding water per application	(kg N/ha)	default=0.0000	default=0.0000
	____Leak_rate	rate of the flood water leaking from the bottom of the flooded soil profile	(mm water/day)	default=0.0000	default=0.0000
	____Water_gather_index	factor (> or = 1) indicating the area from which the rain water is collected to supply a unit of the crop field	(ha/ha)	default=1.0000	default=1.0000
	____Watertable_file	Name and link to the water table file		default=None0.000000	default=None0.000000
	____Empirical_para_1	initial WT depth	(cm)	default=0.0000	default=0.0000
	____Empirical_para_2	surface inflow fraction of precipitation	(-)	default=0.0000	default=0.0000
	____Empirical_para_3	lowest WT depth ceasing surface outflow	(cm)	default=0.0000	default=0.0000
	____Empirical_para_4	intensity factor for surface outflow,	(-)	default=0.0000	default=0.0000
	____Empirical_para_5	lowest WT ceasing ground outflow	(cm)	default=0.0000	default=0.0000
	____Empirical_para_6	intensity factor for ground outflow	(-)	default=0.0000	default=0.0000
	____Irrigation_applications	number of applications in the year	(-)	+	default=0
	____Irrigation_control	allows the user to schedule drainage which is managed to keep the water table at a certain depth	(-)	default=0	default=0
	____Irrigation_index	define an irrigation index between 0 and 1. If a modeled water stress occurs, a fraction, equal to the index, of the water will be automatically delivered to the soil to meet the predicted water deficit	(-)	default=0.0000	default=0.0000
	____Irrigation_method	irrigation method used, flood, sprinkler and drip are options subject to different evaporation or leaching water losses and hence have different water use efficiencies **1** - furrow **2** - sprinkler **3** - drip (0cm) **4** - drip (15cm)	(-)	+	default=0
	_____Irrigation#	sequential number of each application	(-)	+	no need to define
	_____Irri_month	month of the fertilization application	(-)	+	no need to define
	_____Irri_day	day of the fertilization application	(-)	+	no need to define
	_____Water_amount	amount of water used	(cm)		no need to define
	_____Irri_method	sequential irrigation method used, flood, sprinkler and drip are options subject to different evaporation or leaching water losses and hence have different water use efficiencies **1** - furrow **2** - sprinkler **3** - drip (0cm) **4** - drip (15cm)	(-)	+	no need to define
	_____TileIrriDays	duration of tile system used	(d)	default=0	no need to define
	____ControlledDrainage_applications	Allows the user to schedule drainage which is managed to keep the water table at a certain depth, number of applications	(-)	default=0	default=0
	_____CDrain#	sequential number of each application	(-)	no need to define	no need to define
	_____CDrain_stmonth	starting month from which the drainage was applied	(-)	no need to define	no need to define
	_____CDrain_stday	starting day from which the drainage was applied	(-)	no need to define	no need to define
	_____CDrain_endmonth	end month to which the drainage was applied	(-)	no need to define	no need to define
	_____CDrain_endday	end day to which the drainage was applied	(-)	no need to define	no need to define
	_____CDrain_Depth	depth to which the drainage was applied	(m)	no need to define	no need to define
	____Grazing_applications	number of grazing application periods in the year	(-)	default=0	default=0
	____Cut_applications	number of cutting applications in the year	(-)	default=0	default=0
	_____Cut#	sequential number of each cutting	(-)	no need to define	no need to define
	_____Cut_month	month of the cutting application	(-)	no need to define	no need to define
	_____Cut_day	day of the cutting application	(-)	no need to define	no need to define
	_____Cut_fraction	cut fraction of the defined part(s). The default value is 0.8.	(-)	no need to define	no need to define
	_____Cut_part	define which part of the plant is cut. The options are 1 - grain (or fruit), 2 - leaf, 3 - stem and/or root	(-)	no need to define	no need to define
Extra parameters	_____DrainDepth(m)	tile drain location in the 2 m profile. Should be placed within the profile so typically it is between 50cm and 150 cm	(m)	default=1.0000	default=1.0000
	_____DrainSpace(m)	This is a mainly a 1-d model but the drain spacing is empirically used to simulate quasi-2d flow rate to tiles. Wider drain spacing will result in lower flow to tiles.	(m)	default=10.0000	default=10.0000
	_____DrainRadius(m)	this also controls the flow rate of water to tiles. Larger radius results in higher flow rates	(m)	default=0.0700	default=0.0700
	_____Drain_to_Bedrock(m)	by default set to 3m. Flow rate to drains is directly proportional to effective depth	(m)	default=3.0000	default=3.0000
	_____keDrain_Factor	rate of horizontal effective saturated conductivity to the tiles. It is a function of the saturated conductivity defined in the soil profile but this factor can be used to slow or increase the horizontal flow rate	(-)	default=0.6000	default=0.6000
	_____MaxN_movement	primary control that influences the maximum nitrogen movement across the soil layers. It is a factor that controls that maximum threshold value.	(-)	default=0.5000	default=0.5000
	_____MobileN_Factor	at a timestep of 1 hour, this determines the amount of NO3 available to be mobilized with water flux to move to the next layer	(-)	default=0.9000	default=0.9000
	_____Pref_NLayerFraction	the fraction of N that is not susceptible to preferential leaching (i.e. bypass all layers to move directly to the tiles) when the water table is above the tiles	(-)	default=0.7500	default=0.7500

	_____N_Leaching_Factor	a factor that controls the fraction of NO3 (and a small amount of Urea) in a layer that moves with water fluxes between layers	(-)	default=1.4000	default=1.4000
	_____Soil_Evaporation_Factor	Controls the effective soil evaporative rate. >1 = increased soil evap	(-)	default=1.0000	default=1.0000
	_____Runoff_Water_Factor	fraction of excess snowmelt that can't infiltrate the soil that leads directly to runoff	(-)	default=0.2000	default=0.2000
	_____Runoff_N_Factor	factor that controls the amount of N that moves with runoff from the top 2 soil layers	(-)	default=1.0000	default=1.0000
	_____Overall_NitrificationF	controls maximum nitrification kg/ha amount per hour	(-)	default=1.0000	default=1.0000
	_____Snow_Insulation_Factor	factor that controls the influence of snow on surface soil temperatures	(-)	default=1.0000	default=1.0000
	_____Snow_Melt_Factor	controls the Rate of Snowmelt as a function of air temperature	(-)	default=1.0000	default=1.0000
	_____Denitrifier_Grow	the growth rate of microbial denitrifiers in the anaerobic balloon	(-)	default=1.0000	default=1.0000
	_____Nitrier_Grow	controls the growth rate of microbial nitrifiers in the anaerobic balloon	(-)	default=1.0000	default=1.0000
	_____N2O_Rain_Factor	controls the influence of rain on the denitrification rate. This is an empirical factor that increases N2O, NO and N2 emission peaks in response to rainfalls	(-)	default=0.8000	default=0.8000
	_____Spring_Melt_N2O_F	controls the influence of freezing events on substrate availability to promote dentrifier activity in the spring melt period	(-)	default=1.0000	default=1.0000
	_____N_Retention_F	a control used to restrict N movement on a per-layer basis. This is an exponential algorithm that makes N more and more difficult to be moved as the absolute amount of N in a layer decreases	(-)	default=0.3000	default=0.3000
	_____NH3_Vol_Multi	controls the influence of windspeed on the volatilization rate of ammonia produced during the NH3:NH4 equilibrium and Henry's law	(-)	default=1.0000	default=1.0000
	_____Pref_N_Move2	defined as the N that does not bypass the layer to layer movement on N to preferentially leach out of the soil profile.	(-)	default=0.9600	default=0.9600
	_____AutoHarvest	let the model autoharvest crops when GDD/TDD reaches maturity and after a brief drying out of the crop	(-)	default=1	default=1
	_____SoilStructEffect	let soil characteristics (i.e. water holding capacity) change be correlated with soil organic matter changes (i.e. as a proxy of soil health)	(-)	default=0.0000	default=0.0000
	_____SoilReset	after a 10 year sequence (normally tied to a spinup period) let the soil conditions be reset every year afterwards so that every subsequent year is using the end of the 10th year as its initial conditions (i.e. year 11, year 12 +++)	(-)	default=0.0000	default=0.0000
	_____UseSpinUpFile	to read from file and the frequency to read from that file (every 1 year, 2 years etc). This file is in the format that is automatically written out in the DNDC\Result\inter\ directory and labelled soil_1, soil_2 etc	(-)	default=0	default=0
	_____ReadSpinUpYears	define how many years are read from spinup file	(-)	default=0	default=0
	_____SpinUpFileName	Define the spinup file name	(-)	default=	default=
	_____WTEffectonSoilWaterContent	this is tied to the influence of the water table on water contents above the water table and the extractability of this water for transpiration. A lower value will force more water update from the water table (and increase soil water contents)	(-)	default=1.0000	default=1.0000
	_____RainFallInterceptFactor	this allows the user to control the amount of intercepted rainfall that is lost to the canopy and evaporated	(-)	default=0.0000	default=0.0000
	_____SolarRadEffectonSoilTemp	controls the effect of solar radiation on surface soil temperature. A higher value will increase overall soil temperatures in the peak of summer growing season	(-)	default=1.0000	default=1.0000
	_____UreaHydrolysisFactor	controls the overall hydrolysis rate (temp, water, [substrate])	(-)	default=1.0000	default=1.0000
	_____UreaHydrolysisWaterFactor	controls the effect of water content on hydrolysis		default=1.0000	default=1.0000
	_____NH3SoilDepthFactor	controls the influence of soil depth on reducing NH3 emissions. This represents in a crude way the diffusivity ease of NH3 from depth along with the binding of NH3 to soil colloids within the soil matrix. Default = 1.0. Decreasing this value will make the impact of depth greater	(-)	default=1.0000	default=1.0000
	_____UreaDiffusionFactor	control used to control how fast urea can diffuse into the soil matrix. The default is 0.08 and increasing the value upwards will increase the rate of urea diffusion	(-)	default=1.0000	default=1.0000
	_____N2N2OFactor	larger values increases the amount of N2 formed from N2O	(-)	default=4.0000	default=4.0000
		OUTPUTS			
Soil section	Litter C pool		(kg C/ha)	no need to have this information	no need to have this information
	Litter N pool		(kg N/ha)	no need to have this information	no need to have this information
	Humads C pool		(kg C/ha)	no need to have this information	no need to have this information
	Humads N pool		(kg N/ha)	no need to have this information	no need to have this information
	Humus C pool		(kg C/ha)	no need to have this information	no need to have this information
	Humus N pool		(kg N/ha)	no need to have this information	no need to have this information
	Total C pool		(kg C/ha)	+	no need to have this information
	Total N pool		(kg N/ha)	+	no need to have this information
	Inorganic N in NO_3- pool		(kg N/ha)	no need to have this information	no need to have this information
	Inorganic N in NH_4+ pool		(kg N/ha)	no need to have this information	no need to have this information
	Inorganic N in NH_3(w) pool		(kg N/ha)	no need to have this information	no need to have this information
	Inorganic N in Urea pool		(kg N/ha)	no need to have this information	no need to have this information
	Inorganic N in NO(w) pool		(kg N/ha)	no need to have this information	no need to have this information
	Inorganic N in clay-NH_4 pool		(kg N/ha)	no need to have this information	no need to have this information
	Inorganic N in N_2O+N_2 pool		(kg N/ha)	no need to have this information	no need to have this information
	Inorganic N in Total pool		(kg N/ha)	+	no need to have this information
	C mineralization		(kg C/ha)	+	no need to have this information
	N mineralization		(kg N/ha)	+	no need to have this information
	C content in 0 – 10 cm layer		(kg C/kg)	+	no need to have this information
	C content in 10 – 20 cm layer		(kg C/kg)	+	no need to have this information
	C content in 20 – 30 cm layer		(kg C/kg)	+	no need to have this information
	C content in 30 – 40 cm layer		(kg C/kg)	+	no need to have this information

	C content in 40 – 50 cm layer		(kg C/kg)	+	no need to have this information
	C content in 0 – 10 cm layer		(kg C/ha)	no need to have this information	no need to have this information
	C content in 10 – 20 cm layer		(kg C/ha)	no need to have this information	no need to have this information
	C content in 20 – 30 cm layer		(kg C/ha)	no need to have this information	no need to have this information
	C content in 30 – 40 cm layer		(kg C/ha)	no need to have this information	no need to have this information
	C content in 40 – 50 cm layer		(kg C/ha)	no need to have this information	no need to have this information
	Soil weight in 0 – 10 cm layer		(kg/ha)	no need to have this information	no need to have this information
	Soil weight in 10 – 20 cm layer		(kg/ha)	no need to have this information	no need to have this information
	Soil weight in 20 – 30 cm layer		(kg/ha)	no need to have this information	no need to have this information
	Soil weight in 30 – 40 cm layer		(kg/ha)	no need to have this information	no need to have this information
	Soil weight in 40 – 50 cm layer		(kg/ha)	no need to have this information	no need to have this information
Fluxes section	Manure input C flux		(kg C/ha/yr)	no need to have this information	no need to have this information
	Manure input N flux		(kg N/ha/yr)	no need to have this information	no need to have this information
	Shoot litter input C flux		(kg C/ha/yr)	no need to have this information	no need to have this information
	Shoot litter input N flux		(kg N/ha/yr)	no need to have this information	no need to have this information
	Root litter input C flux		(kg C/ha/yr)	no need to have this information	no need to have this information
	Root litter input N flux		(kg N/ha/yr)	no need to have this information	no need to have this information
	Root exudation input C flux		(kg C/ha/yr)	no need to have this information	no need to have this information
	Rain-N deposit		(kg N/ha/yr)	no need to have this information	no need to have this information
	Irrigation N input		(kg N/ha/yr)	no need to have this information	no need to have this information
	Fertilizer-N		(kg N/ha/yr)	no need to have this information	no need to have this information
	Soil N fixation		(kg N/ha/yr)	no need to have this information	no need to have this information
	Soil-CO_2 emission		(kg C/ha/yr)	+	no need to have this information
	CH_4 emission		(kg C/ha/yr)	+	no need to have this information
	Soil C runoff		(kg C/ha/yr)	no need to have this information	no need to have this information
	Soil N runoff		(kg N/ha/yr)	no need to have this information	no need to have this information
	Soil C leaching		(kg C/ha/yr)	no need to have this information	no need to have this information
	Soil N leaching		(kg N/ha/yr)	no need to have this information	no need to have this information
	Crop N uptake from soil		(kg N/ha/yr)	+	no need to have this information
	NH_3 volatilization		(kg N/ha/yr)	no need to have this information	no need to have this information
	N_2O		(kg N/ha/yr)	+	no need to have this information
	NO		(kg N/ha/yr)	no need to have this information	no need to have this information
	N_2		(kg N/ha/yr)	+	no need to have this information
	Indirect N_2O		(kg N/ha/yr)	no need to have this information	no need to have this information
	Indirect N_2		(kg N/ha/yr)	no need to have this information	no need to have this information
Crop section	Cropping season		(-)	no need to have this information	no need to have this information
	Crop name		(-)	+	+
	Planting date		(d)	no need to have this information	no need to have this information
	Growing days		(d)	no need to have this information	no need to have this information
	Growing season TDD		(°C)	no need to have this information	no need to have this information
	Water demand (mm)		(mm)	+	no need to have this information
	Water uptake (mm)		(mm)	+	no need to have this information
	Water stress		(-)	no need to have this information	no need to have this information
	Crop N demand		(kg N/ha)	+	no need to have this information
	Crop N from soil		(kg N/ha)	+	no need to have this information
	Crop N from air NH3		(kg N/ha)	+	no need to have this information
	Crop N fixation		(kg N/ha)	+	no need to have this information
	Nitrogen stress		(-)	+	no need to have this information
	Crop N (kg N/ha)		(kg N/ha)	+	+
	Crop C (kg C/ha)		(kg C/ha)	+	+
	Crop Grain C		(kg C/ha)	+	+
	Crop Leaf C		(kg C/ha)	+	no need to have this information
	Crop stem C		(kg C/ha)	+	no need to have this information
	Crop Root C		(kg C/ha)	+	no need to have this information
	Photosynthesis		(kg C/ha)	no need to have this information	no need to have this information
	Shoot respiration		(kg C/ha/yr)	no need to have this information	no need to have this information
	Root respiration		(kg C/ha/yr)	no need to have this information	no need to have this information
	Crop NPP		(kg C/ha/yr)	+	no need to have this information
	NEE		(kg C/ha/yr)	+	no need to have this information
	Stubble		(kg C/ha)	+	+
	Fruit cut		(kg C/ha)	+	+
	Leaf cut		(kg C/ha)	+	+
	Stem cut		(kg C/ha)	+	+
	Root cut		(kg C/ha)	+	+
	Livestock feed demand		(kg C/ha)	+	+
	Grazed biomass		(kg C/ha)	+	+
Water section	Precipitation		(mm water/year)	no need to have this information	no need to have this information
	Irrigation		(mm water/year)	no need to have this information	no need to have this information
	Manure water		(mm water/year)	no need to have this information	no need to have this information
	PET		(mm water/year)	no need to have this information	no need to have this information
	Transpiration		(mm water/year)	no need to have this information	no need to have this information
	Soil evaporation		(mm water/year)	no need to have this information	no need to have this information
	Run off		(mm water/year)	no need to have this information	no need to have this information
	Leaching		(mm water/year)	no need to have this information	no need to have this information
	Initial soil profile water		(mm water/year)	no need to have this information	no need to have this information
	End soil profile water		(mm water/year)	+	no need to have this information
	Initial Deep water pool		(mm water/year)	no need to have this information	no need to have this information
	End Deep water pool		(mm water/year)	no need to have this information	no need to have this information
	Mean wind speed (m/s)		(m/s)	no need to have this information	no need to have this information
	Soil P Day 1		(kg P/ha)	no need to have this information	no need to have this information
	Soil P Day 365		(kg P/ha)	+	no need to have this information
	Fertilizer P (kg P/ha): 0.00		(kg P/ha)	no need to have this information	no need to have this information
	Manure P (kg P/ha): 0.00		(kg P/ha)	no need to have this information	no need to have this information
	P flux of crop uptake (kg P/ha)		(kg P/ha)	no need to have this information	no need to have this information
	P flux of runoff (kg P/ha)		(kg P/ha)	no need to have this information	no need to have this information
	P flux of leaching (kg P/ha)		(kg P/ha)	+	no need to have this information
	P flux of residue incorporation (kg P/ha): 0.00		(kg P/ha)	no need to have this information	no need to have this information

STICS DETAILED INPUT/OUTPUT

	VARIABLE	DESCRIPTION	UNIT	In Optimal?	In Minimal?
INPUTS					
GLOBAL PARAMETERS					
General parameters (param_gen.xml file)	ahres	parameter of organic residues humification: hres=1-ahres*CsurNres/(bhres+CsurNres)	($g \cdot g^{-1}$)	default value from param_gen.xml file	default value from param_gen.xml file
	akres	parameter of organic residues decomposition: kres=akres+bkres/CsurNres	(d^{-1})	default value from param_gen.xml file	default value from param_gen.xml file
	albedomulchresidus	albedo of crop mulch	(SD)	default value from param_gen.xml file	default value from param_gen.xml file
	alphapH	maximal soil pH variation per unit of inorganic N added with slurry	($kg^{-1} \cdot ha$)	default value from param_gen.xml file	default value from param_gen.xml file
	awb	parameter determining C/N ratio of biomass during organic residues decomposition: CsurNbio=awb+bwb/CsurNres	(SD)	default value from param_gen.xml file	default value from param_gen.xml file
	beta	parameter of increase of maximal transpiration when a water stress occurs	(SD)	default value from param_gen.xml file	default value from param_gen.xml file
	bformnappe	coefficient for the water table shape (artificially drained soil)	(SD)	default value from param_gen.xml file	default value from param_gen.xml file
	bhres	parameter of organic residues humification: hres=1-ahres*CsurNres/(bhres+CsurNres)	($g \cdot g^{-1}$)	default value from param_gen.xml file	default value from param_gen.xml file
	bkres	potential rate of decomposition of organic residues: kres=akres+bkres/CsurNres	($g \cdot g^{-1}$)	default value from param_gen.xml file	default value from param_gen.xml file
	bwb	parameter determining C/N ratio of biomass during organic residues decomposition: CsurNbio=awb+bwb/CsurNres	($g \cdot g^{-1}$)	default value from param_gen.xml file	default value from param_gen.xml file
	cmax_pdenit	Corg value above which denitrification potential is constant and max	(-)	default value from param_gen.xml file	default value from param_gen.xml file
	cmin_pdenit	Corg value below which denitrification potential is constant and min	(-)	default value from param_gen.xml file	default value from param_gen.xml file
	CNresmax	maximum value of C/N ratio of organic residue	($g \cdot g^{-1}$)	default value from param_gen.xml file	default value from param_gen.xml file
	CNresmin	minimum value of C/N ratio of organic residue	($g \cdot g^{-1}$)	default value from param_gen.xml file	default value from param_gen.xml file
	code_hourly_wfps_denit	choice of activating or not hourly WFPS calculation for denit (1 = yes, 2 = no)	(-), code 1/2	default value from param_gen.xml file	default value from param_gen.xml file
	code_hourly_wfps_nit	choice of activating or not hourly WFPS calculation for nit (1 = yes, 2 = no)	(-), code 1/2	default value from param_gen.xml file	default value from param_gen.xml file
	code_pdenit	choice of denitrification potential (1 = soil parameter or 2 = calculated from Corg)	(-), code 1/2	default value from param_gen.xml file	default value from param_gen.xml file
	code_ratiodenit	choice of constant (= 1) or variable(= 2) N_2O ratio for denitrification	(-), code 1/2	default value from param_gen.xml file	default value from param_gen.xml file
	code_rationit	choice of constant or variable N_2O ratio for nitrification (1 = constant, 2 = variable)	(-), code 1/2	default value from param_gen.xml file	default value from param_gen.xml file
	code_tnit	choice of temperature function for nitrification (1 = piecewise linear or 2 = gaussian)	(-), code 1/2	default value from param_gen.xml file	default value from param_gen.xml file
	code_vnit	choice of nitrification rate dependence on NH_4 (1 = linear or 2 = Michaelis-Menten)	(-), code 1/2	default value from param_gen.xml file	default value from param_gen.xml file
	codeactimulch	option to activate the natural mulch effect i.e. drying out of soil surface (1 = yes, 2 = no)	(-), code 1/2	default value from param_gen.xml file	default value from param_gen.xml file
	codefrmur	code defining the maturity status of the fruits in the output variable CHARGEFRUIT (1 = including ripe fruits (last box N), 2 = excluding ripe fruits (first N-1 boxes))	(-), code 1/2	default value from param_gen.xml file	default value from param_gen.xml file
	codefxn	option defining the effect of soil nitrate on N fixation (1 = no effect, 2 = effect of nitrate amount , 3 = effect of nitrate concentration)	(-), code 1/2/3	default value from param_gen.xml file	default value from param_gen.xml file
	codeh2oact	option to activate water stress effect on the crop (1 = yes, 2 = no)	(-), code 1/2	default value from param_gen.xml file	default value from param_gen.xml file
	codeinitprec	option to activate reinitialization of initial conditions in case of chained simulations (1 = yes, 2 = no)	(-), code 1/2	default value from param_gen.xml file	default value from param_gen.xml file
	codeinnact	option of activation of N stress effect on the crop (1 = yes, 2 = no)	(-), code 1/2	default value from param_gen.xml file	default value from param_gen.xml file
	codemicheur	option of calculation of hourly microclimatic outputs (output file humidite.sti) (1 = yes, 2 = no)	(-), code 1/2	default value from param_gen.xml file	default value from param_gen.xml file
	codeminopt	option to maintain a constant water content in bare soil during the simulation (1 = yes, 2 = no)	(-), code 0/1	default value from param_gen.xml file	default value from param_gen.xml file
	codemsfinal	option defining the biomass and yield conservation after harvest (1 = yes (values maintained equal to harvest), 2 = no (values set at 0))	(-), code 1/2	default value from param_gen.xml file	default value from param_gen.xml file
	codeoutscient	option to write outputs files with scientific format (1 = yes, 2 = no)	(-), code 1/2	default value from param_gen.xml file	default value from param_gen.xml file
	codeprofmes	option of soil depth for calculating water and N stocks (1 = profmes, 2 = soil depth)	(-), code 1/2	default value from param_gen.xml file	default value from param_gen.xml file
	codesensibilite	option to activate the sensitivity analysis version of the model (1 = yes, 2 = no)	(-), code 1/2	default value from param_gen.xml file	default value from param_gen.xml file
	codeseprapport	option to select the column separator in the rapport.sti output file (1 = space separator, 2 = separator indicated in the separateurrapport parameter)	(-), code 1/2	default value from param_gen.xml file	default value from param_gen.xml file
	codesymbiose	option for calculating symbiotic N fixation (1 = critical dilution curve, 2 = calculated N fixation)	(-), code 1/2	default value from param_gen.xml file	default value from param_gen.xml file
	codetycailloux	pebble type code	(-), code 1 to 10	default value from param_gen.xml file	default value from param_gen.xml file
	codetypeng	fertiliser type code	(-), code 1 to 8	default value from param_gen.xml file	default value from param_gen.xml file
	codetypres	organic residue type code	(-), code 1 to 21	default value from param_gen.xml file	default value from param_gen.xml file
	codhnappe	mode of calculation of watertable level (1 = mean height, 2 = height at the distance distdrain)	(-), code 1/2	default value from param_gen.xml file	default value from param_gen.xml file
	coefb	parameter defining radiation effect on conversion efficiency	(SD)	default value from param_gen.xml file	default value from param_gen.xml file
	concrr	inorganic N concentration (NH_4+NO_3-N) in the rain	($kg \cdot ha^{-1}$ mm^{-1})	default value from param_gen.xml file	default value from param_gen.xml file
	CroCo	fraction of organic residue which is decomposable	(SD)	default value from param_gen.xml file	default value from param_gen.xml file
	cwb	minimum ratio C/N of microbial biomass decomposing organic residues	($g \cdot g^{-1}$)	default value from param_gen.xml file	default value from param_gen.xml file
	dacohes	bulk density of soil below which root growth is reduced due to a lack of soil cohesion	($g \cdot cm^{-3}$)	default value from param_gen.xml file	default value from param_gen.xml file
	daseuilbas	bulk density of soil above which root growth is maximal	($g \cdot cm^{-3}$)	default value from param_gen.xml file	default value from param_gen.xml file
	daseuilhaut	bulk density of soil above which root growth becomes impossible	($g \cdot cm^{-3}$)	default value from param_gen.xml file	default value from param_gen.xml file
	deneng	maximal fraction of the mineral fertilizer that can be denitrified (used if codedenit is not activated)	(SD)	default value from param_gen.xml file	default value from param_gen.xml file
	difN	diffusion coefficient of nitrate N in soil at field capacity	($cm^2 \cdot d^{-1}$)	default value from param_gen.xml file	default value from param_gen.xml file
	diftherm	soil thermal diffusivity	($cm^2 \cdot s^{-1}$)	default value from param_gen.xml file	default value from param_gen.xml file
	distdrain	distance to the drain to calculate watertable height	(cm)	default value from param_gen.xml file	default value from param_gen.xml file
	dpHvolmax	maximal pH increase following the application of slurry	(SD)	default value from param_gen.xml file	default value from param_gen.xml file
	engamm	fraction of ammonium in the N fertilizer	(SD)	default value from param_gen.xml file	default value from param_gen.xml file
	fhminsat	relative soil mineralisation rate at water saturation	(SD)	default value from param_gen.xml file	default value from param_gen.xml file
	finert	initial fraction of soil organic N inactive for mineralisation (= stable SON/ total SON)	(SD)	default value from param_gen.xml file	default value from param_gen.xml file

	flagecriture	option for writing the output files (1 = mod_history.sti, 2=daily outputs,4= report outputs, 8=balance outputs,16 = profile outputs, 32= debug outputs, 64 = screen outputs, 128 = agmip outputs) add them to have several types of outputs	(0-511)	default value from param_gen.xml file	default value from param_gen.xml file
	fmin1	relative potential mineralization rate: K2 = fmin1 * exp(-fmin2*argi) / (1+fmin3*calc)	(d^{-1})	default value from param_gen.xml file	default value from param_gen.xml file
	fmin2	parameter defining the effect of clay on the potential mineralization rate: K2 = fmin1 * exp(-fmin2*argi) / (1+fmin3*calc)	(-1%)	default value from param_gen.xml file	default value from param_gen.xml file
	fmin3	parameter defining the effect of CaCO3 on the potential mineralization rate: K2 = fmin1 * exp(-fmin2*argi) / (1+fmin3*calc)	(-1%)	default value from param_gen.xml file	default value from param_gen.xml file
	fNCbiomin	minimal value for the ratio N/C of the microbial biomass when N limits decomposition	(SD)	default value from param_gen.xml file	default value from param_gen.xml file
	fnx	potential proportion of NH4 nitrified each day if linear model	(d^{-1})	default value from param_gen.xml file	default value from param_gen.xml file
	fredkN	reduction factor of decomposition rate of organic residues when mineral N is limiting	(SD)	default value from param_gen.xml file	default value from param_gen.xml file
	fredlN	reduction factor of decomposition rate of microbial biomass when mineral N is limiting	(SD)	default value from param_gen.xml file	default value from param_gen.xml file
	fredNsup	additional reduction factor of residues decomposition rate when mineral N is very limited in soil	(SD)	default value from param_gen.xml file	default value from param_gen.xml file
	ftemh	parameter (1/2) of the temperature function on humus decomposition rate	(K^{-1})	default value from param_gen.xml file	default value from param_gen.xml file
	ftemha	parameter (2/2) of the temperature function on humus decomposition rate	(*)	default value from param_gen.xml file	default value from param_gen.xml file
	ftemr	parameter (1/2) of the temperature function on decomposition rate of organic residues	(K^{-1})	default value from param_gen.xml file	default value from param_gen.xml file
	ftemra	parameter (2/2) of the temperature function on decomposition rate of organic residues	(*)	default value from param_gen.xml file	default value from param_gen.xml file
	hcccx	gravimetric water content at field capacity of each type of pebble	(% w)	default value from param_gen.xml file	default value from param_gen.xml file
	hminm	relative water content (fraction of field capacity) below which mineralisation rate is nil	(SD)	default value from param_gen.xml file	default value from param_gen.xml file
	hminn	relative water content (fraction of field capacity) below which nitrification rate is nil	(SD)	default value from param_gen.xml file	default value from param_gen.xml file
	hoptm	relative water content (fraction of field capacity) below which mineralisation rate is maximum	(SD)	default value from param_gen.xml file	default value from param_gen.xml file
	hoptn	relative water content (fraction of field capacity) below which nitrification rate is maximum	(SD)	default value from param_gen.xml file	default value from param_gen.xml file
	iniprofil	option of smoothing out the initial N and water profiles (spline function) (1 = yes, 2 = no)	(-), code 0/1	default value from param_gen.xml file	default value from param_gen.xml file
	irrlev	amount of irrigation applied automatically on the sowing day to allow germination when the model calculates irrigation	(mm)	default value from param_gen.xml file	default value from param_gen.xml file
	Kamm	affinity constant for NH_4 in nitrification if michaelis_menten option used	(mg N/L)	default value from param_gen.xml file	default value from param_gen.xml file
	kbio	potential decay rate of microbial biomass decomposing organic residues	(d^{-1})	default value from param_gen.xml file	default value from param_gen.xml file
	kcouvmlch	extinction coefficient connecting the soil cover to the amount of plant mulch	(*)	default value from param_gen.xml file	default value from param_gen.xml file
	Kd	Affinity constant for NO_3 in denitrification	(mg N/L)	default value from param_gen.xml file	default value from param_gen.xml file
	kdesat	rate constant of de-saturation	(d^{-1})	default value from param_gen.xml file	default value from param_gen.xml file
	khaut	extinction coefficient connecting LAI to crop height	(*)	default value from param_gen.xml file	default value from param_gen.xml file
	lvopt	root length density (RLD) above which water and N uptake are maximum and independent of RLD	($cm \cdot cm^{-3}$)	default value from param_gen.xml file	default value from param_gen.xml file
	masvolcx	bulk density of each type of pebble	($g \cdot cm^{-3}$)	default value from param_gen.xml file	default value from param_gen.xml file
	max_pdenit	max value of denitrification potential	(-)	default value from param_gen.xml file	default value from param_gen.xml file
	min_pdenit	min value of denitrification potential	(-)	default value from param_gen.xml file	default value from param_gen.xml file
	mouillabilmulch	maximum wettability of crop mulch	($mm \cdot t^{-1} \cdot ha$)	default value from param_gen.xml file	default value from param_gen.xml file
	nh4_min	minimum (fixed ?) NH_4 concentration found in soil	(mg N/kg)	default value from param_gen.xml file	default value from param_gen.xml file
	orgeng	maximal amount of fertilizer N that can be immobilized in the soil (fraction for type 8)	($kg \cdot ha^{-1}$)	default value from param_gen.xml file	default value from param_gen.xml file
	parsurrg	ratio of PAR to RG (global radiation)	(SD)	default value from param_gen.xml file	default value from param_gen.xml file
	pHmaxden	pH beyond which the N_2O molar fraction is minimum (<= ratiodenit)	(pH)	default value from param_gen.xml file	default value from param_gen.xml file
	pHmaxnit	soil pH above which nitrification is maximum	(pH)	default value from param_gen.xml file	default value from param_gen.xml file
	pHmaxvol	soil pH above which NH_3 volatilisation derived from fertiliser is maximum	(pH)	default value from param_gen.xml file	default value from param_gen.xml file
	pHminden	pH below which the N_2O molar fraction is 100%	(pH)	default value from param_gen.xml file	default value from param_gen.xml file
	pHminnit	soil pH below which nitrification is nil	(pH)	default value from param_gen.xml file	default value from param_gen.xml file
	pHminvol	soil pH below which NH_3 volatilisation derived from fertiliser is nil	(pH)	default value from param_gen.xml file	default value from param_gen.xml file
	pHvols	parameter used to calculate the variation of soil pH after the addition of slurry	(pH)	default value from param_gen.xml file	default value from param_gen.xml file
	plNmin	minimal amount of rain required to start an automatic N fertilisation	($mm \cdot d^{-1}$)	default value from param_gen.xml file	default value from param_gen.xml file
	pminruis	minimal amount of rain required to produce runoff	($mm \cdot d^{-1}$)	default value from param_gen.xml file	default value from param_gen.xml file
	primingmax	maximum priming ratio (relative to SOM decomposition rate)	(SD)	default value from param_gen.xml file	default value from param_gen.xml file
	proflabour	minimal soil depth for ploughing (if soil compaction is activated)	(cm)	default value from param_gen.xml file	default value from param_gen.xml file
	proftravmin	minimal soil depth for chisel tillage (if soil compaction is activated)	(cm)	default value from param_gen.xml file	default value from param_gen.xml file
	prophumtassrec	soil moisture content (fraction of field capacity) above which compaction may occur and delay harvest	(SD)	default value from param_gen.xml file	default value from param_gen.xml file
	prophumtasssem	soil moisture content (fraction of field capacity) above which compaction may occur and delay sowing	(SD)	default value from param_gen.xml file	default value from param_gen.xml file
	proprac	ratio of root mass to aerial mass at harvest	($g \cdot g^{-1}$)	default value from param_gen.xml file	default value from param_gen.xml file
	psihucc	soil water potential corresponding to field capacity	(Mpa)	default value from param_gen.xml file	default value from param_gen.xml file
	psihumin	soil water potential corresponding to wilting point	(Mpa)	default value from param_gen.xml file	default value from param_gen.xml file
	qmulchdec	maximal amount of decomposable mulch	($t \cdot ha^{-1}$)	default value from param_gen.xml file	default value from param_gen.xml file
	qmulchruis0	amount of mulch above which runoff is suppressed	($t \cdot ha^{-1}$)	default value from param_gen.xml file	default value from param_gen.xml file
	QNpltminINN	minimal amount of N in the plant required to compute INN	($kg \cdot ha^{-1}$)	default value from param_gen.xml file	default value from param_gen.xml file
	ratiodenit	constant value of N_2O ratio for denitrification	(SD)	default value from param_gen.xml file	default value from param_gen.xml file
	rationit	constant value of N_2O ratio for nitrification	(SD)	default value from param_gen.xml file	default value from param_gen.xml file
	rayon	average root radius	(cm)	default value from param_gen.xml file	default value from param_gen.xml file

	rdrain	drain radius	(cm)	default value from param_gen.xml file	default value from param_gen.xml file
	scale_tdenitopt	parameter related to the range of optimum temperature for denitrification	(-)	default value from param_gen.xml file	default value from param_gen.xml file
	scale_tnitopt	parameter related to the range of optimum temperature for nitrification	(-)	default value from param_gen.xml file	default value from param_gen.xml file
	separateurrapport	column separator in rapport.sti file	(SD)	default value from param_gen.xml file	default value from param_gen.xml file
	tdenitopt_gauss	optimum temperature for denitrification	(°C)	default value from param_gen.xml file	default value from param_gen.xml file
	tnitmax	maximal temperature above which nitrification stops	(°C)	default value from param_gen.xml file	default value from param_gen.xml file
	tnitmin	minimal temperature below which nitrification stops	(°C)	default value from param_gen.xml file	default value from param_gen.xml file
	tnitopt	optimal temperature (1/2) for nitrification	(°C)	default value from param_gen.xml file	default value from param_gen.xml file
	tnitopt_gauss	optimal temperature (1/2) for nitrification	(°C)	default value from param_gen.xml file	default value from param_gen.xml file
	tnitopt2	optimal temperature (2/2) for nitrification	(°C)	default value from param_gen.xml file	default value from param_gen.xml file
	trefh	reference temperature for decomposition of humified organic matter	(°C)	default value from param_gen.xml file	default value from param_gen.xml file
	trefr	reference temperature for decomposition of organic residues	(°C)	default value from param_gen.xml file	default value from param_gen.xml file
	Vabs2	N uptake rate at which fertilizer loss is divided by 2	($kg \cdot ha^{-1} \cdot d^{-1}$)	default value from param_gen.xml file	default value from param_gen.xml file
	vnitmax	maximum nitrification rate if michaelis_menten option used	(mg N kg^{-1} d^{-1})	default value from param_gen.xml file	default value from param_gen.xml file
	voleng	maximal fraction of mineral fertilizer that can be volatilized	(SD)	default value from param_gen.xml file	default value from param_gen.xml file
	wfpsc	wfps threshold beyond which denitrification occurs	(SD)	default value from param_gen.xml file	default value from param_gen.xml file
	Wh	N/C ratio of soil humus	($g \cdot g^{-1}$)	default value from param_gen.xml file	default value from param_gen.xml file
	Xorgmax	maximal amount of N immobilised in soil derived from the mineral fertilizer	($kg \cdot ha^{-1}$)	default value from param_gen.xml file	default value from param_gen.xml file
	y0msrac	minimal amount of root mass at harvest (when aerial biomass is nil)	($t \cdot ha^{-1}$)	default value from param_gen.xml file	default value from param_gen.xml file
	yres	Carbon assimilation yield by the microbial biomass during crop residues decomposition	($g \cdot g^{-1}$)	default value from param_gen.xml file	default value from param_gen.xml file
Plant parameters (*_plt.xml file)	Crop file *_plt.xml	Name of the crop *_plt.xml file: baresoil_plt.xml – bare soil, corn_plt.xml – maize, DurumWheat_ACALOU_plt.xml – durum wheat, DurumWheat_ALLUR_plt.xml – durum wheat, DurumWheat_AMARILLO_plt.xml – durum wheat, DurumWheat_ARCALIS_plt.xml – durum wheat, DurumWheat_ARTIMON_plt.xml – durum wheat, DurumWheat_BIENSUR_plt.xml – durum wheat, DurumWheat_LLOYD_plt.xml – durum wheat, DurumWheat_MONTSEGUR_plt.xml – durum wheat, DurumWheat_NEFER_plt.xml – durum wheat, DurumWheat_NEODUR_plt.xml – durum wheat, DurumWheat_ORJAUNE_plt.xml – durum wheat, grass_plt.xml – forage grass, mustard_CoverCrop_plt.xml – mustard, pea_plt.xml – pea, proto_alfalfa_plt.xml proto_banana_plt.xml – banana, proto_barley_InterCrop_plt.xml – barley, proto_barley_plt.xml – barley, proto_fescue_plt.xml – fescue, proto_flax_plt.xml – flax, proto_lettuce_plt.xml – lettuce, proto_pea_InterCrop_plt.xml - pea proto_potato_plt.xml – potato, proto_sorghum_plt.xml – sorghum, proto_soybean_plt.xml – soybean, proto_strawberry_plt.xml - strawberry proto_sugarcane_plt.xml - sugarcane proto_sunflower_plt.xml – sunflower, proto_tomato_plt.xml – tomato, proto_winterbarley_plt.xml – winter barley, rapeseed_plt.xml - rapeseed ryegrass_CoverCrop_plt.xml – ryegrass, sugarbeet_plt.xml – sugarbeet, vine_CABFRA_plt.xml – vine, vine_CHARCCH_plt.xml – vine, vine_CHARCC_plt.xml – vine, vine_CHARDOB_plt.xml – vine, vine_CHENIN_plt.xml – vine, vine_GRENAC_plt.xml – vine, vine_MERLOT_plt.xml – vine, vine_PINCCH_plt.xml – vine, vine_PINCC_plt.xml – vine, vine_PINOTB_plt.xml – vine, vine_SYRAH_plt.xml – vine, vine_UGNIB_plt.xml – vine, wheat_plt.xml – wheat	(-)	+	+
	abscission	fraction of senescent leaves falling to the soil	(SD)	default value from *_plt.xml file	default value from *_plt.xml file
	adens	Interplant competition parameter	(SD)	default value from *_plt.xml file	default value from *_plt.xml file
	adfol	parameter determining the leaf density evolution within the chosen shape	(m^{-1})	default value from *_plt.xml file	default value from *_plt.xml file
	adil	parameter of the critical dilution curve [Nplante]=adil MS^(-bdil)	(% DM)	default value from *_plt.xml file	default value from *_plt.xml file
	adilmax	parameter of the maximum dilution curve [Nplante]=adilmax MS^(-bdilmax)	(% DM)	default value from *_plt.xml file	default value from *_plt.xml file
	afpf	parameter of the logistic function defining sink strength of fruits (indeterminate growth) : relative fruit age at which growth is maximal	(SD)	default value from *_plt.xml file	default value from *_plt.xml file
	afruitpot	maximal number of set fruits per degree-day (indeterminate growth)	($degree\text{-}d^{-1}$)	default value from *_plt.xml file	default value from *_plt.xml file
	allocfrmax	maximal daily allocation to fruits	(SD)	default value from *_plt.xml file	default value from *_plt.xml file
	alphaCO2	coefficient accounting for the modification of radiation use efficiency in case of atmospheric CO2 increase	(SD)	default value from *_plt.xml file	default value from *_plt.xml file
	alphaphot	parameter of photoperiodic effect on leaf lifespan	(SD)	default value from *_plt.xml file	default value from *_plt.xml file
	ampfroid	semi thermal amplitude for vernalising effect	(°C)	default value from *_plt.xml file	default value from *_plt.xml file
	bdens	minimal density above which interplant competition starts	(m^{-2})	default value from *_plt.xml file	default value from *_plt.xml file
	bdil	parameter of the critical dilution curve [Nplante]=adil MS^(-bdil)	(SD)	default value from *_plt.xml file	default value from *_plt.xml file
	bdilmax	parameter of the maximum dilution curve [Nplante]=adilmax MS^(-bdilmax)	(SD)	default value from *_plt.xml file	default value from *_plt.xml file

	belong	parameter of the curve of coleoptile elongation	(degree·d^{-1})	default value from *_plt.xml file	default value from *_plt.xml file
	bfpf	parameter of the logistic curve defining sink strength of fruits (indeterminate growth): maximum growth rate relative to maximum fruit weight	(SD)	default value from *_plt.xml file	default value from *_plt.xml file
	celong	parameter of the plantlet elongation curve	(SD)	default value from *_plt.xml file	default value from *_plt.xml file
	cfpf	parameter of the first potential growth phase of fruit, corresponding to an exponential type function describing the cell division phase	(SD)	default value from *_plt.xml file	default value from *_plt.xml file
	cgrain	slope of the relationship between grain number and growth rate	(grains·g^{-1}·d)	default value from *_plt.xml file	default value from *_plt.xml file
	cgrainv0	number of grains produced when growth rate is zero	(grains·m^{-2})	default value from *_plt.xml file	default value from *_plt.xml file
	codazofruit	option to activate the direct effect of N plant status on the fruit/grain number (1 = no, 2 = yes)	(code 1/2)	default value from *_plt.xml file	default value from *_plt.xml file
	codazorac	option to activate the N influence on root partitioning within the soil profile (1 = yes, 2 = no)	(code 1/2)	default value from *_plt.xml file	default value from *_plt.xml file
	codcalinflo	option for calculating the inflorescences number (1 = read in param.par, 2 = calculated at the amf stage)	(code 1/2)	default value from *_plt.xml file	default value from *_plt.xml file
	codebeso	option of computation water requirements (1 = k.ETP approach, 2= resistive approach)	(code 1/2)	default value from *_plt.xml file	default value from *_plt.xml file
	codebfroid	option of chilling requirements (1 = no need, 2 = vernalising days, 3 = development stage)	(code 1/2/3)	default value from *_plt.xml file	default value from *_plt.xml file
	codedormance	option for the calculation of dormancy and chilling requirements (1 = forcing, 2 = Richardson, 3 = Bidabe)	(code 1/2/3)	default value from *_plt.xml file	default value from *_plt.xml file
	codefixpot	option of calculation of the maximal symbiotic fixation (1 = fixed, 2 =depending on growth rate)	(code 1/2)	default value from *_plt.xml file	default value from *_plt.xml file
	codegdh	time step used for calculating development units (1 = hourly, 2 = daily)	(code 1/2)	default value from *_plt.xml file	default value from *_plt.xml file
	codegdhdeb	option of time step used for calculating bud break date (1 = daily, 2 = hourly growing degrees)	(code 1/2)	default value from *_plt.xml file	default value from *_plt.xml file
	codegermin	option of simulation of a germination phase or a delay at the beginning of the crop (1) or direct starting (2)	(code 1/2)	default value from *_plt.xml file	default value from *_plt.xml file
	codehypo	option of simulation of a phase of hypocotyl growth (1) or planting of plantlets (2)	(code 1/2)	default value from *_plt.xml file	default value from *_plt.xml file
	codeindetermin	option of simulation of the leaf growth and fruit growth (1 = determinate, 2 =indeterminate)	(code 1/2)	default value from *_plt.xml file	default value from *_plt.xml file
	codeINN	option to compute INN (1 = cumulative, 2 = instantaneous)	(code 1/2)	default value from *_plt.xml file	default value from *_plt.xml file
	codeintercept	option of simulation rainfall interception by leaves (1 = yes, 2 = no)	(code 1/2)	default value from *_plt.xml file	default value from *_plt.xml file
	codeir	option of computing the ratio grain weight/total biomass: proportional to time (1), proportional to sum temperatures (2)	(code 1/2)	default value from *_plt.xml file	default value from *_plt.xml file
	codelaitr	option used for calculating intercepted radiation (1 = LAI, 2 = soil cover)	(code 1/2)	default value from *_plt.xml file	default value from *_plt.xml file
	codelegume	is the crop a legume fixing N ? (1 = yes, 2 = no)	(code 1/2)	default value from *_plt.xml file	default value from *_plt.xml file
	codemonocot	type of plant: 1 = monocot, 2 =dicot	(code 1/2)	default value from *_plt.xml file	default value from *_plt.xml file
	codeperenne	option defining the annual (1) or perenial (2) character of the plant	(code 1/2)	default value from *_plt.xml file	default value from *_plt.xml file
	codephot	option of plant photoperiodism (1 = yes, 2 = no)	(code 1/2)	default value from *_plt.xml file	default value from *_plt.xml file
	codeplante	Name code of the plant in 3 letters	(SD)	default value from *_plt.xml file	default value from *_plt.xml file
	codeplisoleN	code for N requirement calculations at the beginning of the cycle (1 = dense plant population, 2 = isolated plants)	(code 1/2)	default value from *_plt.xml file	default value from *_plt.xml file
	coderacine	option of simulating root growth and extension (1 = standard profile, 2 = root length density)	(code 1/2)	default value from *_plt.xml file	default value from *_plt.xml file
	coderetflo	option to activate the slow down effect of water stress on development before the stage DRP (starting date of filling of harvested organs) , (1 = yes, 2 = no)	(code 1/2)	default value from *_plt.xml file	default value from *_plt.xml file
	codestrphot	option to activate the photoperiodic stress on lifespan (1 = yes, 2 = no)	(code 1/2)	default value from *_plt.xml file	default value from *_plt.xml file
	codetemp	option to calculate thermal time for plant growth (1 = air temperature, 2 = crop temperature)	(code 1/2)	default value from *_plt.xml file	default value from *_plt.xml file
	codetemprac	option to calculate thermal time for root growth (1 = crop temperature, 2 = soil temperature)	(code 1/2)	default value from *_plt.xml file	default value from *_plt.xml file
	codetransrad	option of simulating radiation interception (1 = Beer's law, 2 = radiative transfer)	(code 1/2)	default value from *_plt.xml file	default value from *_plt.xml file
	codetremp	option to activate heat effect on grain filling (1 = yes, 2 = no)	(code 1/2)	default value from *_plt.xml file	default value from *_plt.xml file
	codevar	cultivar name	(SD)	default value from *_plt.xml file	default value from *_plt.xml file
	codgelflo	option to activate frost effect at anthesis (1 = no, 2 = yes)	(code 1/2)	default value from *_plt.xml file	default value from *_plt.xml file
	codgeljuv	option to activate frost effect on LAI at the juvenile stage (1 = no, 2 = yes)	(code 1/2)	default value from *_plt.xml file	default value from *_plt.xml file
	codgellev	option to activate frost effect on plantlet (1 = no, 2 = yes)	(code 1/2)	default value from *_plt.xml file	default value from *_plt.xml file
	codgelveg	option to activate frost effect on LAI at adult stage (1 = no, 2 = yes)	(code 1/2)	default value from *_plt.xml file	default value from *_plt.xml file
	codlainet	option of calculation of the LAI (1 : direct LAInet, 2 : LAInet = gross LAI - senescent LAI)	(code 1/2)	default value from *_plt.xml file	default value from *_plt.xml file
	codtrophrac	trophic effect on root length growth (1 = permanent link, 2 = link by thresholds ,3 = no effect)	(code 1/2/3)	default value from *_plt.xml file	default value from *_plt.xml file
	coefamflax	multiplier coefficient of the development phase AMF (maximum acceleration of leaf growth, end of juvenile phase) - LAX (maximum leaf area index, end of leaf growth)to use crop temperature	(SD)	default value from *_plt.xml file	default value from *_plt.xml file
	coefdrpmat	multiplier coefficient of the development phase DRP (starting date of filling of harvested organs) - MAT to use crop temperature	(SD)	default value from *_plt.xml file	default value from *_plt.xml file
	coefflodrp	multiplier coefficient of the development phase FLO (anthesis) - DRP (starting date of filling of harvested organs) to use crop temperature	(SD)	default value from *_plt.xml file	default value from *_plt.xml file
	coeflaxsen	multiplier coefficient of the development phase LAX (maximum leaf area index, end of leaf growth) - SEN (beginning of leaf senescence) to use crop temperature	(SD)	default value from *_plt.xml file	default value from *_plt.xml file
	coeflevamf	multiplier coefficient of the development phase LEV (emergence) - AMF (maximum acceleration of leaf growth, end of juvenile phase) to use crop temperature	(SD)	default value from *_plt.xml file	default value from *_plt.xml file
	coeflevdrp	multiplier coefficient of the development phase LEV (emergence) - DRP (starting date of filling of harvested organs) to use crop temperature	(SD)	default value from *_plt.xml file	default value from *_plt.xml file
	coefmshaut	ratio biomass/ useful height cut of crops	t.ha-1.m-1	default value from *_plt.xml file	default value from *_plt.xml file
	coefsenlan	multiplier coefficient of the development phase SEN (beginning of leaf senescence) - LAN (leaf index nil) to use crop temperature	(SD)	default value from *_plt.xml file	default value from *_plt.xml file
	concNnodseuil	maximal concentration of mineral N in soil for nodule onset	(kg·ha^{-1}·mm^{-1})	default value from *_plt.xml file	default value from *_plt.xml file
	concNrac0	nitrate-N concentration (if codefxN=3) or nitrate-N amount (if codefxN=2) above which N fixation is totally inhibited	(kg·ha^{-1}·mm^{-1}) or (kg·ha^{-1}·cm^{-1})	default value from *_plt.xml file	default value from *_plt.xml file
	concNrac100	nitrate-N concentration (if codefxN=3) or nitrate-N amount (if codefxN=2) below which N fixation is maximum	(kg·ha^{-1}·mm^{-1}) or (kg·ha^{-1}·cm^{-1})	default value from *_plt.xml file	default value from *_plt.xml file
	contrdamax	maximal reduction in root growth rate due to soil strengthness (high bulk density)	(SD)	default value from *_plt.xml file	default value from *_plt.xml file
	croirac	elongation rate of the root apex	(cm·degree-d^{-1})	default value from *_plt.xml file	default value from *_plt.xml file
	debsenrac	sum of degrees.days defining the beginning of root senescence (root life time)	(degree-d)	default value from *_plt.xml file	default value from *_plt.xml file
	deshydbase	rate of change of fruit water content vs thermal time (>0 or <0)	(g·g-1 FM·degree-d^{-1})	default value from *_plt.xml file	default value from *_plt.xml file

	dfolbas	minimal foliar density within the considered shape	(m^2 leaf·m^{-2})	default value from *_plt.xml file	default value from *_plt.xml file
	dfolhaut	maximal foliar density within the considered shape	(m^2 leaf·m^{-2})	default value from *_plt.xml file	default value from *_plt.xml file
	dfpf	parameter of the first potential growth phase of fruit, corresponding to an exponential type function describing the cell division phase	(SD)	default value from *_plt.xml file	default value from *_plt.xml file
	dlaimax	maximum rate of the setting up of LAI	(m^2 leaf·plant^{-1}·degree-d^{-1})	default value from *_plt.xml file	default value from *_plt.xml file
	dlaimaxbrut	maximum rate of the setting up of LAI	(m^2 leaf·plant^{-1}·degree-d^{-1})	default value from *_plt.xml file	default value from *_plt.xml file
	dlaimin	accelerating parameter for the lai growth rate	(SD)	default value from *_plt.xml file	default value from *_plt.xml file
	dltamsmaxsen	threshold value of growth rate from which there is no more photoperiodic effect on senescence	(t·ha^{-1}·d^{-1})	default value from *_plt.xml file	default value from *_plt.xml file
	dltamsminsen	threshold value of growth rate from which the photoperiodic effect on senescence is maximal	(t·ha^{-1}·d^{-1})	default value from *_plt.xml file	default value from *_plt.xml file
	draclong	maximum rate of root length production per plant	(cm·plant^{-1}·degree-d^{-1})	default value from *_plt.xml file	default value from *_plt.xml file
	dureefruit	total growth period of a fruit at the setting stage to the physiological maturity	(degree-d)	default value from *_plt.xml file	default value from *_plt.xml file
	durvieF	maximal lifespan of an adult leaf expressed in summation of Q10=2 (2**(T-Tbase))	(SD)	default value from *_plt.xml file	default value from *_plt.xml file
	durviesupmax	relative additional lifespan due to N excess in plant (INN > 1)	(SD)	default value from *_plt.xml file	default value from *_plt.xml file
	efcroijuv	maximum radiation use efficiency during the juvenile phase(LEV=emergence - AMF= maximum acceleration of leaf growth, end of juvenile phase)	(g·MJ^{-1})	default value from *_plt.xml file	default value from *_plt.xml file
	efcroirepro	maximum radiation use efficiency during the grain filling phase (DRP= starting date of filling of harvested organs - MAT= maturity)	(g·MJ^{-1})	default value from *_plt.xml file	default value from *_plt.xml file
	efcroiveg	maximum radiation use efficiency during the vegetative stage (AMF = maximum acceleration of leaf growth, end of juvenile phase - DRP=starting date of filling of harvested organs)	(g·MJ^{-1})	default value from *_plt.xml file	default value from *_plt.xml file
	elmax	maximum elongation of the coleoptile in darkness condition	(cm)	default value from *_plt.xml file	default value from *_plt.xml file
	envfruit	fraction of envelop in grainmaxi (w:w)	(SD)	default value from *_plt.xml file	default value from *_plt.xml file
	extin	extinction coefficient of photosynthetic active radiation in the canopy	(SD)	default value from *_plt.xml file	default value from *_plt.xml file
	fixmax	maximal N symbiotic fixation rate	(kg·ha^{-1}·d^{-1})	default value from *_plt.xml file	default value from *_plt.xml file
	fixmaxgr	maximal N symbiotic fixation rate per unit of grain growth rate	(kg·r^{-1})	default value from *_plt.xml file	default value from *_plt.xml file
	fixmaxveg	maximal N symbiotic fixation rate per unit of vegetative growth rate	(kg·r^{-1})	default value from *_plt.xml file	default value from *_plt.xml file
	forme	option to define the shape of leaf density profile (1 = rectangle, 2 = triangle)	(code 1/2)	default value from *_plt.xml file	default value from *_plt.xml file
	h2ofeuiljaune	water content of yellow leaves (relative to fresh matter)	(g·g^{-1} FW)	default value from *_plt.xml file	default value from *_plt.xml file
	h2ofeuilverte	water content of green leaves (relative to fresh matter)	(g·g^{-1} FW)	default value from *_plt.xml file	default value from *_plt.xml file
	h2ofrvert	water content of fruits before the beginning of dehydration (DEBDESHYD) (/fresh matter)	(g·g^{-1} FW)	default value from *_plt.xml file	default value from *_plt.xml file
	h2oreserve	reserve water content (/fresh matter)	(g·g^{-1} FW)	default value from *_plt.xml file	default value from *_plt.xml file
	h2otigestruc	structural stem part water content (/fresh matter)	(g.g-1 FW)	default value from *_plt.xml file	default value from *_plt.xml file
	hautbase	basal height of crop	(m)	default value from *_plt.xml file	default value from *_plt.xml file
	hautmax	maximum height of crop	(m)	default value from *_plt.xml file	default value from *_plt.xml file
	idebdorm	day of the dormancy entrance	julian.d	default value from *_plt.xml file	default value from *_plt.xml file
	ifindorm	day of dormancy break	julian.d	default value from *_plt.xml file	default value from *_plt.xml file
	inflomax	maximal number of inflorescences per plant	SD	default value from *_plt.xml file	default value from *_plt.xml file
	infrecouv	ulai at the stage AMF (maximal rate of leaf growth)	SD	default value from *_plt.xml file	default value from *_plt.xml file
	inngrain1	minimal INN for net absorption of N during grain filling	SD	default value from *_plt.xml file	default value from *_plt.xml file
	inngrain2	INN minimal for null net absorption of N during grain filling	SD	default value from *_plt.xml file	default value from *_plt.xml file
	INNimin	INNI (instantaneous INN) corresponding to INNmin	SD	default value from *_plt.xml file	default value from *_plt.xml file
	INNmin	minimum value of INN possible for the crop	SD	default value from *_plt.xml file	default value from *_plt.xml file
	innsen	parameter of the N stress function active on senescence (INNsenes), bilinear function vs INN passing through the point (INNmin, INNsen)	SD	default value from *_plt.xml file	default value from *_plt.xml file
	innturgmin	parameter of the N stress function active on leaf expansion (INNLAI), bilinear function vs INN passing through the point (INNmin, INNturgmin)	SD	default value from *_plt.xml file	default value from *_plt.xml file
	irmax	maximum harvest index	SD	default value from *_plt.xml file	default value from *_plt.xml file
	julvernal	day of initiation of vernalisation in perennial crops (between 1 and 365)	julian.d	default value from *_plt.xml file	default value from *_plt.xml file
	jvc	number of vernalising days	d	default value from *_plt.xml file	default value from *_plt.xml file
	jvcmini	minimum number of vernalising days	d	default value from *_plt.xml file	default value from *_plt.xml file
	Kmabs1	affinity constant of N uptake by roots for the fast uptake system	Âµmole.L-1	default value from *_plt.xml file	default value from *_plt.xml file
	Kmabs2	affinity constant of N uptake by roots for the low uptake system	Âµmole.L-1	default value from *_plt.xml file	default value from *_plt.xml file
	kmax	maximum crop coefficient for water requirements (= MET/PET)	SD	default value from *_plt.xml file	default value from *_plt.xml file
	krepracperm	parameter of biomass root partitioning : evolution of the ratio root/total (permanent trophic link)	SD	default value from *_plt.xml file	default value from *_plt.xml file
	krepracseu	parameter of biomass root partitioning : evolution of the ratio root/total (trophic link by thresholds)	SD	default value from *_plt.xml file	default value from *_plt.xml file
	kstemflow	extinction coefficient connecting LAI to stemflow	*	default value from *_plt.xml file	default value from *_plt.xml file
	ktrou	extinction coefficient of PAR through the crop (used in the radiative transfer module)	*	default value from *_plt.xml file	default value from *_plt.xml file
	laicomp	LAI above which competition between plants starts	m2.m-2	default value from *_plt.xml file	default value from *_plt.xml file
	laiplantule	LAI of plantlet at the plantation	m2.m-2	default value from *_plt.xml file	default value from *_plt.xml file
	longsperac	specific root length	cm.g-1	default value from *_plt.xml file	default value from *_plt.xml file
	lvfront	root density at the root apex	cm.cm-3	default value from *_plt.xml file	default value from *_plt.xml file
	masecmeta	biomass of the plantlet supposed to be composed of metabolic N	t.ha-1	default value from *_plt.xml file	default value from *_plt.xml file
	masecNmax	aerial biomass above which N dilution occurs (critical and maximal curves)	t.ha-1	default value from *_plt.xml file	default value from *_plt.xml file
	masecplantule	initial shoot biomass of plantlet	t.ha-1	default value from *_plt.xml file	default value from *_plt.xml file
	maxazorac	mineral N concentration in soil above which root growth is maximum	kg.ha-1.cm-1	default value from *_plt.xml file	default value from *_plt.xml file

	minazorac	mineral N concentration in soil below which root growth is reduced	kg.ha-1.cm-1	default value from *_plt.xml file	default value from *_plt.xml file
	minefnra	reduction factor on root growth when soil mineral N is limiting (< minazorac)	SD	default value from *_plt.xml file	default value from *_plt.xml file
	mouillabil	maximum wettability of leaves	mm.LAI-1	default value from *_plt.xml file	default value from *_plt.xml file
	nbfeuilplant	leaf number per plant when planting	nb pl-1	default value from *_plt.xml file	default value from *_plt.xml file
	nbfgellev	leaf number at the end of the juvenile phase (frost sensitivity)	nb pl-1	default value from *_plt.xml file	default value from *_plt.xml file
	nbgrmax	maximum number of fruits per surface area	nb.m-2	default value from *_plt.xml file	default value from *_plt.xml file
	nbgrmin	minimum number of fruits per surface area	nb.m-2	default value from *_plt.xml file	default value from *_plt.xml file
	nbinflo	imposed number of inflorescences per plant	nb.pl-1	default value from *_plt.xml file	default value from *_plt.xml file
	nbjgerlim	maximum number of days after grain imbibition allowing full germination	d	default value from *_plt.xml file	default value from *_plt.xml file
	nbjgrain	number of days used to compute the number of viable grains	d	default value from *_plt.xml file	default value from *_plt.xml file
	nboite	number of boxes or age classes of fruits used to calculate fruit growth for undeterminate crops	SD	default value from *_plt.xml file	default value from *_plt.xml file
	nlevlim1	number of days after germination after which plant emergence is reduced	d	default value from *_plt.xml file	default value from *_plt.xml file
	nlevlim2	number of days after germination after which plant emergence is impossible	d	default value from *_plt.xml file	default value from *_plt.xml file
	Nmeta	proportion of metabolic N in the plantlet	%	default value from *_plt.xml file	default value from *_plt.xml file
	Nreserve	maximal amount of N in plant reserves (difference between the maximal and critical dilution curves) (percentage of aerial biomass)	%	default value from *_plt.xml file	default value from *_plt.xml file
	parazofmorte	parameter relating the C/N of dead leaves and the INN	SD	default value from *_plt.xml file	default value from *_plt.xml file
	pentinflores	parameter used to calculate the inflorescences number	10*inflo*kg-1	default value from *_plt.xml file	default value from *_plt.xml file
	pentlaimax	parameter of the logistic curve of LAI growth	SD	default value from *_plt.xml file	default value from *_plt.xml file
	pentrecouv	parameter of the logistic curve of soil cover rate	SD	default value from *_plt.xml file	default value from *_plt.xml file
	pgrainmaxi	maximum grain weight (at 0% water content)	g	default value from *_plt.xml file	default value from *_plt.xml file
	phobase	basal photoperiod	hours	default value from *_plt.xml file	default value from *_plt.xml file
	phobasesen	photoperiod under which the photoperiodic stress affects the lifespan of leaves	hours	default value from *_plt.xml file	default value from *_plt.xml file
	phosat	saturating photoperiod	hours	default value from *_plt.xml file	default value from *_plt.xml file
	phyllotherme	thermal duration between the apparition of two successive leaves on the main stem	degree-d	default value from *_plt.xml file	default value from *_plt.xml file
	potgermi	soil water potential under which seed imbibition is impeded	MPa	default value from *_plt.xml file	default value from *_plt.xml file
	profnod	maximum depth of N2 fixation by legume crops	cm	default value from *_plt.xml file	default value from *_plt.xml file
	propjgermin	minimal proportion of the duration nbjgerlim when the temperature is higher than the temperature threshold Tdmax	%	default value from *_plt.xml file	default value from *_plt.xml file
	psisto	potential of stomatal closing (absolute value)	bars	default value from *_plt.xml file	default value from *_plt.xml file
	psiturg	potential of the beginning of decrease of the cellular extension (absolute value)	bars	default value from *_plt.xml file	default value from *_plt.xml file
	q10	Q10 used for the dormancy break calculation	SD	default value from *_plt.xml file	default value from *_plt.xml file
	rapforme	ratio of thickness to /width of the crop shape (negative when the base of the form < top)	SD	default value from *_plt.xml file	default value from *_plt.xml file
	rapsenturg	threshold soil water content active to simulate water senescence stress as a proportion of the turgor stress	SD	default value from *_plt.xml file	default value from *_plt.xml file
	ratiodurvieI	life span of early leaves expressed as a fraction of the life span of the last leaves emitted DURVIEF	SD	default value from *_plt.xml file	default value from *_plt.xml file
	ratiosen	fraction of senescent biomass (relative to total biomass)	SD	default value from *_plt.xml file	default value from *_plt.xml file
	remobres	fraction of daily remobilisable C reserves	SD	default value from *_plt.xml file	default value from *_plt.xml file
	repracpermax	maximum root biomass relative to total biomass (permanent trophic link)	SD	default value from *_plt.xml file	default value from *_plt.xml file
	repracpermin	minimum root biomass relative to total biomass (permanent trophic link)	SD	default value from *_plt.xml file	default value from *_plt.xml file
	repracseumax	maximum root biomass relative to total biomass (trophic link by thresholds)	SD	default value from *_plt.xml file	default value from *_plt.xml file
	repracseumin	minimum root biomass relative to total biomass (trophic link by thresholds)	SD	default value from *_plt.xml file	default value from *_plt.xml file
	rsmin	minimal stomatal resistance of leaves	s.m-1	default value from *_plt.xml file	default value from *_plt.xml file
	sea	specific area of fruit envelops	cm2.g-1	default value from *_plt.xml file	default value from *_plt.xml file
	sensanox	index of anoxia sensitivity (0 = insensitive)	SD	default value from *_plt.xml file	default value from *_plt.xml file
	sensiphot	index of photoperiod sensitivity (1=insensitive)	SD	default value from *_plt.xml file	default value from *_plt.xml file
	sensrsec	index of root sensitivity to drought (1=insensitive)	SD	default value from *_plt.xml file	default value from *_plt.xml file
	slamax	maximum SLA (specific leaf area) of green leaves	cm2.g-1	default value from *_plt.xml file	default value from *_plt.xml file
	slamin	minimum SLA (specific leaf area) of green leaves	cm2.g-1	default value from *_plt.xml file	default value from *_plt.xml file
	spfrmax	maximal sources/sinks value allowing the trophic stress calculation for fruit onset	SD	default value from *_plt.xml file	default value from *_plt.xml file
	spfrmin	minimal sources/sinks value allowing the trophic stress calculation for fruit onset	SD	default value from *_plt.xml file	default value from *_plt.xml file
	splaimax	maximal sources/sinks value allowing the trophic stress calculation for leaf growing	SD	default value from *_plt.xml file	default value from *_plt.xml file
	splaimin	minimal value of ratio sources/sinks for the leaf growth	SD	default value from *_plt.xml file	default value from *_plt.xml file
	stadebbchamf	equivalent stage in BBCH-scale (amf= maximum acceleration of leaf growth, end of juvenile phase)	SD	default value from *_plt.xml file	default value from *_plt.xml file
	stadebbchdebdes	equivalent stage in BBCH-scale (debdes= date of onset of water dynamics in harvested organs)	SD	default value from *_plt.xml file	default value from *_plt.xml file
	stadebbchdrp	equivalent stage in BBCH-scale (drp = starting date of filling of harvested organs)	SD	default value from *_plt.xml file	default value from *_plt.xml file
	stadebbchfindorm	equivalent stage in BBCH-scale (end of dormancy)	SD	default value from *_plt.xml file	default value from *_plt.xml file
	stadebbchflo	equivalent stage in BBCH-scale (flowering)	SD	default value from *_plt.xml file	default value from *_plt.xml file
	stadebbchger	equivalent stage in BBCH-scale (germination)	SD	default value from *_plt.xml file	default value from *_plt.xml file
	stadebbchlax	equivalent stage in BBCH-scale (lax = maximum leaf area index, end of leaf growth)	SD	default value from *_plt.xml file	default value from *_plt.xml file
	stadebbchlev	equivalent stage in BBCH-scale (emergence)	SD	default value from *_plt.xml file	default value from *_plt.xml file

	stadebbchmat	equivalent stage in BBCH-scale (maturity)	SD	default value from *_plt.xml file	default value from *_plt.xml file
	stadebbchnou	equivalent stage in BBCH-scale (fruit set)	SD	default value from *_plt.xml file	default value from *_plt.xml file
	stadebbchplt	equivalent stage in BBCH-scale (sowing)	SD	default value from *_plt.xml file	default value from *_plt.xml file
	stadebbchrec	equivalent stage in BBCH-scale (harvest)	SD	default value from *_plt.xml file	default value from *_plt.xml file
	stadebbchsen	equivalent stage in BBCH-scale (senescence)	SD	default value from *_plt.xml file	default value from *_plt.xml file
	stamflax	cumulative thermal time between the stages AMF (maximum acceleration of leaf growth, end of juvenile phase) and LAX (maximum leaf area index, end of leaf growth)	degree-d	default value from *_plt.xml file	default value from *_plt.xml file
	stdnofno	cumulative thermal time between the beginning and the end of nodulation	degree-d	default value from *_plt.xml file	default value from *_plt.xml file
	stdordebour	cumulative thermal time between the dormancy break and the bud break	degree-d	default value from *_plt.xml file	default value from *_plt.xml file
	stdrpdes	cumulative thermal time between the DRP stage (starting date of filling of harvested organs) and DEBDES (date of onset of water dynamics in harvested organs)	degree-d	default value from *_plt.xml file	default value from *_plt.xml file
	stdrpmat	cumulative thermal time between the stages DRP (starting date of filling of harvested organs) and MAT (maturity)	degree-d	default value from *_plt.xml file	default value from *_plt.xml file
	stdrpnou	cumulative thermal time between the stages DRP (starting date of filling of harvested organs) and NOU (end of setting)	degree-d	default value from *_plt.xml file	default value from *_plt.xml file
	stemflowmax	maximal fraction of rainfall flowing down along the stems	SD	default value from *_plt.xml file	default value from *_plt.xml file
	stflodrp	cumulative thermal time between FLO (anthesis) and DRP (starting date of filling of harvested organs) (only for indication)	degree-d	default value from *_plt.xml file	default value from *_plt.xml file
	stfnofvino	cumulative thermal time between the end of the nodulation and the end of the nodule life	degree-d	default value from *_plt.xml file	default value from *_plt.xml file
	stlaxsen	cumulative thermal time between the stages LAX (maximum leaf area index, end of leaf growth) and SEN (beginning of leaf senescence)	degree-d	default value from *_plt.xml file	default value from *_plt.xml file
	stlevamf	cumulative thermal time between the stages LEV (emergence) and AMF (maximum acceleration of leaf growth, end of juvenile phase)	degree-d	default value from *_plt.xml file	default value from *_plt.xml file
	stlevdno	cumulative thermal time between emergence and the beginning of nodulation	degree-d	default value from *_plt.xml file	default value from *_plt.xml file
	stlevdrp	cumulative thermal time between the stages LEV (emergence) and DRP (starting date of filling of harvested organs)	degree-d	default value from *_plt.xml file	default value from *_plt.xml file
	stoprac	stage when root growth stops (LAX= maximum leaf area index, end of leaf growth or SEN=beginning of leaf senescence)	SD	default value from *_plt.xml file	default value from *_plt.xml file
	stpltger	cumulative thermal time allowing germination	degree-d	default value from *_plt.xml file	default value from *_plt.xml file
	stressdev	maximum phasic delay allowed due to stresses	SD	default value from *_plt.xml file	default value from *_plt.xml file
	stsenlan	cumulative thermal time between the stages SEN (beginning of leaf senescence) et LAN	degree-d	default value from *_plt.xml file	default value from *_plt.xml file
	tauxrecouvkmax	soil cover rate corresponding to the maximal crop coefficient for water requirement (plant surface / soil surface)	m2.m-2	default value from *_plt.xml file	default value from *_plt.xml file
	tauxrecouvmax	maximal soil cover rate (plant surface / soil surface)	m2.m-2	default value from *_plt.xml file	default value from *_plt.xml file
	tcmax	maximum temperature at which growth ceases	degreeC	default value from *_plt.xml file	default value from *_plt.xml file
	tcmin	minimum temperature at which growth ceases	degreeC	default value from *_plt.xml file	default value from *_plt.xml file
	tcxstop	temperature beyond which foliar growth stops	degreeC	default value from *_plt.xml file	default value from *_plt.xml file
	tdebgel	temperature below which frost affects plant growth	degreeC	default value from *_plt.xml file	default value from *_plt.xml file
	tdmax	maximum temperature above which development stops	degreeC	default value from *_plt.xml file	default value from *_plt.xml file
	tdmaxdeb	maximal temperature for hourly calculation of phasic duration between dormancy and bud breaks	degreeC	default value from *_plt.xml file	default value from *_plt.xml file
	tdmin	minimum temperature below which development stops	degreeC	default value from *_plt.xml file	default value from *_plt.xml file
	tdmindeb	minimal thermal threshold for hourly calculation of phasic duration between dormancy and bud breaks	degreeC	default value from *_plt.xml file	default value from *_plt.xml file
	temax	maximal temperature above which plant growth stops	degreeC	default value from *_plt.xml file	default value from *_plt.xml file
	temin	minimum temperature for development	degreeC	default value from *_plt.xml file	default value from *_plt.xml file
	tempdeshyd	increase in fruit dehydration rate due to the increase in crop temperature (Tcult-Tair)	% water.degreeC-1	default value from *_plt.xml file	default value from *_plt.xml file
	tempnod1	temperature parameter (1/4) used to calculate N fixation by legumes	degreeC	default value from *_plt.xml file	default value from *_plt.xml file
	tempnod2	temperature parameter (2/4) used to calculate N fixation by legumes	degreeC	default value from *_plt.xml file	default value from *_plt.xml file
	tempnod3	temperature parameter (3/4) used to calculate N fixation by legumes	degreeC	default value from *_plt.xml file	default value from *_plt.xml file
	tempnod4	temperature parameter (4/4) used to calculate N fixation by legumes	degreeC	default value from *_plt.xml file	default value from *_plt.xml file
	teopt	optimal temperature (1/2) for plant growth	degreeC	default value from *_plt.xml file	default value from *_plt.xml file
	teoptbis	optimal temperature (2/2) for plant growth	degreeC	default value from *_plt.xml file	default value from *_plt.xml file
	tfroid	optimal temperature for vernalisation	degreeC	default value from *_plt.xml file	default value from *_plt.xml file
	tgelflo10	temperature resulting in 10% of frost damages on flowers and fruits	degreeC	default value from *_plt.xml file	default value from *_plt.xml file
	tgelflo90	temperature resulting in 90% of frost damages on flowers and fruits	degreeC	default value from *_plt.xml file	default value from *_plt.xml file
	tgeljuv10	temperature resulting in 10% of frost damage on LAI (juvenile stage)	degreeC	default value from *_plt.xml file	default value from *_plt.xml file
	tgeljuv90	temperature resulting in 90% of frost damage on LAI (juvenile stage)	degreeC	default value from *_plt.xml file	default value from *_plt.xml file
	tgellev10	temperature resulting in 10% of frost damages on plantlet	degreeC	default value from *_plt.xml file	default value from *_plt.xml file
	tgellev90	temperature resulting in 90% of frost damages on plantlet	degreeC	default value from *_plt.xml file	default value from *_plt.xml file
	tgelveg10	temperature resulting in 10% of frost damage on LAI (adult stage)	degreeC	default value from *_plt.xml file	default value from *_plt.xml file
	tgelveg90	temperature resulting in 90% of frost damage on LAI (adult stage)	degreeC	default value from *_plt.xml file	default value from *_plt.xml file
	tgmin	minimum temperature below which emergence is stopped	degreeC	default value from *_plt.xml file	default value from *_plt.xml file
	tigefeuil	ratio stem (structural part)/leaf	SD	default value from *_plt.xml file	default value from *_plt.xml file
	tletale	lethal temperature for the plant	degreeC	default value from *_plt.xml file	default value from *_plt.xml file
	tmaxremp	maximal temperature above which grain filling stops	degreeC	default value from *_plt.xml file	default value from *_plt.xml file
	tminremp	minimal temperature below which grain filling stops	degreeC	default value from *_plt.xml file	default value from *_plt.xml file
	tustressmin	water stress index (min(turfac,inns)) below which there is an extra LAI senescence	SD	default value from *_plt.xml file	default value from *_plt.xml file
	udlaimax	ulai from which the rate of leaf growth decreases	SD	default value from *_plt.xml file	default value from *_plt.xml file
	vigueurbat	plant vigor index allowing to emerge through a soil crust	SD	default value from *_plt.xml file	default value from *_plt.xml file

	vitirazo	rate of increase of the N harvest index vs time	g grain.g-1.d-1	default value from *_plt.xml file	default value from *_plt.xml file
	vitircarb	rate of increase of the C harvest index vs time	g grain.g-1.d-1	default value from *_plt.xml file	default value from *_plt.xml file
	vitircarbT	rate of increase of the C harvest index vs thermal time	g grain.g-1.d-1	default value from *_plt.xml file	default value from *_plt.xml file
	vitno	rate of nodule onset expressed as a proportion of fixmax per degree day	degree-d-1	default value from *_plt.xml file	default value from *_plt.xml file
	vitprophuile	rate of increase of oil harvest index vs time	g oil.g-1.d-1	default value from *_plt.xml file	default value from *_plt.xml file
	vitpropsucre	rate of increase of sugar harvest index vs time	g sugar.g-1.d-1	default value from *_plt.xml file	default value from *_plt.xml file
	vlaimax	ulai at the inflexion point of the function DELTAI=f(ULAI)	SD	default value from *_plt.xml file	default value from *_plt.xml file
	Vmax1	maximum specific N uptake rate with the low affinity transport system	Âµmole.cm-1 h-1	default value from *_plt.xml file	default value from *_plt.xml file
	Vmax2	maximum specific N uptake rate with the high affinity transport system	Âµmole.cm-1 h-1	default value from *_plt.xml file	default value from *_plt.xml file
	zlabour	depth of ploughing (reference profile)	cm	default value from *_plt.xml file	default value from *_plt.xml file
	zpente	depth at which root density is 50% of the surface root density (reference profile)	cm	default value from *_plt.xml file	default value from *_plt.xml file
	zprlim	maximum depth of the root profile (reference profile)	cm	default value from *_plt.xml file	default value from *_plt.xml file
	zracplantule	initial depth of root apex of the plantlet	cm	default value from *_plt.xml file	default value from *_plt.xml file
		LOCAL PARAMETERS			
Soil parameters (sols.xml)	albedo	albedo of the bare dry soil	SD	default value from sols.xml file	default value from sols.xml file
	argi	clay content after decarbonation	%	+	default value from sols.xml file
	cailloux	volumetric content of pebbles per soil layer	m3.m-3	default value from sols.xml file	default value from sols.xml file
	calc	total carbonate content	%	+	+
	capiljour	capillary rise upward water flux	mm.d-1	default value from sols.xml file	default value from sols.xml file
	cfes	parameter defining the soil contribution to evaporation versus depth	SD	default value from sols.xml file	default value from sols.xml file
	codecailloux	option to take into account pebbles in the water and N balances (1 = yes, 2 = no,)	code 0/1	default value from sols.xml file	default value from sols.xml file
	codedenit	option to activate the calculation of denitrification model (1 = yes, 2 = no)	code 1/2	default value from sols.xml file	default value from sols.xml file
	codefente	option to activate an additional water compartment for swelling soils (1 = yes, 2 = no)	code 0/1	default value from sols.xml file	default value from sols.xml file
	codemacropor	option to activate calculation of water flux in soil macroporosity (1 = yes, 2 = no)	code 0/1	default value from sols.xml file	default value from sols.xml file
	codenitrif	option to activate nitrification rate model (1 = yes, 2 = no)	code 1/2	default value from sols.xml file	default value from sols.xml file
	coderemontcap	option to activate capillary rise (1 = yes, 2 = no)	code 1/2	default value from sols.xml file	default value from sols.xml file
	codrainage	option to simulate artificial drainage (1 = yes, no = 2)	code 1/2	default value from sols.xml file	default value from sols.xml file
	concseuil	minimum concentration of HNO_3 in soil	kg.ha-1 mm-1	default value from sols.xml file	default value from sols.xml file
	CsurNsol	Initial C to N ratio of soil humus	SD	default value from sols.xml file	default value from sols.xml file
	DAF	bulk density of fine earth fraction in each soil layer	g.cm-3	+	+
	ecartdrain	distance between mole drains	cm	default value from sols.xml file	default value from sols.xml file
	epc	thickness of each soil layer	cm	default value from sols.xml file	default value from sols.xml file
	epd	thickness of mixing cells in each soil layer (= 2 * dispersion length)	cm	default value from sols.xml file	default value from sols.xml file
	hccf	gravimetric water content at field capacity of each soil layer (/fine earth)	% w	+	default value from sols.xml file
	hminf	gravimetric water content at wilting point of each soil layer (/fine earth)	% w	+	default value from sols.xml file
	humcapil	threshold of soil gravimetric water content under which capillary rise occurs	% w	default value from sols.xml file	default value from sols.xml file
	infil	infiltrability rate at the base of each soil layer (if codemacropor = 1)	mm.d-1	default value from sols.xml file	default value from sols.xml file
	ksol	soil hydraulic conductivity in the vicinity of mole drains	SD	default value from sols.xml file	default value from sols.xml file
	mulchbat	mulch depth from which a crust occurs (a value must be given but if in the plt.xml the vigueurbat parameter is equal to 1 then the parameter is inactive)	cm	default value from sols.xml file	default value from sols.xml file
	Norg	soil organic N content in the first soil layer (supposed constant down to the depth profhum), equal to total nitrogen (Kjeldahl method)	% dry soil	+	+
	numsol	soil number	SD	default value from sols.xml file	default value from sols.xml file
	obstarac	soil depth at which root growth is stopped due to physical constraints	cm	default value from sols.xml file	default value from sols.xml file
	penterui	runoff coefficient taking account for plant mulch	SD	default value from sols.xml file	default value from sols.xml file
	pH	Initial soil pH (water solution)	pH	+	+
	pluiebat	minimal amount of rain required to create a soil crust (a value must be given but if in the plt.xml the vigueurbat parameter is equal to 1 then the parameter is inactive)	mm.d-1	default value from sols.xml file	default value from sols.xml file
	profdenit	soil depth on which denitrification is active (if codedenit is activated)	cm	default value from sols.xml file	default value from sols.xml file
	profdrain	depth of mole drains	cm	default value from sols.xml file	default value from sols.xml file
	profhum	maximum soil depth with an active biological activity (max.60 cm)	cm	default value from sols.xml file	default value from sols.xml file
	profimper	Upper depth of the impermeable layer (from the soil surface). May be greater than the soil depth.	cm	default value from sols.xml file	default value from sols.xml file
	q0	cumulative soil evaporation above which evaporation rate is decreased	mm	default value from sols.xml file	default value from sols.xml file
	ruisolnu	fraction of runoff (relative to total rainfall) in a bare soil	SD	default value from sols.xml file	default value from sols.xml file
	sol nom	Name of the soil defined in the soil file	(-)	default value from sols.xml file	default value from sols.xml file
	typecailloux	Pebbles type defined by a volumetric mass value (masvolx) and a field capacity moisture value (HCCCX) only used if codecailloux=1 . (typecailloux= 1:Beauce limestone1, 2:Beauce limestone2, 3:lutecian limestone, 4:Lutetian Brackish marl and limestone,5:Morainic gravels,6:Unweathered flint, sandstone or granite,7:weathered granite,8:Jurassic limestone,9:Pebbles from Magneraud,10:Other pebbles)	SD	default value from sols.xml file	default value from sols.xml file
	typsol	soil type	SD	+	+
	vpotdenit	potential rate of denitrification for the whole denitrifying layer	kg.ha-1.d-1	default value from sols.xml file	default value from sols.xml file
	z0solnu	roughness length of bare soil	m	default value from sols.xml file	default value from sols.xml file
	zesx	maximal soil depth affected by soil evaporation	cm	default value from sols.xml file	default value from sols.xml file
Crop management	albedomulchplastique	albedo of plastic cover	SD	default value from Mais_tec.xml file	default value from Mais_tec.xml file

(*_tec.xml)	anitcoupe	amount of mineral N added by fertiliser application at each cut of a forage crop	kg.ha-1	default value from Mais_tec.xml file	default value from Mais_tec.xml file
	biorognem	minimal biomass to be removed when topping (automatic calculation)	t.ha-1	default value from Mais_tec.xml file	default value from Mais_tec.xml file
	cadencerec	number of days between two harvests	d	default value from Mais_tec.xml file	default value from Mais_tec.xml file
	CNgrainrec	minimal N content of grain at harvest	SD	default value from Mais_tec.xml file	default value from Mais_tec.xml file
	codabri	option to activate cropping under shelter (1 = no, 2 = yes)	code 1/2	default value from Mais_tec.xml file	default value from Mais_tec.xml file
	codcaleffeuil	option for the method to use for the calculation of leaf removal (1 = no, 2 =yes)	code 1/2	default value from Mais_tec.xml file	default value from Mais_tec.xml file
	codcalrogne	option of calculation of tipping (1 = forced topping, 2 = automatic calculation)	code 1/2	default value from Mais_tec.xml file	default value from Mais_tec.xml file
	codcueille	option of harvest type (1 =single harvest (cutting), 2 = multiple harvests (picking))	code 1/2	+	default value from Mais_tec.xml file
	codeaumin	option to activate the harvest as a function of grain/fruit water content	code 1/2	default value from Mais_tec.xml file	default value from Mais_tec.xml file
	codecalirrig	code to activate the automatic calculation of irrigation requirements (1 = yes, 2 = no)	code 1/2	default value from Mais_tec.xml file	default value from Mais_tec.xml file
	codeclaircie	option for the method of fruit removal (1 = no, 2 = yes for smallest fruits)	code 1/2	default value from Mais_tec.xml file	default value from Mais_tec.xml file
	codedateappH2O	irrigation application dates given as sum of temperatures (1 = yes, 2 = no)	code 1/2	default value from Mais_tec.xml file	default value from Mais_tec.xml file
	codedateappN	mineral fertilizer application dates given as sum of temperatures (1 = yes, 2 = no)	code 1/2	default value from Mais_tec.xml file	default value from Mais_tec.xml file
	codedecirecolte	option to activate moisture and frost effects on harvest decision (1 = yes, 2 = no)	code 1/2	default value from Mais_tec.xml file	default value from Mais_tec.xml file
	codedecisemis	option to activate the moisture effect on harvest decision (1 = yes, 2 = no)	code 1/2	default value from Mais_tec.xml file	default value from Mais_tec.xml file
	codeDST	option to activate the variations in soil physical soil conditions due to tillage (1 = yes, 2 = no)	code 1/2	default value from Mais_tec.xml file	default value from Mais_tec.xml file
	codeDSTnbcouche	number of compacted soil layers (1 = one layer, 2 = two layers)	code 1/2	default value from Mais_tec.xml file	default value from Mais_tec.xml file
	codeDSTtass	option to activate the soil compaction at sowing and harvest (1 = yes, 2 = no)	code 1/2	default value from Mais_tec.xml file	default value from Mais_tec.xml file
	codefauche	option to activate cuts of forage crops (1 = yes, 2 = no)	code 1/2	default value from Mais_tec.xml file	default value from Mais_tec.xml file
	codeffeuil	option to activate thinning (1 = nos, 2 = yes)	code 1/2	default value from Mais_tec.xml file	default value from Mais_tec.xml file
	codefracappN	option to activate splitting applications of N fertiliser (1 = absolute value, 2 = % of total value)	code 1/2	+	+
	codemodfauche	option defining the cut mode (1 = automatic calculation depending on phenologic and trophic state, 2 = pre-established calendar in days, 3 = pre-established calendar in degree-days)	code 1/2/3	default value from Mais_tec.xml file	default value from Mais_tec.xml file
	codepaillage	option: 1 = no cover, 2 = plastic cover partly covering the soil	code 1/2	default value from Mais_tec.xml file	default value from Mais_tec.xml file
	codepalissage	option defining if the plant is fixed onto a vertical suuport (palissage) (1 = no, 2 =yes)	code 1/2	default value from Mais_tec.xml file	default value from Mais_tec.xml file
	coderecolteassoc	option to harvest intercrop species simultaneously, at the physiological maturity date of the earliest one (1 = no, 2 = yes)	code 1/2	default value from Mais_tec.xml file	default value from Mais_tec.xml file
	coderes	residue type: 1=Main crop on surface, 2=Intermediate crop on surface, 3=Manure on surface, 4=Green compost on surface, 5=Sewage sludge on surface, 6=Vinasse on surface, 7=Horn on surface, 8=Grapevine shoots on surface, 9=Others.1 on surface, 10=Others.2 on surface, 11=Main crop ploughed in, 12=Intermediate crop ploughed in, 13=Manure ploughed in, 14=Green compost ploughed in, 15=Sewage sludge ploughed in, 16=Vinasse ploughed in, 17=Cattle horn ploughed in, 18=Grapevine shoots ploughed in, 19=Others.1 ploughed in, 20=Others.2 ploughed in, 21=Dead roots in soil	code 1 to 21	default value from Mais_tec.xml file	default value from Mais_tec.xml file
	codestade	option to force one or several development stages (1 =yes, 2 = no)	code 1/2	default value from Mais_tec.xml file	default value from Mais_tec.xml file
	codetaille	option to activate pruning (1 = no, 2 = yes)	code 1/2	default value from Mais_tec.xml file	default value from Mais_tec.xml file
	codetradtec	description of crop structure with use of radiation transfer (1 =yes, 2 = no)	code1/2	default value from Mais_tec.xml file	default value from Mais_tec.xml file
	codhauteff	option of leaf removal height (1 = bottom of the canopy, 2 = top of the canopy)	code 1/2	default value from Mais_tec.xml file	default value from Mais_tec.xml file
	codlocferti	option to code of fertilisation localisation (1 = at soil surface, 2 = in the soil)	code 1/2	default value from Mais_tec.xml file	default value from Mais_tec.xml file
	codlocirrig	code of irrigation localisation: 1= above the foliage, 2= below the foliage above the soil, 3 = in the soil	code 1/2/3	default value from Mais_tec.xml file	default value from Mais_tec.xml file
	codrecolte	decision to harvest (1 = physiological maturity, 2 = water content, 3=sugar content, 4=nitrogen content, 5=oil content)	code 1 to 5	default=1	default=1
	codrognage	option of foliage control by trimming (1 = no, 2 = yes)	code 1/2	default value from Mais_tec.xml file	default value from Mais_tec.xml file
	concirr	concentration of mineral N (NH4+NO3-N) in irrigation water	kg.ha-1 mm-1	default value from Mais_tec.xml file	default value from Mais_tec.xml file
	couvermulchplastique	fraction of soil covered by the plastic mulch	SD	default value from Mais_tec.xml file	default value from Mais_tec.xml file
	Crespc	C content in organic residue	% FW	default value from Mais_tec.xml file	default value from Mais_tec.xml file
	CsurNres	C/N ratio of residue	g.g-1	default value from Mais_tec.xml file	default value from Mais_tec.xml file
	dachisel	bulk density of soil after soil tillage (Chisel)	g.cm-3	default value from Mais_tec.xml file	default value from Mais_tec.xml file
	dalabour	bulk density of soil after full inversion tillage (plough)	g.cm-3	default value from Mais_tec.xml file	default value from Mais_tec.xml file
	darecolte	bulk density of soil after harvest	g.cm-3	default value from Mais_tec.xml file	default value from Mais_tec.xml file
	dasemis	bulk density of soil after sowing	g.cm-3	default value from Mais_tec.xml file	default value from Mais_tec.xml file
	densitesem	plant sowing density	plants.m-2	default value from Mais_tec.xml file	default value from Mais_tec.xml file
	doseI	irrigation amount	mm.d-1	+	+
	doseirrigmin	minimal amount of irrigation	mm	default value from Mais_tec.xml file	default value from Mais_tec.xml file
	doseN	daily amount of N added through fertilizers	kg.d-1	default value from Mais_tec.xml file	default value from Mais_tec.xml file
	dosimx	maximum water amount of irrigation authorised at each time step (mode automatic irrigation)	mm.d-1	default value from Mais_tec.xml file	default value from Mais_tec.xml file
	eaures	water content of organic residue (relative to fresh weight)	% FW	default value from Mais_tec.xml file	default value from Mais_tec.xml file
	effeuil	fraction of daily leaf removed at thinning	0-1	default value from Mais_tec.xml file	default value from Mais_tec.xml file
	effirr	irrigation efficiency	SD	default value from Mais_tec.xml file	default value from Mais_tec.xml file
	engrais	fertilizer type (1=ammonium nitrate, 2=UAN solution, 3=urea, 4=anhydrous ammonia, 5=ammonium sulfate, 6=ammonium phosphate, 7=calcium nitrate, 8= fixed efficiency fertiliser)	*	+	+
	fracN	proportion of fertiliser N applied at each application	%	+	+
	h2ograinmax	maximal water content of fruits at harvest (/fresh matter)	g.g-1 FW	default value from Mais_tec.xml file	default value from Mais_tec.xml file
	h2ograinmin	minimal water content of fruits at harvest (/fresh matter)	g.g-1 FW	default value from Mais_tec.xml file	default value from Mais_tec.xml file
	hautcoupe	cut height for forage crops (calendar fixed)	m	default value from Mais_tec.xml file	default value from Mais_tec.xml file
	hautcoupedefaut	cut height for forage crops (calendar calculated)	m	default value from Mais_tec.xml file	default value from Mais_tec.xml file

	hautmaxtec	maximal height of the plant allowed by the management	m	default value from Mais_tec.xml file	default value from Mais_tec.xml file
	hautrogne	cutting height for trimmed plants	m	default value from Mais_tec.xml file	default value from Mais_tec.xml file
	huilerec	minimal oil content of fruits at harvest (/fresh matter)	g.g-1 FW	default value from Mais_tec.xml file	default value from Mais_tec.xml file
	iamf	day of the stage AMF (maximal rate of leaf growth, end of juvenile phase) when the stage is observed (else 999)	julian.d	default value from Mais_tec.xml file	default value from Mais_tec.xml file
	idrp	day of the stage DRP (beginning of grain filling) when the stage is observed (else 999)	julian.d	default value from Mais_tec.xml file	default value from Mais_tec.xml file
	iflo	day of anthesis	julian.d	default value from Mais_tec.xml file	default value from Mais_tec.xml file
	ilan	day of the stage LAN () if the stage is observed (else 999)	julian.d	default value from Mais_tec.xml file	default value from Mais_tec.xml file
	ilax	day of the stage LAX (maximal leaf area index) when the stage is observed (else 999)	julian.d	default value from Mais_tec.xml file	default value from Mais_tec.xml file
	ilev	day of the stage LEV (emergence) when the stage is observed (else 999)	julian.d	default value from Mais_tec.xml file	default value from Mais_tec.xml file
	imat	day of the stage MAT (physiological maturity) when the stage is observed (else 999)	julian.d	default value from Mais_tec.xml file	default value from Mais_tec.xml file
	interrang	width of the crop interrow	m	default value from Mais_tec.xml file	default value from Mais_tec.xml file
	iplt0	date of sowing	julian.d	+	+
	irec	date of harvest	julian.d	+	+
	irecbutoir	latest date of harvest (imposed if the crop cycle is not finished at this date)	julian.d	default value from Mais_tec.xml file	default value from Mais_tec.xml file
	isen	day of the stage SEN (beginning of net senescence) when the stage is observed (else 999)	julian.d	default value from Mais_tec.xml file	default value from Mais_tec.xml file
	julapI	date(s) of irrigation	julian.d	+	+
	julapN	date(s) of fertilizer application	julian.d	+	+
	juleclair	day of fruits removal	julian.d	+	+
	juleffeuil	day of leaf removal	julian.d	default value from Mais_tec.xml file	default value from Mais_tec.xml file
	julfauche	date(s) of each cut for forage crops	julian.d	+	+
	julouvre2	day (1/2) of opening the shelter	julian.d	default value from Mais_tec.xml file	default value from Mais_tec.xml file
	julouvre3	day (2/2) of opening the shelter	julian.d	default value from Mais_tec.xml file	default value from Mais_tec.xml file
	julres	date(s) of organic residue addition to soil	julian.d	default value from Mais_tec.xml file	default value from Mais_tec.xml file
	julrogne	day of plant trimming	julian.d	default value from Mais_tec.xml file	default value from Mais_tec.xml file
	jultaille	day of pruning	julian.d	default value from Mais_tec.xml file	default value from Mais_tec.xml file
	jultrav	date(s) of soil tillage	julian.d	+	default value from Mais_tec.xml file
	laidebeff	LAI of the beginning of leaf removal	m2.m-2	default value from Mais_tec.xml file	default value from Mais_tec.xml file
	laieffeuil	LAI removed from the crop at day juleffeuil	m2.m-2	default value from Mais_tec.xml file	default value from Mais_tec.xml file
	lairesiduel	residual LAI after each cut of forage crop	m2.m-2	default value from Mais_tec.xml file	default value from Mais_tec.xml file
	largrogne	trimmed width	m	default value from Mais_tec.xml file	default value from Mais_tec.xml file
	largtec	technical width	m	default value from Mais_tec.xml file	default value from Mais_tec.xml file
	locferti	soil depth at which fertiliser is applied	cm	default value from Mais_tec.xml file	default value from Mais_tec.xml file
	locirrig	soil depth at which irrigation is applied	cm	default value from Mais_tec.xml file	default value from Mais_tec.xml file
	margerogne	topping occurs when plant height exceeds (hautrogne+margerogne) when automatic trimming is activated	m	default value from Mais_tec.xml file	default value from Mais_tec.xml file
	mscoupemini	minimum value of aerial biomass required to make a cut of forage crop	t.ha-1	default value from Mais_tec.xml file	default value from Mais_tec.xml file
	msresiduel	residual aerial biomass after a cut of a forage crop	t.ha-1	default value from Mais_tec.xml file	default value from Mais_tec.xml file
	nbcueille	number of fruit harvestings (1= one at the end, 2 = many during the cycle)	code 1/2	+	+
	nbinfloecl	number of inflorescences or fruits removed at fruit removal	nb.pl-1	default value from Mais_tec.xml file	default value from Mais_tec.xml file
	nbjmaxapresrecolte	maximal delay allowed for harvest (number of days) (if the soil compaction option is activated)	d	default value from Mais_tec.xml file	default value from Mais_tec.xml file
	nbjmaxapressemis	maximal delay allowed for sowing (number of days) (if the soil compaction option is activated)	d	default value from Mais_tec.xml file	default value from Mais_tec.xml file
	nbjres	number of residue additions	d	default value from Mais_tec.xml file	default value from Mais_tec.xml file
	nbjseuiltempref	number of days without frost for sowing (if sowing decision option is activated)	d	default value from Mais_tec.xml file	default value from Mais_tec.xml file
	nbjtrav	number of tillage operations	SD	+	+
	Nminres	proportion of N mineral content of organic residues (/fresh matter)	% FW	default value from Mais_tec.xml file	default value from Mais_tec.xml file
	orientrang	direction of crop rows (relative to north)	rad	default value from Mais_tec.xml file	default value from Mais_tec.xml file
	profhumrecolteuse	soil depth at which moisture is considered to allow harvesting (if soil compaction is activated)	cm	default value from Mais_tec.xml file	default value from Mais_tec.xml file
	profhumsemoir	soil depth at which moisture is considered to allow sowing (if soil compaction is activated)	cm	default value from Mais_tec.xml file	default value from Mais_tec.xml file
	profmes	depth of measurement of the soil water reserve	cm	default value from Mais_tec.xml file	default value from Mais_tec.xml file
	profres	upper depth of organic residue incorporation	cm	default value from Mais_tec.xml file	default value from Mais_tec.xml file
	profsem	depth of sowing	cm	default value from Mais_tec.xml file	default value from Mais_tec.xml file
	proftrav	maximum depth of organic residue incorporation	cm	default value from Mais_tec.xml file	default value from Mais_tec.xml file
	qres	mass of organic residues added to soil (fresh weight)	t.ha-1	default value from Mais_tec.xml file	default value from Mais_tec.xml file
	Qtot_N	amount of total mineral N fertilizer applications	kg.ha-1	+	+
	ratiol	water stress index below which irrigation is started in automatic mode (0 in manual mode)	SD	default value from Mais_tec.xml file	default value from Mais_tec.xml file
	ressuite	type of crop residue (roots or whole_crop or straw+roots or stubble+roots or stubble_of_residu_type_9+roots or stubble_of_residu_type_10+roots ,prunings)	SD	default value from Mais_tec.xml file	default value from Mais_tec.xml file
	rugochisel	roughness length of bare soil after chisel tillage (if soil compaction is activated)	m	default value from Mais_tec.xml file	default value from Mais_tec.xml file
	rugolabour	roughness length of bare soil after mouldboard ploughing (if soil compaction is activated)	m	default value from Mais_tec.xml file	default value from Mais_tec.xml file
	stadecoupedf	stage of automatic cut for forage crops	SD	default value from Mais_tec.xml file	default value from Mais_tec.xml file
	sucrerec	minimal sugar concentration at harvest (/ fresh matter)	g.g-1 FW	default value from Mais_tec.xml file	default value from Mais_tec.xml file
	surfouvre1	relative area of the shelter opened the first day of opening	SD	default value from Mais_tec.xml file	default value from Mais_tec.xml file
	surfouvre2	relative area of the shelter opened the second day of opening	SD	default value from Mais_tec.xml file	default value from Mais_tec.xml file
	surfouvre3	relative area of the shelter opened the third day of opening	SD	default value from Mais_tec.xml file	default value from Mais_tec.xml file

	tempfauche	cumulative thermal time between two cuts of forage crops	degree-d	default value from Mais_tec.xml file	default value from Mais_tec.xml file
	transplastic	transmission coefficient of the plastic shelter	SD	default value from Mais_tec.xml file	default value from Mais_tec.xml file
	upvttapI	thermal time from emergence (UPVT units) driving irrigation	degreeC	default value from Mais_tec.xml file	default value from Mais_tec.xml file
	upvttapN	thermal time from emergence (UPVT units) driving fertilization	degreeC	default value from Mais_tec.xml file	default value from Mais_tec.xml file
	variete	cultivar number corresponding to the cultivar name in the plant file	SD	+	+
Weather file	weather file *.XXX where the XXX are the 3 last digits of the year	name of the weather file	(-)	+	+
	1st column	name of weather file	(-)	+	+
	2nd column	year	(y)	+	+
	3rd column	month	(m)	+	+
	4th column	day in month	(d)	+	+
	5th column	Julian day	(day of the year)	+	+
	6th column	minimum temperature	(°C)	+	+
	7th column	maximum temperature	(°C)	+	+
	8th column	global radiation	(MJ.m-2. j-1)	+	+
	9th column	Penman PET	(mm.j-1)	+	default=-999
	10th column	rainfall	(mm.j-1)	+	+
	11th column	wind	(m.s-1)	+	default=-999
	12th column	vapour pressure	(mbars)	+	default=-999
	13th column	CO2 content	(ppm)	default=400	default=400
Weather station file (*_sta.xml)	aangst	coefficient of the Angstrom's relationship for extraterrestrial radiation	SD	default value from CLIMAISJ_sta.xml	default value from CLIMAISJ_sta.xml
	aclim	climatic component of A to calculate actual soil evaporation	mm	default value from CLIMAISJ_sta.xml	default value from CLIMAISJ_sta.xml
	aks	parameter of calculation of the energetic loss between the inside and the outside of a greenhouse	W.m-2.K-1	default value from CLIMAISJ_sta.xml	default value from CLIMAISJ_sta.xml
	albveg	albedo of the vegetation	SD	default value from CLIMAISJ_sta.xml	default value from CLIMAISJ_sta.xml
	alphapt	parameter of Priestley-Taylor formula	SD	default value from CLIMAISJ_sta.xml	default value from CLIMAISJ_sta.xml
	altinversion	altitude of inversion of the thermal gradient	m	default value from CLIMAISJ_sta.xml	default value from CLIMAISJ_sta.xml
	altisimul	altitude of simulated site	m	+	+
	altistation	altitude of the input meteorological station	m	+	+
	bangst	coefficient of the Angstrom's relationship for extraterrestrial radiation	SD	default value from CLIMAISJ_sta.xml	default value from CLIMAISJ_sta.xml
	bks	parameter of calculation of the energetic lost between the inside and the outside of a greenhouse	W.m-2.K-1	default value from CLIMAISJ_sta.xml	default value from CLIMAISJ_sta.xml
	cielclair	fraction of sunny hours allowing the inversion of thermal gradient with altitude	SD	default value from CLIMAISJ_sta.xml	default value from CLIMAISJ_sta.xml
	codadret	option to calculate mountain climate taking into account the orientation (1 = south, 2 = north)	code 1/2	default value from CLIMAISJ_sta.xml	default value from CLIMAISJ_sta.xml
	codaltitude	option to activate the calculation of the climate in altitude (1 = no, 2 = yes)	code 1/2	default value from CLIMAISJ_sta.xml	default value from CLIMAISJ_sta.xml
	codecaltemp	option to activate the use of crop temperature for phasic development calculation (1 = empirical relation, 2 =energy balance)	code 1/2	default value from CLIMAISJ_sta.xml	default value from CLIMAISJ_sta.xml
	codeclichange	option to activate climate change (1 = no, 2 =yes)	code 1/2	default value from CLIMAISJ_sta.xml	default value from CLIMAISJ_sta.xml
	codeetp	option for the method of calculating PET (1 = forced Penman, 2 = calculated Penman, 3= Shuttleworth & Wallace, 4 = Priestley & Taylor)	code 1/2/3/4	default value from CLIMAISJ_sta.xml	default value from CLIMAISJ_sta.xml
	codernet	option of calculation of net radiation (1 = Brunt's method, 2 = Cellier's method)	code 1/2	default value from CLIMAISJ_sta.xml	default value from CLIMAISJ_sta.xml
	coefdevil	multiplier coefficient of the exterior radiation to compute PET inside of a greenhouse	SD	default value from CLIMAISJ_sta.xml	default value from CLIMAISJ_sta.xml
	coefrnet	coefficient of calculation of the net radiation under greenhouse	SD	default value from CLIMAISJ_sta.xml	default value from CLIMAISJ_sta.xml
	corecTrosee	temperature to substract to Tmin to estimate dew point temperature (in case of missing air humidity data)	degreeC	default value from CLIMAISJ_sta.xml	default value from CLIMAISJ_sta.xml
	cvent	parameter of the climate calculation under the shelter	SD	default value from CLIMAISJ_sta.xml	default value from CLIMAISJ_sta.xml
	gradtn	thermal gradient in altitude for minimal temperatures	degreeC.m-1	default value from CLIMAISJ_sta.xml	default value from CLIMAISJ_sta.xml
	gradtninv	thermal gradient in altitude for minimal temperatures under the inversion level	degreeC.m-1	default value from CLIMAISJ_sta.xml	default value from CLIMAISJ_sta.xml
	gradtx	thermal gradient in altitude for maximal temperatures	degreeC.m-1	default value from CLIMAISJ_sta.xml	default value from CLIMAISJ_sta.xml
	latitude	latitude of the site	degree	+	+
	NH3ref	NH_3 concentration in the atmosphere	Aµg.m-3	default value from CLIMAISJ_sta.xml	default value from CLIMAISJ_sta.xml
	ombragetx	change in air temperature in the northern hillslope of mountains (activated if codadret=2)	degreeC	default value from CLIMAISJ_sta.xml	default value from CLIMAISJ_sta.xml
	patm	atmospheric pressure	mbar	+	default value from CLIMAISJ_sta.xml
	phiv0	parameter allowing the calculation of the climate under shelter	SD	default value from CLIMAISJ_sta.xml	default value from CLIMAISJ_sta.xml
	ra	aerodynamic resistance (used in volatilization module when we use ETP approach)	s.m-1	default value from CLIMAISJ_sta.xml	default value from CLIMAISJ_sta.xml
	zr	reference height of meteorological data measurement	m	+	default value from CLIMAISJ_sta.xml
Plant and soil inicialization file (*_ini.xml)	beginningstage	initialization parameter for the development stage of the main crop. Several choices are possible: **SNU**: bare soil **PLT**: sowing or planting (annuals) **LEV**: emergence or budding **DOR**: beginning of dormancy (woody plants) **AMF**: maximum acceleration of leaf growth, end of juvenile phase **DRP**: onset of filling of harvested organs **LAX**: maximum leaf area index, end of leaf growth **SEN**: beginning of net senescence (LAInet option)	(-)	default= **PLT**	default= **PLT**
	lai0	initial leaf area index	m2.m-2	default value from mais_ini.xml	default value from mais_ini.xml
	masec0	initial aerial biomass	t.ha-1	default value from mais_ini.xml	default value from mais_ini.xml
	zrac0	initial depth of root apex of the crop	cm	default value from mais_ini.xml	default value from mais_ini.xml
	magrain0	initial grain dry weight	g.m-2	default value from mais_ini.xml	default value from mais_ini.xml
	QNplante0	initial N amount in the plant	kg.ha-1	default value from mais_ini.xml	default value from mais_ini.xml
	resperenne0	initial reserve of biomass	t.ha-1	default value from mais_ini.xml	default value from mais_ini.xml
	densinitial	initial root density in each of the five soil layers	cm.cm-3	default value from mais_ini.xml	default value from mais_ini.xml
	Hinit	initial gravimetric water content of each soil layer (/fine earth)	% w	default value from mais_ini.xml	default value from mais_ini.xml
	NO3init	initial amount of NO3-N in each of the soil layers (/fine earth)	kg.ha-1	default value from mais_ini.xml	default value from mais_ini.xml

	NH4init	initial amount of NH4-N in each of the soil layers	kg.ha-1	default value from mais_ini.xml	default value from mais_ini.xml
Run file (USM.xml)	usm	name of the USM	SD	default='agentN'	default='agentN'
	finit	name of the initialization file	SD	name of plant and soil inicialization file (*_ini.xml)	name of plant and soil inicialization file (*_ini.xml)
	fstation	name of the weather station file	SD	name of weather station file (*_sta.xml)	name of weather station file (*_sta.xml)
	nomsol	name of the soil in the sols.xml file	SD	'sol nom' parameter from soil parameters (sols.xml) file	'sol nom' parameter from soil parameters (sols.xml) file
	datedebut	day of the beginning of the simulation	julian.d	+	+
	datefin	day of the end of simulation	julian.d	+	+
	fclim1	name of the first climate file	SD	name of first weather file *.XXX where the XXX are the 3 last digits of the year	name of first weather file *.XXX where the XXX are the 3 last digits of the year
	fclim2	name of the last climate file	SD	name of the last weather file *.XXX where the XXX are the 3 last digits of the year	name of the last weather file *.XXX where the XXX are the 3 last digits of the year
	culturean	number of calendar years involved in the crop cycle (1 = 1 year e.g. for spring crops, 0 = two years, e.g. for winter crops)	code 1/0	+	+
	codesimul	Type of LAI simulation : 0 = culture (LAI calculated by the model), 1 = feuille (LAI forced)	code 0/1	default=0	default=0
	flai	name of the LAI forcing file (null if none)	SD	default=null	default=null
	fplt	name of the plant file for main plant and if intercropping for associated plant	SD	name of plant parameters (*_plt.xml) file	name of plant parameters (*_plt.xml) file
	ftec	name of the technical file for main plant and if intercropping for associated plant	SD	name of crop management (*_tec.xml) file	name of crop management (*_tec.xml) file
	nbplantes	number of simulated plants (sole crop=1; intercropping=2)	SD	default=1	default=1
OUTPUTS					
	abso(n)	N uptake rate by the crop	kg.ha-1.d-1	no need to have this information	no need to have this information
	age_prairie	age of the forage crop since sowing	year	no need to have this information	no need to have this information
	airg(n)	daily amount of irrigation water	mm.d-1	no need to have this information	no need to have this information
	albedolai	albedo of the crop including soil and vegetation	SD	no need to have this information	no need to have this information
	allocfruit	allocation ratio of assimilates to the fruits	0-1	no need to have this information	no need to have this information
	ammomes	amount of NH4-N in soil over the depth "profmes"	kg.ha-1	no need to have this information	no need to have this information
	amptcultmat	mean daily temperature range (tcult) during the reproductive phase (stages lax - rec)	degreeC	no need to have this information	no need to have this information
	anit(n)	daily amount of fertiliser-N added to crop	kg.ha-1.d-1	no need to have this information	no need to have this information
	anit_engrais(n)	Daily nitrogen provided by fertiliser	kgN.ha-1 j-1	no need to have this information	no need to have this information
	abso(n)	N uptake rate by the crop	kg.ha-1.d-1	no need to have this information	no need to have this information
	age_prairie	age of the forage crop since sowing	year	no need to have this information	no need to have this information
	airg(n)	daily amount of irrigation water	mm.d-1	no need to have this information	no need to have this information
	albedolai	albedo of the crop including soil and vegetation	SD	no need to have this information	no need to have this information
	anoxmoy	index of anoxia over the root depth	0-1	no need to have this information	no need to have this information
	AZamm(1)	amount of NH4-N in the soil layer 1	kg.ha-1	+	no need to have this information
	AZamm(2)	amount of NH4-N in the soil layer 2	kg.ha-1	+	no need to have this information
	AZamm(3)	amount of NH4-N in the soil layer 3	kg.ha-1	+	no need to have this information
	AZamm(4)	amount of NH4-N in the soil layer 4	kg.ha-1	+	no need to have this information
	AZamm(5)	amount of NH4-N in the soil layer 5	kg.ha-1	+	no need to have this information
	azlesd	daily amount of NO3-N leached in mole drains	kg.ha-1.d-1	no need to have this information	no need to have this information
	AZnit(1)	amount of NO3-N in the soil layer 1	kg.ha-1	+	no need to have this information
	AZnit(2)	amount of NO3-N in the soil layer 2	kg.ha-1	+	no need to have this information
	AZnit(3)	amount of NO3-N in the soil layer 3	kg.ha-1	+	no need to have this information
	AZnit(4)	amount of NO3-N in the soil layer 4	kg.ha-1	+	no need to have this information
	AZnit(5)	amount of NO3-N in the soil layer 5	kg.ha-1	+	no need to have this information
	azomes	amount of NO3-N in soil over the depth "profmes"	kg.ha-1	no need to have this information	no need to have this information
	bouchon	index showing if the shrinkage slots are opened (0) or closed (1)	0/1	no need to have this information	no need to have this information
	Cb	amount of C in the microbial biomass decomposing organic residues mixed with soil	kg.ha-1	+	no need to have this information
	Cbmulch	amount of C in the microbial biomass decomposing organic residues at soil surface (mulch)	kg.ha-1	+	no need to have this information
	cdemande	cumulative amount of N needed by the plant (plant needs)	kg.ha-1	+	+
	cEdirect	Total Evaporation (water evaporated by the soil + intercepted by leaves and mulch) integrated over the cropping season	mm	+	+
	cEdirecttout	Total Evaporation (water evaporated by the soil + intercepted by leaves and mulch) integrated over the simulation period	mm	+	no need to have this information
	cep	cumulative transpiration over the cropping season	mm	+	no need to have this information
	ces	cumulative evaporation over the cropping season	mm	+	no need to have this information
	cestout	cumulative evaporation over the simulation period	mm	+	no need to have this information
	cet	cumulative evapotranspiration over the cropping season	mm	+	no need to have this information
	cet_from_lev	cumulative evapotranspiration over the cropping season (from emergence or budbreak)	mm	+	no need to have this information
	cetm	cumulative maximum evapotranspiration over the cropping season	mm	no need to have this information	no need to have this information
	Cetmtout	cumulative maximum evapotranspiration over the simulation period	mm	no need to have this information	no need to have this information
	cetp	cumulative potential evapotranspiration (pet) over the cropping season	mm	+	no need to have this information

	chargefruit	number of filling grains or ripe fruits	m-2	no need to have this information	no need to have this information
	Chuma	amount of active C in humified organic matter	kg.ha-1	no need to have this information	no need to have this information
	Chumi	amount of inert C in humified organic matter	kg.ha-1	no need to have this information	no need to have this information
	Chumt	amount of C in humified organic matter (active + inert fractions)	kg.ha-1	no need to have this information	no need to have this information
	cintermulch	cumulative amount of rain intercepted by the mulch	mm	no need to have this information	no need to have this information
	cinterpluie	cumulative amount of rain intercepted by the leaves	mm	no need to have this information	no need to have this information
	Cmulch	amount of C in the whole plant mulch	kg.ha-1	no need to have this information	no need to have this information
	Cmulchdec	amount of C in the decomposable mulch	kg.ha-1	no need to have this information	no need to have this information
	Cmulchnd	amount of C in the non decomposable mulch	kg.ha-1	no need to have this information	no need to have this information
	CNgrain	N concentration in fruits	% dry weight	+	no need to have this information
	Cnondec(1)	amount of C in the undecomposable mulch made of residues of type 1	kg.ha-1	no need to have this information	no need to have this information
	Cnondec(10)	amount of C in the undecomposable mulch made of residues of type 10	kg.ha-1	no need to have this information	no need to have this information
	Cnondec(2)	amount of C in the undecomposable mulch made of residues of type 2	kg.ha-1	no need to have this information	no need to have this information
	Cnondec(3)	amount of C in the undecomposable mulch made of residues of type 3	kg.ha-1	no need to have this information	no need to have this information
	Cnondec(4)	amount of C in the undecomposable mulch made of residues of type 4	kg.ha-1	no need to have this information	no need to have this information
	Cnondec(5)	amount of C in the undecomposable mulch made of residues of type 5	kg.ha-1	no need to have this information	no need to have this information
	Cnondec(6)	amount of C in the undecomposable mulch made of residues of type 6	kg.ha-1	no need to have this information	no need to have this information
	Cnondec(7)	amount of C in the undecomposable mulch made of residues of type 7	kg.ha-1	no need to have this information	no need to have this information
	Cnondec(8)	amount of C in the undecomposable mulch made of residues of type 8	kg.ha-1	no need to have this information	no need to have this information
	Cnondec(9)	amount of C in the undecomposable mulch made of residues of type 9	kg.ha-1	no need to have this information	no need to have this information
	CNplante	N concentration in the aboveground plant	% dry weight	+	no need to have this information
	co2(n)	atmospheric CO2 content above 330 ppm	ppm	no need to have this information	no need to have this information
	CO2hum	daily amount of CO2-C emitted due to the mineralisation of soil humus	kg.ha-1.d-1	no need to have this information	no need to have this information
	CO2res	daily amount of CO2-C emitted due to the mineralisation of organic residues	kg.ha-1.d-1	no need to have this information	no need to have this information
	CO2sol	daily amount of CO2-C emitted due to soil mineralisation (humus and organic residues)	kg.ha-1.d-1	no need to have this information	no need to have this information
	codebbch_output	code of the bbch stage (see plant file)	0-99	no need to have this information	no need to have this information
	concNO3les	nitrate concentration in drained water	mg NO3.l-1	+	+
	concNO3sol(1)	nitrate concentration in soil layer 1	mg NO3.l-1	+	no need to have this information
	concNO3sol(2)	nitrate concentration in soil layer 2	mg NO3.l-1	+	no need to have this information
	concNO3sol(3)	nitrate concentration in soil layer 3	mg NO3.l-1	+	no need to have this information
	concNO3sol(4)	nitrate concentration in soil layer 4	mg NO3.l-1	+	no need to have this information
	concNO3sol(5)	nitrate concentration in soil layer 5	mg NO3.l-1	+	no need to have this information
	condenit	ratio of actual to potential denitrifying rate	0-1	no need to have this information	no need to have this information
	couvermulch	cover ratio of mulch	0-1	no need to have this information	no need to have this information
	cpluie	cumulative amount of rain over the simulation period	mm	no need to have this information	no need to have this information
	cprecip	cumulative water supply over the cropping season	mm	+	no need to have this information
	cpreciptout	cumulative water supply over the simulation period	mm	+	no need to have this information
	Cr	amount of C in organic residues mixed with soil	kg.ha-1	no need to have this information	no need to have this information
	Crac	amount of C in roots at harvest	kg.ha-1	no need to have this information	no need to have this information
	Cresiduprofil(1)	amount of C in residues over the soil depth "profhum" in the residue type 1	kg.ha-1	no need to have this information	no need to have this information
	Cresiduprofil(10)	amount of C in residues over the soil depth "profhum" in the residue type 10	kg.ha-1	no need to have this information	no need to have this information
	Cresiduprofil(2)	amount of C in residues over the soil depth "profhum" in the residue type 2	kg.ha-1	no need to have this information	no need to have this information
	Cresiduprofil(3)	amount of C in residues over the soil depth "profhum" in the residue type 3	kg.ha-1	no need to have this information	no need to have this information
	Cresiduprofil(4)	amount of C in residues over the soil depth "profhum" in the residue type 4	kg.ha-1	no need to have this information	no need to have this information
	Cresiduprofil(5)	amount of C in residues over the soil depth "profhum" in the residue type 5	kg.ha-1	no need to have this information	no need to have this information
	Cresiduprofil(6)	amount of C in residues over the soil depth "profhum" in the residue type 6	kg.ha-1	no need to have this information	no need to have this information
	Cresiduprofil(7)	amount of C in residues over the soil depth "profhum" in the residue type 7	kg.ha-1	no need to have this information	no need to have this information
	Cresiduprofil(8)	amount of C in residues over the soil depth "profhum" in the residue type 8	kg.ha-1	no need to have this information	no need to have this information
	Cresiduprofil(9)	amount of C in residues over the soil depth "profhum" in the residue type 9	kg.ha-1	no need to have this information	no need to have this information
	crg	cumulative global radiation over the cropping season	MJ.m-2	no need to have this information	no need to have this information
	crgtout	cumulative global radiation over the simulation period	MJ.m-2	no need to have this information	no need to have this information
	ctairtout	cumulative air temperature (tair) over the simulation period	degreeC	no need to have this information	no need to have this information
	ctcult	cumulative crop temperature (tcult) over the cropping season	degreeC	no need to have this information	no need to have this information
	ctculttout	cumulative crop temperature (tcult) over the simulation period	degreeC	no need to have this information	no need to have this information
	ctetptout	cumulative potential evapotranspiration (pet) over the simulation period	mm	+	no need to have this information
	ctmoy	cumulative air temperature over the cropping season	degreeC	no need to have this information	no need to have this information
	Ctousresidusprofil	amount of C contained in soil residues over the biologically active depth (profhum)	kg.ha-1	no need to have this information	no need to have this information
	cum_et0	cumulative maximum evapotranspiration over the cropping season (eop+eos)	mm	no need to have this information	no need to have this information

	cum_et0_from_lev	cumulative maximum evapotranspiration over the cropping season from germination or budbreak (eop+eos)	mm	no need to have this information	no need to have this information
	cum_immob	cumulative amount of N immobilised by the microbial biomass decomposing residues	kg.ha-1	no need to have this information	no need to have this information
	cumlracz	cumulative length of active roots per soil surface	cm.cm-2	no need to have this information	no need to have this information
	cumraint	cumulative intercepted radiation	MJ.m-2	no need to have this information	no need to have this information
	cumrg	cumulative global radiation during the stage sowing-harvest	Mj.m-2	no need to have this information	no need to have this information
	cumvminh	daily amount of N mineralised from humus	kg.ha-1.d-1	no need to have this information	no need to have this information
	cumvminr	daily amount of N mineralised from organic residues	kg.ha-1.d-1	no need to have this information	no need to have this information
	da(1)	bulk density of the layer 1 (recalculated by the model if codeDSTtass is 1)	g.cm-3	no need to have this information	no need to have this information
	da(2)	bulk density of the layer 2 (recalculated by the model if codeDSTtass is 1)	g.cm-3	no need to have this information	no need to have this information
	day_after_sowing	days after sowing or planting	day	no need to have this information	no need to have this information
	day_cut	cut day	julian day	no need to have this information	no need to have this information
	deltai(n)	daily increase in green leaf index per soil surface	m2.m-2.d-1	no need to have this information	no need to have this information
	deltaz	rate of deepening of the root front	cm.d-1	no need to have this information	no need to have this information
	demande	daily amount of N need of the plant	kg.ha-1.d-1	no need to have this information	no need to have this information
	densite	actual sowing density	plants.m-2	no need to have this information	no need to have this information
	densiteequiv	equivalent plant density for the understorey crop	plants.m-2	no need to have this information	no need to have this information
	dfol	"within the shape" leaf density	m2.m-3	no need to have this information	no need to have this information
	diftemp1intercoupe	mean difference between crop and air temperatures during the vegetative phase (emergence - maximum LAI)	degreeC	no need to have this information	no need to have this information
	diftemp2intercoupe	mean difference between crop and air temperatures during the reproductive phase (maximum LAI - maturity)	degreeC	no need to have this information	no need to have this information
	dltags	daily growth rate of the plantlets	t.ha-1.d-1	no need to have this information	no need to have this information
	dltaisen	daily change in the senescent leaf area index	m2.m-2.d-1	no need to have this information	no need to have this information
	dltams(n)	daily growth rate of the plant	t.ha-1.d-1	no need to have this information	no need to have this information
	dltamsen	daily senescence rate of the plant	t.ha-1.d-1	no need to have this information	no need to have this information
	dltaremobil	daily amount of perennial reserves remobilised	t.ha-1.d-1	no need to have this information	no need to have this information
	dltmsrac_plante	pour sorties ArchiSTICS: biomasse journaliere allouee aux racines en g	mï¾²sol	no need to have this information	no need to have this information
	drain	daily amount of water drained at the base of the soil profile	mm.d-1	no need to have this information	no need to have this information
	drain_from_lev	cumulative amount of water drained at the base of the soil profile during the crop cycle(emergence or budbreak-harvest)	mm	no need to have this information	no need to have this information
	drain_from_plt	cumulative amount of water drained at the base of the soil profile during the crop cycle (planting-harvest)	mm	+	no need to have this information
	drat	cumulative amount of water drained at the base of the soil profile during the simulation period	mm	+	no need to have this information
	drlsenmortalle	root biomass corresponding to dead tillers	t.ha-1.d-1	no need to have this information	no need to have this information
	dtj(n)	thermal time for root growth	degreeC.d	no need to have this information	no need to have this information
	dureehumec	number of hours which are "wet" (rainy days or days when tcult < dew point)	hour	no need to have this information	no need to have this information
	dureeRH	number of night hours during which relative humidity exceeds a 90% threshold	hour	no need to have this information	no need to have this information
	durvie(n)	actual life span of the leaf surface	degreeC	no need to have this information	no need to have this information
	eai	equilvalent leaf area for ear	m2.m-2	no need to have this information	no need to have this information
	ebmax	maximum value of radiation use efficiency	cg.MJ-1	no need to have this information	no need to have this information
	ebmax_gr	Maximum radiation use efficiency during the vegetative stage (AMF-DRP)	g MJ-1	no need to have this information	no need to have this information
	Edirect	daily amount of water evaporated by the soil + intercepted by leaves and mulch	mm.d-1	no need to have this information	no need to have this information
	efda	reduction factor on root growth due to physical constraint (through bulk density)	0-1	no need to have this information	no need to have this information
	efdensite	density factor on leaf area growth	0-1	no need to have this information	no need to have this information
	efdensite_rac	density factor on root growth	0-1	no need to have this information	no need to have this information
	efNrac_mean	reduction factor on root growth rate due to mineral N concentration	0-1	no need to have this information	no need to have this information
	em_N2O	daily amount of N2O-N emitted from soil	kg.ha-1.d-1	no need to have this information	no need to have this information
	em_N2Oden	daily amount of N2O-N emitted from soil by denitrification	kg.ha-1.d-1	no need to have this information	no need to have this information
	em_N2Onit	daily amount of N2O-N emitted from soil by nitrification	kg.ha-1.d-1	no need to have this information	no need to have this information
	emd	daily amount of water directly evaporated after leaves interception	mm.d-1	no need to have this information	no need to have this information
	emulch	daily amount of water directly evaporated after mulch interception	mm.d-1	no need to have this information	no need to have this information
	eo	intermediary variable for the computation of evapotranspiration	mm.d-1	no need to have this information	no need to have this information
	eop	daily maximum transpiration flux	mm.d-1	no need to have this information	no need to have this information
	eos	daily maximum evaporation flux	mm.d-1	no need to have this information	no need to have this information
	ep	daily actual transpiration flux	mm.d-1	no need to have this information	no need to have this information
	epc_recal(1)	thickness of the soil layer 1 (recalculated by the model if codeDSTtass is 1)	cm	no need to have this information	no need to have this information
	epc_recal(2)	thickness of the soil layer 2 (recalculated by the model if codeDSTtass is 1)	cm	no need to have this information	no need to have this information
	epc_recal(3)	thickness of the soil layer 3 (recalculated by the model if codeDSTtass is 1)	cm	no need to have this information	no need to have this information
	epc_recal(4)	thickness of the soil layer 4 (recalculated by the model if codeDSTtass is 1)	cm	no need to have this information	no need to have this information
	epc_recal(5)	thickness of the soil layer 5 (recalculated by the model if codeDSTtass is 1)	cm	no need to have this information	no need to have this information
	epsib	radiation use efficiency	t.ha-1.MJ-1.m2	no need to have this information	no need to have this information
	esol	daily actual soil evaporation flux	mm.d-1	no need to have this information	no need to have this information

et	daily evapotranspiration (esol + ep)	mm.d-1	no need to have this information	no need to have this information
et0	daily maximun evapotranspiration flux (transpiration + soil evaporation)	mm	no need to have this information	no need to have this information
etm	daily maximum evapotranspiration (esol + eop)	mm.d-1	no need to have this information	no need to have this information
etpp(n)	'daily potential evapotranspiration as given by Penman"s formula'	mm.d-1	no need to have this information	no need to have this information
exces(1)	amount of water in the macroporosity of the layer 1	mm	no need to have this information	no need to have this information
exces(2)	amount of water in the macroporosity of the layer 2	mm	no need to have this information	no need to have this information
exces(3)	amount of water in the macroporosity of the layer 3	mm	no need to have this information	no need to have this information
exces(4)	amount of water in the macroporosity of the layer 4	mm	no need to have this information	no need to have this information
exces(5)	amount of water in the macroporosity of the layer 5	mm	no need to have this information	no need to have this information
exobiom	reduction factor on biomass growth due to water excess	0-1	no need to have this information	no need to have this information
exofac	waterlogging index	0-1	no need to have this information	no need to have this information
exofac1moy	mean value of the waterlogging index during the vegetative stage (emergence - fruit establishment)	0-1	no need to have this information	no need to have this information
exofac2moy	mean value of the waterlogging index during the reproductive stage (fruit establishment - maturity)	0-1	no need to have this information	no need to have this information
exolai	reduction factor on leaf growth due to water excess	0-1	no need to have this information	no need to have this information
fapar	proportion of the radiation intercepted	0-1	no need to have this information	no need to have this information
fco2	specie-dependant CO2 effect on radiation use efficiency	SD	no need to have this information	no need to have this information
fco2s	specie-dependant CO2 effect onstomate closure	SD	no need to have this information	no need to have this information
fgelflo	reduction factor on the number of fruits due to frost	0-1	no need to have this information	no need to have this information
fixmaxvar	maximal rate of BNF (symbiotic fixation)	kg.ha-1.d-1	no need to have this information	no need to have this information
fixpot	potential rate of BNF (symbiotic fixation)	kg.ha-1.d-1	no need to have this information	no need to have this information
fixreel	actual rate of BNF (symbiotic fixation)	kg.ha-1.d-1	no need to have this information	no need to have this information
flurac	daily amount of N taken up by the plant when N uptake is limited by the plant capacity absorption	kg.ha-1.d-1	no need to have this information	no need to have this information
flusol	daily amount of N taken up by the plant when N uptake is limited by the transfer from soil to root	kg.ha-1.d-1	no need to have this information	no need to have this information
fpari	radiation effect on conversion efficiency	g.MJ-1	no need to have this information	no need to have this information
fpari_gr	radiation factor on the calculation of conversion efficiency	g MJ-1	no need to have this information	no need to have this information
fpft	daily sink capacity of fruits	g.m-2.d-1	no need to have this information	no need to have this information
fpv(n)	daily sink capacity of growing leaves	g.m-2.d-1	no need to have this information	no need to have this information
FsNH3	daily amount of NH3-N emitted from soil by volatilisation	micro g.m-2.d-1	no need to have this information	no need to have this information
fstressgel	reduction factor on leaf growth due to frost	0-1	no need to have this information	no need to have this information
ftemp	reduction factor on biomass growth due to temperature-related epsibmax	0-1	no need to have this information	no need to have this information
fxa	reduction factor on BNF (symbiotic fixation) due to soil anoxia	0-1	no need to have this information	no need to have this information
fxn	reduction factor on BNF (symbiotic fixation) due to mineral N concentration	0-1	no need to have this information	no need to have this information
fxt	reduction factor on BNF (symbiotic fixation) due to soil temperature	0-1	no need to have this information	no need to have this information
fxw	reduction factor on BNF (symbiotic fixation) due to soil water content	0-1	no need to have this information	no need to have this information
gel1	proportion of leaves damaged by frost before amf stage (end of juvenile phase)	0-1	no need to have this information	no need to have this information
gel1_percent	proportion of leaves damaged by frost before amf stage (end of juvenile phase)	%	no need to have this information	no need to have this information
gel2	proportion of leaves damaged by frost after amf stage (end of juvenile phase)	0-1	no need to have this information	no need to have this information
gel2_percent	proportion of leaves damaged by frost after amf stage (end of juvenile phase)	%	no need to have this information	no need to have this information
gel3	proportion of flowers or fruits damaged by frost	0-1	no need to have this information	no need to have this information
gel3_percent	proportion of flowers or fruits damaged by frost	%	no need to have this information	no need to have this information
H2Orec	water content of harvested organs	0-1	+	+
H2Orec_percent	water content of harvested organs	% fresh weight	+	+
hauteur	height of canopy	m	+	no need to have this information
Hmax	maximum height of water table between drains	cm	no need to have this information	no need to have this information
Hnappe	height of water table affecting plant growth	cm	no need to have this information	no need to have this information
Hpb	minimum depth of perched water table	cm	no need to have this information	no need to have this information
Hph	maximum depth of perched water table	cm	no need to have this information	no need to have this information
HR(1)	water content of the soil layer 1	% dry weight	+	+
HR(2)	water content of the soil layer 2	% dry weight	+	+
HR(3)	water content of the soil layer 3	% dry weight	+	+
HR(4)	water content of the soil layer 4	% dry weight	+	+
HR(5)	water content of the soil layer 5	% dry weight	+	+
HR_vol_1_10	water content of the layer 1-10 cm	mm	+	+
HR_vol_1_30	water content of the layer 1-30 cm (table)	mm	+	+
HR_vol_121_150	water content of the layer 121-150 cm (table)	mm	+	+
HR_vol_151_180	water content of the layer 151-180 cm (table)	mm	+	+
HR_vol_31_60	water content of the layer 31-60 cm (table)	mm	+	+
HR_vol_61_90	water content of the layer 61-90 cm (table)	mm	+	+
HR_vol_91_120	water content of the layer 91-120 cm (table)	mm	+	+
huile	oil content of harvested organs	0-1	+	+
huile_percent	oil content of harvested organs	% fresh weight	+	+
humair	air moisture content	0-1	no need to have this information	no need to have this information
humair_percent	air moisture content	% saturation	no need to have this information	no need to have this information
humidite	air moisture content in the canopy	0-1	no need to have this information	no need to have this information
humidite_percent	air moisture content in the canopy	% saturation	no need to have this information	no need to have this information

	humirac_mean	reduction factor on root growth due to soil water content (mean value over the root profile)	0-1	no need to have this information	no need to have this information
	hur(10)_vol	soil water content in the soil at 10 cm	cm/cm	+	no need to have this information
	iamfs	date of amf stage (maximum acceleration of leaf growth, end of juvenile phase)	julian day	no need to have this information	no need to have this information
	idebdess	date of onset of water dynamics in harvested organs	julian day	no need to have this information	no need to have this information
	idebdorms	date of entry into dormancy	julian day	no need to have this information	no need to have this information
	idrps	starting date of filling of harvested organs	julian day	no need to have this information	no need to have this information
	ifindorms	date of emergence from dormancy	julian day	no need to have this information	no need to have this information
	iflos	date of flowering	julian day	no need to have this information	no need to have this information
	igers	date of germination	julian day	no need to have this information	no need to have this information
	ilans	date of lan stage (leaf index nil)	julian day	no need to have this information	no need to have this information
	ilaxs	date of lax stage (leaf index maximum)	julian day	no need to have this information	no need to have this information
	ilevs	date of emergence	julian day	no need to have this information	no need to have this information
	imats	date of start of physiological maturity	julian day	no need to have this information	no need to have this information
	imontaisons	date of start of stem elongation	julian day	no need to have this information	no need to have this information
	infil_recal(1)	infiltrability parameter at the base of the layer 1	mm.d-1	no need to have this information	no need to have this information
	infil_recal(2)	infiltrability parameter at the base of the layer 2	mm.d-1	no need to have this information	no need to have this information
	infil_recal(3)	infiltrability parameter at the base of the layer 3	mm.d-1	no need to have this information	no need to have this information
	infil_recal(4)	infiltrability parameter at the base of the layer 4	mm.d-1	no need to have this information	no need to have this information
	infil_recal(5)	infiltrability parameter at the base of the layer 5	mm.d-1	no need to have this information	no need to have this information
	inn	nitrogen nutrition index (NNI)	0-2	+	no need to have this information
	inn1intercoupe	average NNI during the cut (cut crop vegetative phase: emergence to maximum LAI)	0-2	no need to have this information	no need to have this information
	inn1moy	average NNI during the vegetative stage	0-2	no need to have this information	no need to have this information
	inn2intercoupe	average NNI during the cut (cut crop reproductive phase: maximum LAI to maturity)	0-2	no need to have this information	no need to have this information
	inn2moy	average NNI during the reproductive stage	0-2	no need to have this information	no need to have this information
	innlai	reduction factor on leaf growth due to NNI (nitrogen deficiency)	innmin to 1	no need to have this information	no need to have this information
	inns	reduction factor on biomass growth due to NNI (nitrogen deficiency)	innmin to 1	no need to have this information	no need to have this information
	innsenes	nitrogen stress index affecting leaves death	innmin to 1	no need to have this information	no need to have this information
	inous	ending date for setting of harvested organs	julian day	no need to have this information	no need to have this information
	intermulch	daily amount of water intercepted by the mulch (vegetal)	mm.d-1	no need to have this information	no need to have this information
	interpluie	daily amount of water intercepted by leaves	mm.d-1	no need to have this information	no need to have this information
	iplts	date of sowing or planting	julian day	no need to have this information	no need to have this information
	irazo(n)	nitrogen harvest index	0-1	no need to have this information	no need to have this information
	ircarb(n)	carbon harvest index	0-1	no need to have this information	no need to have this information
	irecs	date of harvest (first if several)	julian day	+	no need to have this information
	irrigjN	amount of mineral N added by irrigation	kg.ha-1	no need to have this information	no need to have this information
	irrigN	cumulative amount of mineral N added by irrigation	kg.ha-1	no need to have this information	no need to have this information
	isens	date of begninning leaf senescence stage	julian day	no need to have this information	no need to have this information
	izrac	water excess stress index on roots	0-1	no need to have this information	no need to have this information
	lai(n)	leaf area index (table)	m2.m-2	no need to have this information	no need to have this information
	lai_mx_av_cut	LAI before cut (for cut crops , for others = lai(n))	SD	no need to have this information	no need to have this information
	laimax	maximum leaf area index	m2.m-2	no need to have this information	no need to have this information
	laisen(n)	leaf area index of senescent leaves (table)	m2.m-2	no need to have this information	no need to have this information
	largeur	width of the plant shape	m	no need to have this information	no need to have this information
	leaching_from_lev	cumulative amount of NO3-N leached at the base of the soil profile during the crop cycle (emergence or budbreak-harvest)	kg.ha-1	no need to have this information	no need to have this information
	leaching_from_plt	cumulative amount of NO3-N leached at the base of the soil profile during the crop cycle	kg.ha-1	no need to have this information	no need to have this information
	lessiv	daily amount of NO3-N leached at the base of the soil profile	kg.ha-1.d-1	no need to have this information	no need to have this information
	LRACH(1)	root length density in soil layer 1	cm.cm-3	no need to have this information	no need to have this information
	LRACH(2)	root length density in soil layer 2	cm.cm-3	no need to have this information	no need to have this information
	LRACH(3)	root length density in soil layer 3	cm.cm-3	no need to have this information	no need to have this information
	LRACH(4)	root length density in soil layer 4	cm.cm-3	no need to have this information	no need to have this information
	LRACH(5)	root length density in soil layer 5	cm.cm-3	no need to have this information	no need to have this information
	lracsentot	cumulative length of senescent roots	cm root.cm -2 soil	no need to have this information	no need to have this information
	mabois	biomass removed by pruning	t.ha-1	no need to have this information	no need to have this information
	maenfruit	biomass of harvested organ envelops	t.ha-1	+	+
	mafeuil	biomass of leaves	t.ha-1	+	+
	mafeuil_kg_ha	Dry matter of leaves	kg.ha-1	+	+
	mafeuiljaune	biomass of yellow leaves	t.ha-1	+	+
	mafeuiltombe	biomass of fallen leaves	t.ha-1	+	+
	mafeuilverte	biomass of green leaves	t.ha-1	+	+
	mafrais	aboveground fresh matter	t.ha-1	+	+
	mafruit	biomass of harvested organs	t.ha-1	+	+
	mafruit_kg_ha	Dry matter of harvested organs	kg.ha-1	+	+
	masec(n)	biomass of aboveground plant (table)	t.ha-1	+	+

	masec_kg_ha	Aboveground dry matter	kg.ha-1	+	+
	masec_mx_av_cut	Aboveground dry matter before cut(for cut crops , for others = masec(n))	t.ha-1	+	+
	masecneo	biomass of newly-formed organs	t.ha-1	+	+
	masectot	dry matter	t.ha-1	+	+
	masecveg	biomass of vegetative organs	t.ha-1	+	+
	matigestruc	biomass of stems (only structural parts)	t.ha-1	+	+
	matigestruc_kg_ha	Dry matter of stems (only structural parts)	kg.ha-1	+	+
	matuber	biomass of harvested organs, tuber weight only calculated for sugarbeet	t.ha-1	+	+
	mortalle	daily number of dying tillers	d-1	+	+
	mortmasec	cumulative biomass of dead tillers	t.ha-1	+	+
	mortreserve	biomass of reserves corresponding to dead tillers	t.ha-1.d-1	+	+
	MSexporte	cumulative amount of harvested biomass	t.ha-1	+	+
	msjaune	Senescent dry matter	t.ha-1	+	+
	msneojaune	newly-formed senescent dry matter	t.ha-1	+	+
	msrac(n)	biomass of roots	t.ha-1	+	+
	msrec_fou	Dry matter of harvested organs for forages	t.ha-1	+	+
	MSrecycle	cumulative amount of biomass returned to soil (unexported at harvest + fallen leaves)	t.ha-1	+	+
	msresjaune	senescent residual dry matter	t.ha-1	+	+
	N_mineralisation	cumulative amount of N mineralized from humus and organic residues	kg.ha-1	+	+
	N_volatilisation	cumulative amount of N volatilised from fertilizer and organic inputs	kg.ha-1	+	+
	Nb	daily amount of N in the microbial biomass decomposing organic residues mixed with soil	kg.ha-1	no need to have this information	no need to have this information
	nbfeuille	number of leaves on main stem	SD	no need to have this information	no need to have this information
	nbinflo_recal	number of inflorescences	SD	no need to have this information	no need to have this information
	nbj0remp	number of shrivelling days	d	no need to have this information	no need to have this information
	nbjechaudage	number of shrivelling days between lax and rec	d	no need to have this information	no need to have this information
	nbjgel	number of frosting days active on the plant	d	no need to have this information	no need to have this information
	nbjpourdecirecolte	number of days until harvest is launched when it is postponed by the "harvest decision" option	d	no need to have this information	no need to have this information
	nbjpourdecisemis	number of days until sowing is launched when it is postponed by the "sowing decision" option	d	no need to have this information	no need to have this information
	Nbmulch	cumulative N in microbial biomass decomposing the decomposable mulch	kg.ha-1	no need to have this information	no need to have this information
	NCbio	n/c ratio of biomass decomposing organic residues	SD	no need to have this information	no need to have this information
	Ndenit	daily denitrification rate in soil (if option "denitrification" is activated)	kg.ha-1.d-1	no need to have this information	no need to have this information
	Nexporte	cumulative amount of N removed by crop harvests	kg.ha-1	no need to have this information	no need to have this information
	nfruit(1)	number of fruits in box 1	SD	no need to have this information	no need to have this information
	nfruit(2)	number of fruits in box 2	SD	no need to have this information	no need to have this information
	nfruit(3)	number of fruits in box 3	SD	no need to have this information	no need to have this information
	nfruit(4)	number of fruits in box 4	SD	no need to have this information	no need to have this information
	nfruit(5)	number of fruits in box 5	SD	no need to have this information	no need to have this information
	nfruit(nboite)	number of fruits in last box	SD	no need to have this information	no need to have this information
	nfruit(nboite-1)	number of fruits in last but one box	SD	no need to have this information	no need to have this information
	nfruitnou	number of set fruits	fruits.m-2	no need to have this information	no need to have this information
	Nhuma	amount of N in active soil organic matter	kg.ha-1	no need to have this information	no need to have this information
	Nhumi	amount of N in inert soil organic matter	kg.ha-1	no need to have this information	no need to have this information
	Nhumt	amount of N in humus soil organic matter (active + inert fractions)	kg.ha-1	no need to have this information	no need to have this information
	nitetcult(n)	number of iterations to calculate tcult	SD	no need to have this information	no need to have this information
	nitrifj	daily nitrification rate in soil (if option "nitrification" is activated)	kg.ha-1	no need to have this information	no need to have this information
	Nmineral_from_lev	cumulative amount of N mineralized during the crop cycle (emergence or budbreak-harvest)	kg.ha-1	+	no need to have this information
	Nmineral_from_plt	cumulative amount of N mineralized during the crop cycle (sowing-harvest)	kg.ha-1	+	no need to have this information
	Nmulchdec	amount of N in the decomposable mulch	kg.ha-1	+	no need to have this information
	Nmulchnd	amount of N in the non decomposable mulch	kg.ha-1	+	no need to have this information
	Nnondec(1)	amount of N in the undecomposable mulch derived from residues type 1	kg.ha-1	+	no need to have this information
	Nnondec(10)	amount of N in the undecomposable mulch derived from residues type 10	kg.ha-1	+	no need to have this information
	Nnondec(2)	amount of N in the undecomposable mulch derived from residues type 2	kg.ha-1	+	no need to have this information
	Nnondec(3)	amount of N in the undecomposable mulch derived from residues type 3	kg.ha-1	+	no need to have this information
	Nnondec(4)	amount of N in the undecomposable mulch derived from residues type 4	kg.ha-1	+	no need to have this information
	Nnondec(5)	amount of N in the undecomposable mulch derived from residues type 5	kg.ha-1	+	no need to have this information
	Nnondec(6)	amount of N in the undecomposable mulch derived from residues type 6	kg.ha-1	+	no need to have this information
	Nnondec(7)	amount of N in the undecomposable mulch derived from residues type 7	kg.ha-1	+	no need to have this information
	Nnondec(8)	amount of N in the undecomposable mulch derived from residues type 8	kg.ha-1	+	no need to have this information
	Nnondec(9)	amount of N in the undecomposable mulch derived from residues type 9	kg.ha-1	+	no need to have this information
	nodn	reduction factor on nodulation establishment (potential BNF) due to mineral N stress	0/1	+	no need to have this information
	Norgeng	daily amount of N immobilized from fertiliser	kg.ha-1.d-1	+	no need to have this information
	Nr	amount of N in the decomposing organic residues mixed with soil	kg.ha-1	+	no need to have this information
	Nrac	amount of N in roots at harvest	kg.ha-1	+	no need to have this information
	Nrecycle	cumulative amount of N returned to soil (unexported at harvest + fallen leaves)	kg.ha-1	+	no need to have this information
	Nresiduprofil(1)	amount of N in residues over the soil depth (profhum) derived from residues type 1	kg.ha-1	+	no need to have this information
	Nresiduprofil(10)	amount of N in residues over the soil depth (profhum) derived from residues type 10	kg.ha-1	+	no need to have this information
	Nresiduprofil(2)	amount of N in residues over the soil depth (profhum) derived from residues type 2	kg.ha-1	+	no need to have this information

	Nresiduprofil(3)	amount of N in residues over the soil depth (profhum) derived from residues type 3	kg.ha-1	+	no need to have this information
	Nresiduprofil(4)	amount of N in residues over the soil depth (profhum) derived from residues type 4	kg.ha-1	+	no need to have this information
	Nresiduprofil(5)	amount of N in residues over the soil depth (profhum) derived from residues type 5	kg.ha-1	+	no need to have this information
	Nresiduprofil(6)	amount of N in residues over the soil depth (profhum) derived from residues type 6	kg.ha-1	+	no need to have this information
	Nresiduprofil(7)	amount of N in residues over the soil depth (profhum) derived from residues type 7	kg.ha-1	+	no need to have this information
	Nresiduprofil(8)	amount of N in residues over the soil depth (profhum) derived from residues type 8	kg.ha-1	+	no need to have this information
	Nresiduprofil(9)	amount of N in residues over the soil depth (profhum) derived from residues type 9	kg.ha-1	+	no need to have this information
	Ntousresidusprofil	amount of N in all organic residues over soil depth (profhum)	kg.ha-1	+	no need to have this information
	numcoupe	cut number	SD	no need to have this information	no need to have this information
	numcult	crop season number	SD	no need to have this information	no need to have this information
	Nvolat_from_lev	cumulative amount of N volatilised during the crop cycle(emergence or budbreak-harvest)	kg.ha-1	+	no need to have this information
	Nvolat_from_plt	cumulative amount of N volatilised during the crop cycle (planting-harvest)	kg.ha-1	+	no need to have this information
	Nvoleng	daily amount of N volatilised from fertiliser	kg.ha-1.d-1	no need to have this information	no need to have this information
	offrenod	daily amount of N fixed symbiotically (BNF)	kg.ha-1.d-1	no need to have this information	no need to have this information
	p1000grain	1000 grains weight	g	+	+
	pdsfruit(1)	weight of fruits in box 1	g.m-2	+	+
	pdsfruit(2)	weight of fruits in box 2	g.m-2	+	+
	pdsfruit(3)	weight of fruits in box 3	g.m-2	+	+
	pdsfruit(4)	weight of fruits in box 4	g.m-2	+	+
	pdsfruit(5)	weight of fruits in box 5	g.m-2	+	+
	pdsfruit(nboite)	weight of fruits in last box	g.m-2	+	+
	pdsfruit(nboite-1)	weight of fruits in last but one box	g.m-2	+	+
	pdsfruitfrais	weight of fresh fruits	g.m-2	+	+
	penfruit	ratio of fruit envelops to plant biomass	0-1	no need to have this information	no need to have this information
	pfeuil(n)	ratio of leaves to plant biomass	0-1	no need to have this information	no need to have this information
	pfeuiljaune	ratio of yellow leaves to plant biomass	0-1	no need to have this information	no need to have this information
	pfeuilverte(n)	ratio of green leaves to non-senescent plant biomass	0-1	no need to have this information	no need to have this information
	phoi	photoperiod	hour	no need to have this information	no need to have this information
	pHvol	pH of soil surface as affected by organic residues application (slurry)	SD	no need to have this information	no need to have this information
	pousfruit	number of fruits transferred from one box to the next	SD	no need to have this information	no need to have this information
	poussracmoy	mean reduction factor on the root growth due to soil constraints (option "true density")	0-1	no need to have this information	no need to have this information
	precip	daily amount of water added to soil (precipitation + irrigation)	mm.d-1	no need to have this information	no need to have this information
	precipjN	daily amount of mineral N added to soil due to precipitation	kg.ha-1.d-1	no need to have this information	no need to have this information
	precipN	cumulative amount of mineral N added to soil due to precipitation	kg.ha-1	no need to have this information	no need to have this information
	preserve	proportion of reserve in total plant biomass	0-1	no need to have this information	no need to have this information
	profexteau	average depth of water absorption by plant	cm	no need to have this information	no need to have this information
	profextN	average depth of N absorption by plant	cm	no need to have this information	no need to have this information
	profnappe	depth of water table	cm	no need to have this information	no need to have this information
	psibase	predawn leaf water potential	MPa	no need to have this information	no need to have this information
	ptigestruc	proportion of structural stems in total plant biomass	0-1	no need to have this information	no need to have this information
	QCapp	cumulative amount of organic C added to soil	kg.ha-1	+	+
	QCO2hum	cumulative amount of CO2-C emitted due to mineralisation of humus	kg.ha-1	+	+
	QCO2mul	cumulative amount of CO2-C emitted due to mineralisation of residues in the mulch	kg.ha-1	+	+
	QCO2res	cumulative amount of CO2-C emitted due to mineralisation of residues (including residues in mulch)	kg.ha-1	+	+
	QCO2sol	cumulative amount of CO2-C emitted due to heterotrophic respiration (QCO2res + QCO2hum)	kg.ha-1	+	+
	QCplantetombe	cumulative amount of C added to soil by fallen leaves due to senescence	kg.ha-1	+	no need to have this information
	QCprimed	cumulative amount of C mineralised by priming effect	kg.ha-1	+	no need to have this information
	QCrac	cumulative amount of C added to soil by dead roots	kg.ha-1	+	no need to have this information
	QCresorg	cumulative amount of C added to soil through organic exogenous residues	kg.ha-1	+	no need to have this information
	QCressuite	cumulative amount of C added to soil due to aerial residues at harvest	kg.ha-1	+	no need to have this information
	QCrogne	cumulative amount of C added to soil by fallen leaves due to trimming	kg.ha-1	+	no need to have this information
	Qdrain	water flow rate in mole drains	mm.d-1	no need to have this information	no need to have this information
	Qdraincum	cumulative amount of water flowing in mole drains	mm	no need to have this information	no need to have this information
	Qem_N2O	cumulative amount of N2O-N emitted from soil	kg.ha-1	+	+
	Qem_N2Oden	cumulative amount of N2O-N emitted from soil by denitrification	kg.ha-1	+	+
	Qem_N2Onit	cumulative amount of N2O-N emitted from soil by nitrification	kg.ha-1	+	+
	Qfix	cumulative amount of N fixed symbiotically (BNF)	kg.ha-1	+	+
	Qles	cumulative amount of NO3-N leached at the base of the soil profile	kg.ha-1	+	+
	Qlesd	cumulative amount of NO3-N leached into mole drains	kg.ha-1	+	+
	Qminh	cumulative amount of mineralized N derived from humus mineralisation	kg.ha-1	+	+
	Qminr	cumulative amount of mineralized N derived from organic residues mineralisation	kg.ha-1	+	+
	qmulch	biomass of plant mulch	t.ha-1	+	+
	QNapp	cumulative amount of organic N added to soil (from straw, roots, leaves, organic amendments,)	kg.ha-1	+	+
	QNdenit	cumulative amount of N denitrified during the simulation period	kg.ha-1	+	+
	QNdenit_from_lev	cumulative amount of N denitrified during the crop cycle (emergence or budbreak-harvest)	kg.ha-1	+	+
	QNdenit_from_plt	cumulative amount of N denitrified during the crop cycle	kg.ha-1	+	+
	QNexport	Amount of nitrogen exported at harvest (harvested and removed parts)	kgN.ha-1	no need to have this information	no need to have this information
	QNgrain	amount of N in harvested organs (grains / fruits)	kg.ha-1	+	+
	Qnitrif	cumulative amount of N nitrified in soil (if option "nitrification" is activated)	kg.ha-1	+	no need to have this information
	QNorgeng	cumulative amount of N immobilized from fertiliser	kg.ha-1	+	no need to have this information

	QNplante	amount of N taken up by the plant	kg.ha-1	+	no need to have this information
	QNplante_mx_av_cut	Amount of nitrogen taken up by the plant before cut(for cut crops , for others = Qnplante(n))	kgN.ha-	no need to have this information	no need to have this information
	QNplantetombe	cumulative amount of N added to soil by fallen leaves due to senescence	kg.ha-1	no need to have this information	no need to have this information
	QNprimed	cumulative amount of N mineralised by priming effect	kg.ha-1	no need to have this information	no need to have this information
	QNrac	cumulative amount of N added to soil by dead roots	kg.ha-1	no need to have this information	no need to have this information
	QNresorg	cumulative amount of organic exogenous N added to soil	kg.ha-1	no need to have this information	no need to have this information
	QNressuite	cumulative amount of N added to soil by aerial residues at harvest	kg.ha-1	no need to have this information	no need to have this information
	QNrogne	cumulative amount of N added to soil by fallen leaves due to trimming	kg.ha-1	no need to have this information	no need to have this information
	QNvoleng	cumulative amount of N volatilised from fertiliser	kg.ha-1	no need to have this information	no need to have this information
	QNvolorg	cumulative amount of N volatilised from organic inputs	kg.ha-1	no need to have this information	no need to have this information
	Qressuite	biomass of residues from the previous crop returned to soil at harvest	t.ha-1	+	no need to have this information
	Qressuite_tot	amount of total harvest residues (aerials + roots)	t.ha-1	no need to have this information	no need to have this information
	ra_recal	aerodynamic resistance between the canopy and the reference level zr	s.m-1	no need to have this information	no need to have this information
	raint	photosynthetic active radiation intercepted by the canopy	MJ.m-2	no need to have this information	no need to have this information
	ras	aerodynamic resistance between the soil and the canopy	s.m-1	no need to have this information	no need to have this information
	Ratm	atmospheric radiation	MJ.m-2	no need to have this information	no need to have this information
	rc	resistance of canopy	s.m-1	no need to have this information	no need to have this information
	rdif	ratio of diffuse radiation to global radiation	0-1	no need to have this information	no need to have this information
	remobilj	daily amount of biomass remobilized for growth	kg.ha-1.d-1	no need to have this information	no need to have this information
	remontee	capillary uptake from the base of the soil profile	mm.d-1	no need to have this information	no need to have this information
	rendementsec	dry biomass of harvested organs	t.ha-1	+	+
	resmes	amount of soil water integrated on the measurement depth	mm	no need to have this information	no need to have this information
	resperenne	biomass of perennial reserves which can be remobilized	t.ha-1	no need to have this information	no need to have this information
	resrac	soil water reserve in the root zone	mm	no need to have this information	no need to have this information
	rfpi	reduction factor on plant development due to photoperiod	0-1	no need to have this information	no need to have this information
	rfvi	reduction factor on plant development due to vernalization	0-1	no need to have this information	no need to have this information
	rlj	rate of root length growth	m.d-1	no need to have this information	no need to have this information
	rltot	total root length (accounting for senescent roots)	cm.cm-2	no need to have this information	no need to have this information
	rmaxi	maximum water reserve used	mm	no need to have this information	no need to have this information
	rnet	net radiation	MJ.m-2	no need to have this information	no need to have this information
	rnetS	net radiation at the soil surface	MJ.m-2	no need to have this information	no need to have this information
	rombre	fraction of the total radiation in the shade	0-1	no need to have this information	no need to have this information
	rsoleil	fraction of the total radiation in the full sun	0-1	no need to have this information	no need to have this information
	RsurRU	fraction of plant available water over the soil profile	0-1	no need to have this information	no need to have this information
	RsurRUrac	fraction of plant available water over the root profile	0-1	no need to have this information	no need to have this information
	RU	maximum plant available water content over the soil profile	mm	no need to have this information	no need to have this information
	ruissel	daily amount of water in total runoff (surface + overflow)	mm.d-1	no need to have this information	no need to have this information
	ruisselsurf	daily amount of water in runoff at soil surface	mm.d-1	no need to have this information	no need to have this information
	ruisselt	cumulative amount of water in total runoff (surface + overflow)	mm	no need to have this information	no need to have this information
	runoff_from_lev	cumulative amount of water in runoff (surface + overflow) during the crop cycle (emergence or budbreak-harvest)	mm	no need to have this information	no need to have this information
	runoff_from_plt	cumulative amount of water in runoff (surface + overflow) during the crop cycle (sowing-harvest)	mm	no need to have this information	no need to have this information
	RUrac	maximum plant available water content over the root profile	mm	no need to have this information	no need to have this information
	saturation	amount of water in the soil macroporosity	mm	no need to have this information	no need to have this information
	senfac	reduction factor on leaf life span due to water stress (increasing senescence rate)	0-1	no need to have this information	no need to have this information
	sla	specific leaf area	cm2.g-1	no need to have this information	no need to have this information
	SoilAvW	amount of plant available water in soil over the depth "profmes"	mm	no need to have this information	no need to have this information
	SoilN	amount of mineral N in soil over the depth "profmes"	kg.ha-1	no need to have this information	no need to have this information
	SoilNM	amount of NO3-N in soil over the depth "profmesN"	kg.ha-1	no need to have this information	no need to have this information
	SoilWatM	amount of plant available water in soil over the depth "profmesW"	mm	no need to have this information	no need to have this information
	som_HUR	cumulative water content of the soil microporosity	mm	no need to have this information	no need to have this information
	som_sat	cumulative amount of water in the soil macroporosity	mm	no need to have this information	no need to have this information
	somcour	cumulative units of development (upvt) between two stages	degreeC.d	no need to have this information	no need to have this information
	somcourdrp	cumulative units of development (upvt) between two reproductive stages	degreeC.d	no need to have this information	no need to have this information
	somcourfauche	sum of temperature beetwen 2 cuts of forage crop	degreeC.d	no need to have this information	no need to have this information
	somcourmont	cumulative units of development from the start of vernalisation	degreeC.d	no need to have this information	no need to have this information
	somdifftculttair	cumulative temperature difference (tcult-tair) during the simulation period	degreeC	no need to have this information	no need to have this information
	somtemp	sum of temperatures (expressed in Q10 =sum (2.0 ** (udevair ou udevcult / 10.))	degreeC.d	no need to have this information	no need to have this information
	somudevair	sum of air temperature (udevair) from sowing to harvest	degreeC	no need to have this information	no need to have this information

	somudevcult	sum of crop temperature (udevcult) from sowing to harvest	degreeC	no need to have this information	no need to have this information
	somupvtsem	sum of development units (upvt) from sowing to harvest	degreeC	no need to have this information	no need to have this information
	sourcepuits	source to sink ratio of assimilates in the plant	SD	no need to have this information	no need to have this information
	spfruit	reduction factor on the fruits number due to trophic stress	0-1	no need to have this information	no need to have this information
	splai	source to sink ratio of assimilates in the leaves	SD	no need to have this information	no need to have this information
	stemflow	daily amount of water runoff along the stem	mm.d-1	no need to have this information	no need to have this information
	str1intercoupe	average stomatal water stress index during the vegetative phase (emergence - maximum LAI) of forage crops	0-1	no need to have this information	no need to have this information
	str2intercoupe	average stomatal water stress index during the reproductive phase (maximum LAI - maturity) of forage crops	0-1	no need to have this information	no need to have this information
	stu1intercoupe	average turgescence water stress index during the vegetative phase (emergence - maximum LAI) of forage crops	0-1	no need to have this information	no need to have this information
	stu2intercoupe	average turgescence water stress index during the reproductive phase (maximum LAI - maturity) of forage crops	0-1	no need to have this information	no need to have this information
	sucre	sugar content of harvested organs	0-1	+	+
	sucre_percent	sugar content of harvested organs	% fresh weight	+	+
	surf(ao)	fraction of the soil surface in the shade	0-1	no need to have this information	no need to have this information
	surf(as)	fraction of the soil surface in the sun	0-1	no need to have this information	no need to have this information
	swfac	stomatic water stress index	0-1	no need to have this information	no need to have this information
	swfac1moy	average stomatic water stress index over the vegetative stage	0-1	no need to have this information	no need to have this information
	swfac2moy	average stomatic water stress index over the reproductive stage	0-1	no need to have this information	no need to have this information
	tairveille	mean air temperature at the previous day	degreeC	no need to have this information	no need to have this information
	tauxcouv(n)	cover rate of the canopy	SD	no need to have this information	no need to have this information
	tcult	crop surface temperature (daily average)	degreeC	no need to have this information	no need to have this information
	tcult_tairveille	difference between canopy temperature and air temperature	degreeC	no need to have this information	no need to have this information
	tcultmax	crop surface temperature (daily maximum)	degreeC	no need to have this information	no need to have this information
	tcultmin	crop surface temperature (daily minimum)	degreeC	no need to have this information	no need to have this information
	tempeff	efficient temperature for growth	degreeC	no need to have this information	no need to have this information
	tetp(n)	efficient potential evapotranspiration (entered or calculated)	mm.d-1	no need to have this information	no need to have this information
	tetstomate	threshold of soil water content limiting transpiration and photosynthesis	% vol	no need to have this information	no need to have this information
	teturg	threshold of soil water content limiting the growth of leaves (in surface area)	% vol	no need to have this information	no need to have this information
	tmax(n)	maximum active temperature of atmosphere	degreeC	no need to have this information	no need to have this information
	tmaxext(n)	maximum temperature of external atmosphere	degreeC	no need to have this information	no need to have this information
	tmin(n)	minimum active temperature of atmosphere	degreeC	no need to have this information	no need to have this information
	tminext(n)	minimum temperature of external atmsphere	degreeC	no need to have this information	no need to have this information
	tmoy(n)	mean active temperature of atmosphere	degreeC	no need to have this information	no need to have this information
	tmoyext(n)	mean temperature of external atmosphere	degreeC	no need to have this information	no need to have this information
	tmoyIpltJuin	mean temperature from sowing or planting (iplt stage) until June 30	degreeC	no need to have this information	no need to have this information
	tmoyIpltSept	mean temperature from sowing or planting (iplt stage) until September 30	degreeC	no need to have this information	no need to have this information
	tncultmat	average of minimum crop temperatures (tcultmin) between the stages lax and rec	degreeC	no need to have this information	no need to have this information
	tnhc	cumulative "normalized" time for the mineralisation of humus	d	no need to have this information	no need to have this information
	tnrc	cumulative "normalized" time for the mineralisation of organic residues	d	no need to have this information	no need to have this information
	totapN	cumulative amount of mineral N added by mineral fertilisers and organic fertilisers	kg.ha-1	no need to have this information	no need to have this information
	totapNres	cumulative amount of mineral N added by organic fertilisers	kg.ha-1	no need to have this information	no need to have this information
	totir	cumulative amount of water inputs (precipitation + irrigation)	mm	no need to have this information	no need to have this information
	tpm(n)	water vapour pressure in air	hPa	no need to have this information	no need to have this information
	trg(n)	active radiation (entered or calculated)	MJ.m-2	no need to have this information	no need to have this information
	trgext(n)	exterior radiation	MJ.m-2	no need to have this information	no need to have this information
	trr(n)	daily rainfall	mm.d-1	no need to have this information	no need to have this information
	TS(1)	mean soil temperature (in layer 1)	degreeC	no need to have this information	no need to have this information
	TS(2)	mean soil temperature (in layer 2)	degreeC	no need to have this information	no need to have this information
	TS(3)	mean soil temperature (in layer 3)	degreeC	no need to have this information	no need to have this information
	TS(4)	mean soil temperature (in layer 4)	degreeC	no need to have this information	no need to have this information
	TS(5)	mean soil temperature (in layer 5)	degreeC	no need to have this information	no need to have this information
	tsol(10)	temperature in the soil at 10 cm	degrees	no need to have this information	no need to have this information
	turfac	turgescence water stress index	0-1	no need to have this information	no need to have this information
	turfac1moy	average turgescence water stress index during the vegetative stage	0-1	no need to have this information	no need to have this information
	turfac2moy	average turgescence water stress index during the reproductive stage	0-1	no need to have this information	no need to have this information
	tustress	reduction factor on leaf growth due to the effective water stress (= min(turfac,innlai))	0-1	no need to have this information	no need to have this information
	tvent(n)	mean daily wind speed at 2 m high above soil	m.s-1	no need to have this information	no need to have this information
	udevair	effective temperature for crop development, computed with tair	degreeC.d	no need to have this information	no need to have this information
	udevcult	effective temperature for crop development, computed with tcult	degreeC.d	no need to have this information	no need to have this information
	ulai(n)	relative development unit for LAI	0-3	no need to have this information	no need to have this information

	upvt(n)	development unit	degreeC.d	no need to have this information	no need to have this information
	vitmoy	mean canopy growth rate	g.m-2.d-1	no need to have this information	no need to have this information
	xmlch1	thickness of the dry layer created by evaporation from the soil and mulch	cm	no need to have this information	no need to have this information
	zrac	maximum depth reached by root system	cm	no need to have this information	no need to have this information

WOFOST DETAILED INPUT/OUTPUT

	VARIABLE	DESCRIPTION	UNIT	In Optimal?	In Minimal?
		INPUTS			
Weather file	CABO weather file *.XXX where the XXX are the 3 last digits of the year	name of the CABO weather file	(-)	+	+
	Station name	header with the name of the meteorological station	(-)	default=agentN where the N is the agent number	default=agentN where the N is the agent number
	Year	header with the year	(-)	+	+
	Author	header with the name of the file creator	(-)	default=agentN where the N is the agent number	default=agentN where the N is the agent number
	Source	header with the source data provider	(-)	default=agentN where the N is the agent number	default=agentN where the N is the agent number
	WCCDESCRIPTION	the WCC-variable 'WCCDESCRIPTION' with the description of the weather station (this description must be exactly the same (including spaces) for different files of the same weather station, otherwise WCC will not recognize these files as belonging to the same station)	(-)	default=agentN where the N is the agent number	default=agentN where the N is the agent number
	WCCFORMAT	the WCC-variable 'WCCFORMAT' with an indication for the weather format. WCCFORMAT=2 indicates daily weather data (CABO-format)	(-)	default=2	default=2
	WCCYEARNR	the WCC-variable 'WCCYEARNR' that gives the year	(y)	+	+
	LONG	longitude of the station	(decimal degree)	+	+
	LAT	latitude of the station	(decimal degree)	+	+
	ALT	altitude of the station	(m)	+	+
	A	the A coefficient for the Ångström formula	(-)	+	default=-0.18
	B	the B coefficients for the Ångström formula	(-)	+	default=-0.55
	1st column	station number	(-)	default=1	default=1
	2nd column	year	(y)	+	+
	3rd column	day number	(day of year)	+	+
	4th column	irradiation	($kJ \cdot m^{-2} \cdot d^{-1}$)	+	+
	5th column	minimum temperature	(°C)	+	+
	6th column	maximum temperature	(°C)	+	+
	7th column	early morning vapor pressure	(kPa)	+	+
	8th column	mean wind speed at 2 m above ground	($m \cdot s^{-1}$)	+	+
	9th column	precipitation	($mm \cdot d^{-1}$)	+	+
Soil file	soil file *.new	name of the .new soil file	(-)	+	+
	SOLNAM	description of the soil	(-)	default=SoilN where the N is the agent number	default value from *.new file
	SMTAB	volumetric soil moisture content as function of pF	([log (cm); $cm^3\ cm^{-3}$])	+	default value from *.new file
	SMW	soil moisture content at wilting point	($cm^3\ cm^{-3}$)	+	default value from *.new file
	SMFCF	soil moisture content at field capacity	($cm^3\ cm^{-3}$)	+	default value from *.new file
	SM0	soil moisture content at saturation	($cm^3\ cm^{-3}$)	+	default value from *.new file
	CRAIRC	critical soil air content for aeration	($cm^3\ cm^{-3}$)	+	default value from *.new file
	CONTAB	10-log hydraulic conductivity as function of pF	([log (cm); log (cm/day)])	+	default value from *.new file
	K0	hydraulic conductivity of saturated soil	($cm\ d^{-1}$)	+	default value from *.new file
	SOPE	maximum percolation rate root zone	($cm\ d^{-1}$)	+	default value from *.new file
	KSUB	maximum percolation rate subsoil	($cm\ d^{-1}$)	+	default value from *.new file
	SPADS	1st topsoil seepage parameter deep seedbed	(-)	+	default value from *.new file
	SPODS	2nd topsoil seepage parameter deep seedbed	(-)	+	default value from *.new file
	SPASS	1st topsoil seepage parameter shallow seedbed	(-)	+	default value from *.new file
	SPOSS	2nd topsoil seepage parameter shallow seedbed	(-)	+	default value from *.new file
	DEFLIM	required moisture deficit deep seedbed	(-)	+	default value from *.new file
Crop file	crop file *.cab	name of the .cab crop file BAR301.CAB – spring barley (EU) FBE0801.CAB - Faba bean (Vicia faba) (EU) MAG201.CAB – Maize (DE & LU) MAG202.CAB – Maize (Southern DE & Northern FR) MAG203.CAB – Maize (Central FR & Northern IT) MAG204.CAB – Maize (Southern FR, Northern IT, ES & PT) MAG205.CAB – Maize (GR, Southern IT, Southern ES) POT701.CAB – potato (DE, FR, NL, BE, LU, UK, IE, DK) POT702.CAB – potato (Southern FR) POT703.CAB – potato (Northern and Central IT) POT704.CAB – potato (Southern IT, GR, ES, PR) RAP1001.CAB – winter oilseed rape (EU without Southern FR, Southern IT, Southern ES) RAP1002.CAB – winter oilseed rape (Southern FR, Southern IT) RAP1003.CAB – winter oilseed rape (Southern ES) RAP1004.CAB - oilseed rape (ES) RIC501.CAB – rice (FR, IT, GR, ES, PR) SOY0901.CAB – soybean (Northern FR) SOY0902.CAB – soybean (Central FR) SOY0903.CAB – soybean (Northern ES) SOY0904.CAB – soybean (Southern FR) SOY0905.CAB – soybean (IT) SOY0906.CAB – soybean (ES & GR) SUG0601.CAB – sugar beet (DE, Northern and Central FR, NL, BE, LU, UK, IE, DK) SUG0602.CAB – sugar beet (Southern FR, Northern and Central IT, ES, PT) SUG0603.CAB – sugar beet (Southern ES and Southern IT) SUG0604.CAB – sugar beet (GR) SUN1101.CAB – sunflower (FR, IT, ES, GR) WWH101.CAB – winter wheat (Northern IE, Scotland, northern UK, DK) WWH102.CAB – winter wheat (IE, central and southern UK, NL, northern DE) WWH103.CAB – winter wheat (southern NL, DE, BE, LU) WWH104.CAB – winter wheat (central DE, northern FR) WWH105.CAB – winter wheat (FR, northern & central IT, northern ES, northern PT) WWH106.CAB – winter wheat (southern IT, central & eastern ES, southern PT) WWH107.CAB – winter wheat (southern ES & Central and Southern GR)	(-)	+	+
	CRPNAM	name of the crop	(-)	default value from *.cab file	default value from *.cab file
	TBASEM	lower threshold temperature for emergence	(°C)	default value from *.cab file	default value from *.cab file
	TEFFMX	maximum effective temperature for emergence	(°C)	default value from *.cab file	default value from *.cab file
	TSUMEM	temperature sum from sowing to emergence	(°C d)	default value from *.cab file	default value from *.cab file
	IDSL	indicates whether pre-anthesis development depends on temp. (=0), daylength (=1) , or both (=2)	(-)	default value from *.cab file	default value from *.cab file
	DLO	optimum daylength for development	(h)	default value from *.cab file	default value from *.cab file
	DLC	critical daylength (lower threshold)	(h)	default value from *.cab file	default value from *.cab file
	TSUM1	temperature sum from emergence to anthesis	(°C d)	default value from *.cab file	default value from *.cab file
	TSUM2	temperature sum from anthesis to maturity	(°C d)	default value from *.cab file	default value from *.cab file
	DTSMTB	daily increase in temperature sum as function of average temperature	([°C ; °C d])	default value from *.cab file	default value from *.cab file
	DVSI	initial DVS	(-)	default value from *.cab file	default value from *.cab file
	DVSEND	development stage at harvest (= 2.0 at maturity)	(-)	default value from *.cab file	default value from *.cab file
	TDWI	initial total crop dry weight	($kg\ ha^{-1}$)	default value from *.cab file	default value from *.cab file
	LAIEM	leaf area index at emergence	($ha\ ha^{-1}$)	default value from *.cab file	default value from *.cab file
	RGRLAI	maximum relative increase in LAI	($ha\ ha^{-1}\ d^{-1}$)	default value from *.cab file	default value from *.cab file
	SLATB	specific leaf area as a function of DVS	([-; $ha\ kg^{-1}$])	default value from *.cab file	default value from *.cab file
	SPA	specific pod area	($ha\ kg^{-1}$)	default value from *.cab file	default value from *.cab file
	SSATB	specific stem area as function of DVS	([-; $ha\ kg^{-1}$])	default value from *.cab file	default value from *.cab file
	SPAN	life span of leaves growing at 35 Celsius	(d)	default value from *.cab file	default value from *.cab file
	TBASE	lower threshold temperature for aging of leaves	(°C)	default value from *.cab file	default value from *.cab file
	KDIFTB	extinction coefficient for diffuse visible light as function of DVS	([-; -])	default value from *.cab file	default value from *.cab file
	EFFTB	light-use efficiency for single leaf as function of daily mean temperature	([°C; $kg\ ha^{-1}\ h^{-1}\ j^{-1}\ m^2\ s$])	default value from *.cab file	default value from *.cab file
	AMAXTB	maximum leaf CO2 assimilation as function of DVS	([-; -])	default value from *.cab file	default value from *.cab file
	TMPFTB	reduction factor of AMAX as function of average temperature	([°C; -])	default value from *.cab file	default value from *.cab file
	TMNFTB	reduction factor of gross assimilation rate as function of low minimum temperature	([°C; -])	default value from *.cab file	default value from *.cab file
	CVL	efficiency of conversion into leaves	($kg\ kg^{-1}$)	default value from *.cab file	default value from *.cab file
	CVO	efficiency of conversion into storage organs	($kg\ kg^{-1}$)	default value from *.cab file	default value from *.cab file

	CVR	efficiency of conversion into roots	(kg kg^{-1})	default value from *.cab file	default value from *.cab file
	CVS	efficiency of conversion into stems	(kg kg^{-1})	default value from *.cab file	default value from *.cab file
	Q10	relative increase in respiration rate per 10 Celsius temperature increase	(-)	default value from *.cab file	default value from *.cab file
	RML	relative maintenance respiration rate leaves	(kg CH_2O kg^{-1} d^{-1})	default value from *.cab file	default value from *.cab file
	RMO	relative maintenance respiration rate storage organs	(kg CH_2O kg^{-1} d^{-1})	default value from *.cab file	default value from *.cab file
	RMR	relative maintenance respiration rate roots	(kg CH_2O kg^{-1} d^{-1})	default value from *.cab file	default value from *.cab file
	RMS	relative maintenance respiration rate stems	(kg CH_2O kg^{-1} d^{-1})	default value from *.cab file	default value from *.cab file
	RFSETB	reduction factor for senescence as function of DVS	([-; -])	default value from *.cab file	default value from *.cab file
	FRTB	fraction of total dry matter to roots as a function of DVS	([-; kg kg^{-1}])	default value from *.cab file	default value from *.cab file
	FLTB	fraction of above-ground dry matter to leaves as a function of DVS	([-; kg kg^{-1}])	default value from *.cab file	default value from *.cab file
	FSTB	fraction of above-ground dry matter to stems as a function of DVS	([-; kg kg^{-1}])	default value from *.cab file	default value from *.cab file
	FOTB	fraction of above-ground dry matter to storage organs as a function of DVS	([-; kg kg^{-1}])	default value from *.cab file	default value from *.cab file
	PERDL	maximum relative death rate of leaves due to water stress	(-)	default value from *.cab file	default value from *.cab file
	RDRRTB	relative death rate of roots as a function of DVS	([-; kg kg^{-1} d^{-1}])	default value from *.cab file	default value from *.cab file
	RDRSTB	relative death rate of stems as a function of DVS	([-; kg kg^{-1} d^{-1}])	default value from *.cab file	default value from *.cab file
	CFET	correction factor transpiration rate	(-)	default value from *.cab file	default value from *.cab file
	DEPNR	crop group number for soil water depletion	(-)	default value from *.cab file	default value from *.cab file
	IAIRDU	air ducts in roots present (=1) or not (=0)	(-)	default value from *.cab file	default value from *.cab file
	RDI	initial rooting depth	(cm)	default value from *.cab file	default value from *.cab file
	RRI	maximum daily increase in rooting depth	(cm d^{-1})	default value from *.cab file	default value from *.cab file
	RDMCR	maximum rooting depth	(cm)	default value from *.cab file	default value from *.cab file
	NMINSO	minimum concentrations of N in storage organs	(kg kg^{-1})	default value from *.cab file	default value from *.cab file
	NMINVE	minimum concentrations of N in vegetative organs	(kg kg^{-1})	default value from *.cab file	default value from *.cab file
	NMAXSO	maximum concentrations of N in storage organs	(kg kg^{-1})	default value from *.cab file	default value from *.cab file
	NMAXVE	maximum concentrations of N in vegetative organs	(kg kg^{-1})	default value from *.cab file	default value from *.cab file
	PMINSO	minimum concentrations of P in storage organs	(kg kg^{-1})	default value from *.cab file	default value from *.cab file
	PMINVE	minimum concentrations of P in vegetative organs	(kg kg^{-1})	default value from *.cab file	default value from *.cab file
	PMAXSO	maximum concentrations of P in storage organs	(kg kg^{-1})	default value from *.cab file	default value from *.cab file
	PMAXVE	maximum concentrations of P in vegetative organs	(kg kg^{-1})	default value from *.cab file	default value from *.cab file
	KMINSO	minimum concentrations of K in storage organs	(kg kg^{-1})	default value from *.cab file	default value from *.cab file
	KMINVE	minimum concentrations of K in vegetative organs	(kg kg^{-1})	default value from *.cab file	default value from *.cab file
	KMAXSO	maximum concentrations of K in storage organs	(kg kg^{-1})	default value from *.cab file	default value from *.cab file
	KMAXVE	maximum concentrations of K in vegetative organs	(kg kg^{-1})	default value from *.cab file	default value from *.cab file
	YZERO	maximum amount vegetative organs at zero yield	(kg ha^{-1})	default value from *.cab file	default value from *.cab file
	NFIX	fraction of N-uptake from biological fixation	(kg kg^{-1})	default value from *.cab file	default value from *.cab file
Timer file	RUNNAM	run name (max. 6 characters, between quotes).	(-)	default='WCC'	default='WCC'
	IWEATH	format of weather: 0 (WOFOST-monthly), 1 (WOFOST-climate), or 2 (CABO).	(-)	default=2	default=2
	CLFILE	file name of weather station.	(-)	name of CABO weather file *.XXX where the XXX are the 3 last digits of the year	name of CABO weather file *.XXX where the XXX are the 3 last digits of the year
	ISYR	first year for which crop growth is simulated.	(y)	+	'Year' variable from weather file
	INYEAR	number of years to simulate crop growth.	(-)	default=1	default=1
	IRNDAT	option for the use/selection of rainfall data: 0 (generates statistics with varying total monthly rainfall and number of rainy days), 1 (distributes monthly rainfall over given number of days), 2 (reads rainfall data out of separate file) or 3 (rainfall as it occurs in weather file). See Chapter 4 about the input of rainfall to learn more about this option).	(-)	default=3	default=3
	RAFILE	name of rainfall station	(-)	default='<none>'	default='<none>'
	ISYRR	(first) year of rainfall data to be used (if IRNDAT = 2). If IRNDAT ≠ 2, then ISYRR = - Wageningen Environmental Research – WOFOST user manual - 2014 (update spring 2021) 61 999	(-)	default=-999	default=-999
	INYRG	number of runs for which rainfall has to be generated (IRNDAT = 0), or distributed (IRNDAT = 1). If IRNDAT ≠ 0 or 1, then INYRG = 1 (WOFOST does not accept 0!). This variable is also used for the number of rainfall years (IRNDAT = 2).	(-)	default=1	default=1
	CRFILE	name of crop file	(-)	name of the .cab crop file	name of the .cab crop file
	ISTCHO	options for start simulation: 0 (fixed emergence day), 1 (fixed sowing day) and 2 (variable sowing day).	(-)	default=1	default=1
	IDEM	day of emergence (day of year). Used if ISTCHO = 0.	(day of year)	default=1	default=1
	IDSOW	day of sowing (day of year). Used if ISTCHO = 1.	(day of year)	+	+
	IDESOW	earliest possible day of sowing (day of year). Used if ISTCHO = 2.	(day of year)	default=100	default=100
	IDLSOW	ultimate sowing day (day of year). Used if ISTCHO = 2.	(day of year)	default=140	default=140
	IENCHO	option to determine end of simulation: 1 (fixed end day), 2 (maturity, but not to exceed maximum duration), or 3 (earliest of both days).	(day of year)	default=2	default=2
	IDAYEN	ultimate day of harvest (day of year). Used if IENCHO = 1 or 3.	(day of year)	default=270	default=270
	IDURMX	maximum number of days from emergence to end of simulation used if IENCHO = 2 or 3.	(d)	default=350	default=350
	IBAL	option for output summary water balance: 0 (no summary), 1 (for whole system), 2 (for root zone), or 3 (for whole system and root zone).	(-)	default=1	default=1
	PRDEL	output interval: one output line per time interval. Output lines for day of emergence, anthesis and the last day are always provided. If the output interval is longer than the growing period, the detailed output will be reduced to these three lines. No detailed output will be produced, if the interval is set at zero days.	(-)	default=1.0	default=1.0
	CRPNAM	description of crop	(-)	'CRPNAM' variable from crop file	'CRPNAM' variable from crop file
	SOLNAM	description of soil	(-)	'SOLNAM' variable from soil file	'SOLNAM' variable from soil file
	CLMNAM	description of weather station	(-)	'WCCDESCRIPTION' variable from climate file	'WCCDESCRIPTION' variable from climate file
	RAINAM	description of rainfall station	(-)	default='<none>'	default='<none>'
	ISAY	start date of the water balance	(day of year)	default=1	default=1
Site file	SOFILE	name of soil file	(-)	name of the .new soil file	name of the .new soil file
	IZT	ground water influence: 0 (no) or 1 (yes).	(-)	default=0	default=0
	IFUNRN	non-infiltrating fraction of rain is function of storm size (1) or not (0).	(-)	default=0	default=0
	IDRAIN	presence (1) or absence (0) of drains	(-)	default=0	default=0
	SSMAX	maximum surface storage capacity (cm water).	(cm water)	default=0.000000	default=0.000000
	WAV	initial amount of available soil water in the rootable soil (moisture content above permanent wilting point) (cm water).	(cm water)	default=20.000000	default=20.000000
	ZTI	initial depth of the ground water table (cm). The value 999 is maximum initial depth of the ground water table.	(cm)	default=999.000000	default=999.000000
	DD	drainage depth (cm).	(cm)	default=20.000000	default=20.000000
	RDMSOL	maximum rooting depth allowed by soil (cm). This is dictated by soil characteristics like profile depth and presence of ground water.	(cm)	default=120.000000	default=120.000000
	NOTINF	(maximum) non-infiltrating fraction of rainfall. Range: 0 - 1.	(-)	default=0.000000	default=0.000000
	NBASE	basic supply of nitrogen by the unfertilized soil (N, kg•ha-1). Range: 0 - 100	kg ha^{-1}	+	default=60.000000
	NREC	apparent nitrogen recovery. Increase in uptake of N as fraction of applied N. Range: 0 - 1.	(-)	default=0.500000	default=0.500000
	PBASE	basic supply of phosphorus by the unfertilized soil (P, kg•ha-1). Range: 0 - 10.	kg ha^{-1}	+	default=10.000000
	PREC	apparent phosphorus recovery. Increase in uptake of P as fraction of applied P. Range: 0 - 1.	(-)	default= 0.100000	default=0.100000
	KBASE	basic supply of potassium by the unfertilized soil (K, kg•ha-1). Range: 0 - 100.	kg ha^{-1}	+	default=60.000000
	KREC	apparent potassium recovery. Increase in uptake of K as fraction of applied K. Range: 0 - 1.	(-)	default=0.500000	default=0.500000
	SSI	initial surface storage (cm water).	(cm water)	default=0.000000	default=0.000000
	SMLIM	maximum moisture content in topsoil (cm water). This value should be between moisture content at wilting point and moisture content at saturation.	(cm water)	default=0.250000	default=0.250000
Rerun file	RUNNAM	name of the run	(-)	RUNOPT.DAT	RUNOPT.DAT
Run file	IOPT2	start/Stop option: 2 (run WOFOST with default input from data files), 4 (run WOFOST from reruns file without default run) and 5 (run FSEOPT for calibration of WOFOST; only possible in TERMINAL mode and not available in WCC).	(-)	default=2	default=2
	IPRODL	production levels: 1 (simulation of potential crop growth), 2 (simulation of water limited crop growth), 3 (calculation of nutrient limited crop growth).	(-)	default=3	default=2
	IOXWL	type of water-limited crop growth: 0 (effects of drought only), 1 (effects of both drought and oxygen shortage).	(-)	default=0	default=0
	TIMFIL	timer filename	(-)	default='WCCTI.TIM'	default='WCCTI.TIM'
	SITFIL	site filename	(-)	default='WCCSI.SIT'	default='WCCSI.SIT'
	WOFRER	rerun filename	(-)	default='WCCRR.RER'	default='WCCRR.RER'
	WOFOUT	filename detailed output	(-)	default='WCC.OUT'	default='WCC.OUT'
	SERIES	final results for series of years: 0 (no), 1 (yes). This option has meaning only when running WOFOST in TERMINAL mode. The WCC gives always output when the run covers more than 1 year.	(-)	default=0	default=0
	REPORT	report: 1 (one line per year and statistics). This is the only valid option also for running WOFOST in TERMINAL mode.	(-)	default=1	default=1

	FIXNAM	output filename for summary output of potential and water limited production (max 8 characters; no extension because WOFOST uses *.WPS and *.PPS as extension). This is only used when running WOFOST in TERMINAL mode; WCC uses its own filename.	(-)	default='WCC'	default='WCC'
	RQUIRD	long term means results. This is a summary file of the summary files of potential and water limited production: 0 (no), 1 (yes). In WCC, the summary is only shown when there are more than two years (because of calculating statistics) and the rerun option is used. File name of this summary file is FIXNAM and the extension *.SUM.	(-)	default=0	default=0
		OUTPUTS			
OUTPUTS		Potential production			
		detailed output			
		daily results			
	YEAR	year of the simulation time step	(y)	no need to have this information	no need to have this information
	DAY	day of year of the simulation time step	(1-366)	no need to have this information	no need to have this information
	IDSEM	number of days since emergence	(d)	no need to have this information	no need to have this information
	DVS	development stage of crop	(-)	no need to have this information	no need to have this information
	TSUM	thermal time since emergence	(°C d)	no need to have this information	no need to have this information
	WLV	dry weight of living leaves	(kg ha^{-1})	no need to have this information	no need to have this information
	WST	dry weight of living stems	(kg ha^{-1})	no need to have this information	no need to have this information
	WSO	dry weight of living storage organs	(kg ha)	no need to have this information	no need to have this information
	TAGP	total above ground production (dead and living plant organs)	(kg ha^{-1})	no need to have this information	no need to have this information
	LAI	leaf area index (leaf area)/(soil area)	(ha ha^{-1})	no need to have this information	no need to have this information
	TRA	transpiration rate	(mm d^{-1})	no need to have this information	no need to have this information
	GASS	gross assimilation rate	(kg (CH_2O) ha^{-1} d^{-1})	no need to have this information	no need to have this information
	MRES	maintenance respiration rate	(kg (CH_2O) ha^{-1} d^{-1})	no need to have this information	no need to have this information
	DMI	rate of dry matter increase	(kg ha^{-1} d^{-1})	no need to have this information	no need to have this information
		summary of detailed output			
	HALT	day number at harvest	(day of the year)	no need to have this information	no need to have this information
	ANTH	duration of pre-anthesis phase	(d)	no need to have this information	no need to have this information
	TWRT	total dry weight of roots (dead and living)	(kg ha^{-1})	no need to have this information	no need to have this information
	TWLV	total dry weight of leaves (dead and living)	(kg ha^{-1})	no need to have this information	no need to have this information
	TWST	total dry weight of stems (dead and living)	(kg ha^{-1})	no need to have this information	no need to have this information
	TWSO	total dry weight of storage organs (dead and living)	(kg ha^{-1})	no need to have this information	no need to have this information
	TAGP	total above ground production (dead + living)	(kg ha^{-1})	no need to have this information	no need to have this information
	HINDEX	harvest index: weight of storage organs / weight of total above ground crop	(-)	no need to have this information	no need to have this information
	TRANSP	total transpiration	(cm water)	no need to have this information	no need to have this information
	TRC	transpiration coefficient rate	(kg (water) / kg (dry matter))	no need to have this information	no need to have this information
	GASST	total gross assimilation	(kg (CH_2O) ha^{-1})	no need to have this information	no need to have this information
	MREST	total maintenance respiration	(kg (CH_2O) ha^{-1})	no need to have this information	no need to have this information
		summary output			
	YR	simulation year, which always refers to the year when the simulation has started (e.g. sowing or emergence)	(y)	+	+
	RUNNAM	name of the simulation run	(name)	no need to have this information	no need to have this information
	SOW	sowing date (in case of fixed emergence value is -99) days between sowing and emergence (in case of fixed emergence value is 0)	(day in year) (d)	no need to have this information	no need to have this information
	EM	emergence date	(day in year)	no need to have this information	no need to have this information
	ANT	duration of pre-anthesis phase	(d)	no need to have this information	no need to have this information
	FLWR	day of flowering	(day in year)	no need to have this information	no need to have this information
	DUR	duration of simulation period	(d)	no need to have this information	no need to have this information
	HALT	day number at harvest	(day in year)	no need to have this information	no need to have this information
	TWRT	total dry weight of roots (dead and living)	(kg ha^{-1})	+	no need to have this information
	TWLV	total dry weight of leaves (dead and living)	(kg ha^{-1})	+	no need to have this information
	TWST	total dry weight of stems (dead and living)	(kg ha^{-1})	+	no need to have this information
	TWSO	total dry weight of storage organs (dead and living)	(kg ha^{-1})	+	+
	TAGP	total above ground production (dead and living plant organs)	(kg ha^{-1})	+	+
	LAIM	maximum leaf area index	(ha ha^{-1})	no need to have this information	no need to have this information
	HINDEX	harvest index weight of storage organs / weight of total above ground crop	(-)	no need to have this information	no need to have this information
	TRC	transpiration coefficient rate	(kg (water) / kg (dry matter))	no need to have this information	no need to have this information
	GASST	total gross assimilation	(kg (CH_2O) ha^{-1})	no need to have this information	no need to have this information
	MREST	total maintenance respiration	(kg (CH_2O) ha^{-1})	no need to have this information	no need to have this information
	TRANSP	total transpiration	(cm water)	no need to have this information	no need to have this information
	EVSOL	total evaporation from soil surface	(cm water)	no need to have this information	no need to have this information
		Water-limited crop production			
		detailed output			
		daily results			
	YEAR	year of the simulation time step	(y)	no need to have this information	no need to have this information
	DAY	day of year of the simulation time step	(1-366)	no need to have this information	no need to have this information
	WLV	dry weight of living leaves	(kg ha^{-1})	no need to have this information	no need to have this information
	WST	dry weight of living stems	(kg ha^{-1})	no need to have this information	no need to have this information
	WSO	dry weight of living storage organs	(kg ha^{-1})	no need to have this information	no need to have this information
	TAGP	total above ground production (dead and living plant organs) (only given when simulated without groundwater influence)	(kg ha^{-1})	no need to have this information	no need to have this information
	LAI	leaf area index (leaf area)/(soil area)	(ha ha^{-1})	no need to have this information	no need to have this information
	RD	depth of actual root zone	(cm)	no need to have this information	no need to have this information
	SM	soil moisture content in actual root zone	(cm^{3} (water) / (cm^{3} (soil))	no need to have this information	no need to have this information
	RESRV	available soil water in potential root zone (in and below actual root zone) (only given when simulated without groundwater influence)	(cm water)	no need to have this information	no need to have this information
	AVAIL	amount of water available in actual root zone (only given when simulated without groundwater influence)	(cm water)	no need to have this information	no need to have this information
	RAIN	total rainfall in the simulation period	(mm)	no need to have this information	no need to have this information
	TRA	transpiration rate	(mm d^{-1})	no need to have this information	no need to have this information
	EVA(P)	evaporation rate from soil or from water stored on soil surface	(mm d^{-1})	no need to have this information	no need to have this information
	SS	surface storage	(cm water)	no need to have this information	no need to have this information
	ZT	depth of groundwater table	(cm below soil surface)	no need to have this information	no need to have this information
	wet	days characterized by reduced crop growth due to oxygen shortage	(d)	no need to have this information	no need to have this information
	dry	days characterized by reduced crop growth due to water shortage	(d)	no need to have this information	no need to have this information
		summary of detailed output			
	HALT	day number at harvest	(day of the year)	no need to have this information	no need to have this information
	ANTH	duration of pre-anthesis phase	(d)	no need to have this information	no need to have this information
	TWRT	total dry weight of roots (dead and living)	(kg ha^{-1})	no need to have this information	no need to have this information
	TWLV	total dry weight of leaves (dead and living)	(kg ha^{-1})	no need to have this information	no need to have this information
	TWST	total dry weight of stems (dead and living)	(kg ha^{-1})	no need to have this information	no need to have this information
	TWSO	total dry weight of storage organs (dead and living)	(kg ha^{-1})	no need to have this information	no need to have this information
	TAGP	total above ground production (dead + living)	(kg ha^{-1})	no need to have this information	no need to have this information
	HINDEX	harvest index: weight of storage organs / weight of total above ground crop	(-)	no need to have this information	no need to have this information
	TRC	transpiration coefficient rate	(kg (water) / kg (dry matter))	no need to have this information	no need to have this information
	GASST	total gross assimilation	(kg (CH_2O) ha^{-1})	no need to have this information	no need to have this information
	MREST	total maintenance respiration	(kg (CH_2O) ha^{-1})	no need to have this information	no need to have this information
	wet	total number of days characterized by reduced crop growth due to oxygen shortage	(d)	no need to have this information	no need to have this information
	dry	total number of days characterized by reduced crop growth due to water shortage	(d)	no need to have this information	no need to have this information
	init max root zone	initial water content (either for the maximum rooting zone or, when ground water influence is assumed, for the first 10 m)	(cm water)	no need to have this information	no need to have this information
	final max root zone	final water content (either for the maximum rooting zone or, when ground water influence is assumed, for the first 10 m)	(cm water)	no need to have this information	no need to have this information
	change	difference between initial and the final water content (either for the maximum rooting zone or, when ground water influence is assumed, for the first 10 m)	(cm water)	no need to have this information	no need to have this information
	init surf storage	initial surface storage of water	(cm water)	no need to have this information	no need to have this information
	final surf storage	final surface storage of water	(cm water)	no need to have this information	no need to have this information
	change	difference between initial and the final surface storage of water	(cm water)	no need to have this information	no need to have this information
	irrigation	irrigation (always 0, since there is no option for irrigation in WOFOST)	(cm water)	no need to have this information	no need to have this information

	evap water surface	evaporation (from the surface water)	(cm water)	no need to have this information	no need to have this information
	rainfall	sum of yearly rainfall	(cm water)	no need to have this information	no need to have this information
	evap soil surface	evaporation (from the soil surface)	(cm water)	no need to have this information	no need to have this information
	transpiration	transpiration (by the crop) together: water loss to atmosphere)	(cm water)	no need to have this information	no need to have this information
	to atmos	evaporation and transpiration together: water loss to atmosphere	(cm water)	no need to have this information	no need to have this information
	surface runoff	runoff	(cm water)	no need to have this information	no need to have this information
	lost to deep soil	percolation to the ground water and the water loss through the drains (when groundwater is present)	(cm water)	no need to have this information	no need to have this information
	TOTAL INIT + IN	initial water content and the water that entered the system	(cm water)	no need to have this information	no need to have this information
	TOTAL FINAL + OUT	the final water content and the water lost	(cm water)	no need to have this information	no need to have this information
	checksum	check the water balance	(cm water)	no need to have this information	no need to have this information
	init water stock	initial water content in the root zone	(cm water)	no need to have this information	no need to have this information
	final water stock	final water content in the root zone	(cm water)	no need to have this information	no need to have this information
	infiltration	infiltration into the root zone (i.e. rainfall minus runoff)	(cm water)	no need to have this information	no need to have this information
	evap soil surface	evaporation (from the soil)	(cm water)	no need to have this information	no need to have this information
	added by root growth	increase in available water due to root growth	(cm water)	no need to have this information	no need to have this information
	transpiration	transpiration (by the crop)	(cm water)	no need to have this information	no need to have this information
	percolation	percolation to the ground water	(cm water)	no need to have this information	no need to have this information
	TOTAL INIT + IN	initial water content and the water that entered the system	(cm water)	no need to have this information	no need to have this information
	TOTAL FINAL + OUT	the final water content and the water lost	(cm water)	no need to have this information	no need to have this information
	checksum	check the water balance	(cm water)	no need to have this information	no need to have this information
		summary output			
	YEAR	simulation year	(y)	+	+
	RUNNAM	name of the simulation run	(name)	no need to have this information	no need to have this information
	SOW	sowing date (in case of fixed emergence value is -99)	(day in year)	no need to have this information	no need to have this information
	EM	emergence date	(day in year)	no need to have this information	no need to have this information
	DUR	duration of simulation period	(d)	no need to have this information	no need to have this information
	TWLV	total dry weight of leaves (dead and living)	(kg ha^{-1})	+	no need to have this information
	TWST	total dry weight of stems (dead and living)	(kg ha^{-1})	+	no need to have this information
	TWSO	total dry weight of storage organs (dead and living)	(kg ha^{-1})	+	+
	TAGP	total above ground production (dead and living plant organs)	(kg ha^{-1})	+	+
	LAIM	maximum leaf area index	(ha ha^{-1})	no need to have this information	no need to have this information
	HINDEX	harvest index weight of storage organs / weight of total above ground crop	(-)	no need to have this information	no need to have this information
	TRC	transpiration coefficient rate	(kg (water) / kg (dry matter))	+	no need to have this information
	RAINT	total rainfall in the simulation period	(cm water)	+	no need to have this information
	DELWAT	difference between final and initial available water in the root zone	(cm water)	+	no need to have this information
	TRAT	total transpiration	(cm water)	+	no need to have this information
	EVSOL	total evaporation from soil surface	(cm water)	+	no need to have this information
	LOSST	total water percolated to deep soil, not available for plant growth	(cm water)	+	no need to have this information
	TSR	total surface runoff during simulation period	(cm water)	+	no need to have this information
	RYLD	relative yield water-limited yield / potential yield	(%)	no need to have this information	no need to have this information
	RAGP	relative total above ground production water-limited production / potential production	(%)	no need to have this information	no need to have this information
		Nutrient-limited crop production			
	Leaves	total dry weight of leaves (dead and living) for potential production	(kg ha^{-1})	+	no need to have this information
	Stems	total dry weight of stems (dead and living) for potential production	(kg ha^{-1})	+	no need to have this information
	Storage organ	total dry weight of storage organs (dead and living) for potential production	(kg ha^{-1})	+	no need to have this information
	Ratio SO/straw	Storage organ to straw ratio for potential production	(-)	no need to have this information	no need to have this information
	Harvest index	harvest index: weight of storage organs / weight of total above ground crop for potential production	(-)	no need to have this information	no need to have this information
	Fertilizer N	Amount of N fertilizer needed to obtain production for potential production	(kg ha^{-1})	+	no need to have this information
	Fertilizer P	Amount of N fertilizer needed to obtain production for potential production	(kg ha^{-1})	+	no need to have this information
	Fertilizer K	Amount of N fertilizer needed to obtain production for potential production	(kg ha^{-1})	+	no need to have this information
	Leaves	total dry weight of leaves (dead and living) for nutrient limited production	(kg ha^{-1})	+	no need to have this information
	Stems	total dry weight of stems (dead and living) for nutrient limited production	(kg ha^{-1})	+	no need to have this information
	Storage organ	total dry weight of storage organs (dead and living) for nutrient limited production	(kg ha^{-1})	+	no need to have this information
	Ratio SO/straw	Storage organ to straw ratio for nutrient limited production	(-)	no need to have this information	no need to have this information
	Harvest index	harvest index: weight of storage organs / weight of total above ground crop for nutrient limited production	(-)	no need to have this information	no need to have this information
	Fertilizer N	Amount of N fertilizer needed to obtain production for nutrient limited production	(kg ha^{-1})	+	no need to have this information
	Fertilizer P	Amount of N fertilizer needed to obtain production for nutrient limited production	(kg ha^{-1})	+	no need to have this information
	Fertilizer K	Amount of N fertilizer needed to obtain production for nutrient limited production	(kg ha^{-1})	+	no need to have this information
	Leaves	total dry weight of leaves (dead and living) for water limited production	(kg ha^{-1})	+	no need to have this information
	Stems	total dry weight of stems (dead and living) for water limited production	(kg ha^{-1})	+	no need to have this information
	Storage organ	total dry weight of storage organs (dead and living) for water limited production	(kg ha^{-1})	+	no need to have this information
	Ratio SO/straw	Storage organ to straw ratio for water limited production	(-)	no need to have this information	no need to have this information
	Harvest index	harvest index: weight of storage organs / weight of total above ground crop for water limited production	(-)	no need to have this information	no need to have this information
	Fertilizer N	Amount of N fertilizer needed to obtain production for water limited production	(kg ha^{-1})	+	no need to have this information
	Fertilizer P	Amount of N fertilizer needed to obtain production for water limited production	(kg ha^{-1})	+	no need to have this information
	Fertilizer K	Amount of N fertilizer needed to obtain production for water limited production	(kg ha^{-1})	+	no need to have this information