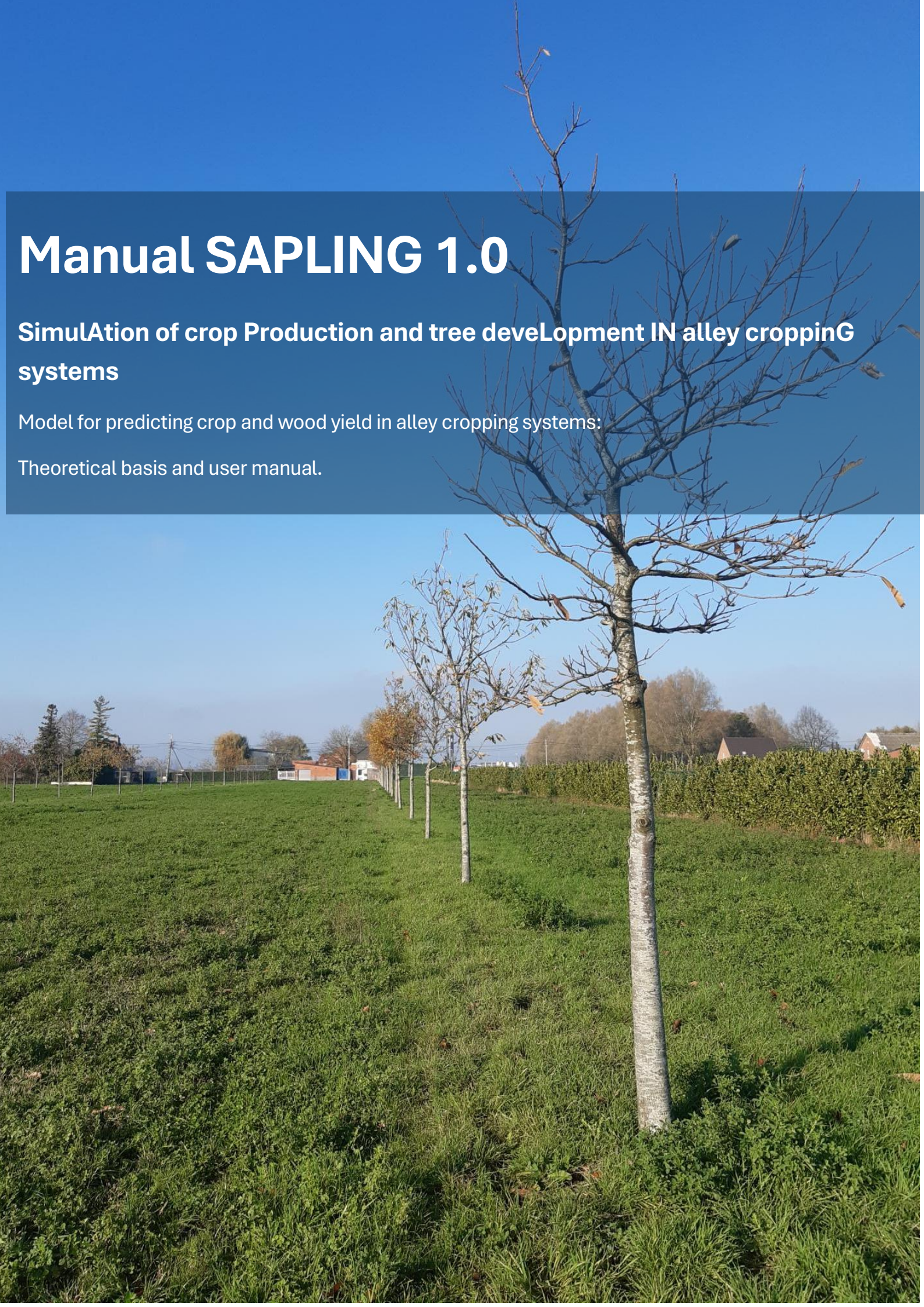
Manual SAPLING 1.0

SimulAtion of crop Production and tree deveLopment IN alley croppinG systems

Model for predicting crop and wood yield in alley cropping systems:

Theoretical basis and user manual.



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PREFACE

This manual is intended as a guide for users of the "**SimulAtion of crop Production and tree deveLopment IN alley croppinG systems" (SAPLING) tool, version 1.0**. In this guide, we take a closer look at each step of SAPLING by explaining what you do in each step, what information you need to provide, which background information is relevant, and which practical tips can help you use the web tool effectively. SAPLING is part of the knowledge-sharing platform "Agroforestry Planner," which includes a suite of decision support tools.

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DISCLAIMER

SAPLING is a decision-support tool that simulates crop yields, crop quality, wood production, and economic outcomes in alley-cropping agroforestry systems during the first ten years after establishment. The calculations are based on empirical research, literature, and assumptions representative of temperate agricultural systems in Northwest Europe (DE, BE, NL, LU, DK, FR, GB).

The results depend on the parameters the user enters, such as plot design, reference yields, tree and crop species, crop rotations, and market prices. Users are responsible for providing realistic, context-specific, and up-to-date information. SAPLING's output should be interpreted as indicative and directional. They provide insights into possible trends, relative differences, and order-of-magnitude effects, but do not constitute exact predictions.

The results of SAPLING are intended to support the exploration, design, planning, and comparison of scenarios. ILVO and the partners of the Agroforestry Flanders Consortium cannot be held liable for decisions or consequences resulting from the use of this tool. For feedback, questions, or comments regarding SAPLING, you can always contact us via info@agroforestryvlaanderen.be.

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INTRODUCTION SAPLING

WHY SAPLING?

Agroforestry is receiving increasing attention in temperate agricultural systems as a promising agroecological practice. It can contribute to climate mitigation and adaptation, as well as greater diversity and resilience on the farm. Additionally, agroforestry provides opportunities to compensate for lower crop yields through the production of wood, fruit, or nuts. In practice, however, these economic benefits often only appear several years after planting. During the early stages, farmers already experience the effects of trees on their crops, while the yields from the trees themselves remain limited. A clear understanding of the impact of trees on crop yields and quality during these early years is therefore essential for assessing the economic feasibility of agroforestry.

Despite their growing interest in agroforestry, farmers often lack clear, quantitative information at the field and farm level. In particular, uncertainty about potential yield losses represents a major barrier to adoption. Decision support tools that provide insights into yields and economic outcomes can help reduce this uncertainty and create realistic expectations.

WHAT IS SAPLING?

The SAPLING tool was developed to meet the need for quantitative and economic support in agroforestry planning. SAPLING is part of the Agroforestry Planner Flanders and supports the design of agroforestry systems by combining simulations of crop yields, crop quality, and wood production with an economic evaluation. The tool focuses on alley-cropping systems and simulates yields over a ten-year period following the establishment of the alley-cropping system.

SAPLING is applicable to a range of arable crops and tree species commonly found in temperate agricultural regions in Northwest Europe. For each crop, models were developed in which yield and quality variables are described as a function of H, defined as the ratio between the distance to the tree row and the tree height. These models are entirely based on empirical research conducted by ILVO (partly in collaboration with Ghent University) and largely published in Pardon et al. (2018) and Pardon et al. (2025). Tree biomass is calculated based on species-specific allometric relationships and growth data from literature.

SAPLING is an interactive decision-support tool that allows users to adjust various input parameters, such as the design of the alley-cropping system, reference yields, tree and crop species, crop rotations, and market prices of crops and wood. The outputs provide insights into the annual yields and losses of both crops and the woody component, their economic valuation, and the overall balance.

The tool was developed as a dynamic and extensible instrument that can be further refined with in situ measurements and expanded to other agroforestry systems and field designs. In this way, SAPLING supports scientists, policymakers, and land managers in quantifying the agronomic and economic performance of alley-cropping systems during the first ten years following the establishment of an agroforestry plot.

SAPLING STEP-BY-STEP GUIDE

1 DESIGN FIELD

- Select a field, either as a rectangle or directly on a real map.
- Adjust the dimensions and orientation so the field matches the actual situation or the needs of your simulation.

2 PLACING TREE ROWS

- Define where the tree rows will be placed and which tree species will be used.
- You can quickly generate a basic design or manually adjust each row for a more precise field layout.

3 CROP ROTATION

- Set up a 10-year rotation using the available crops or fallow land.
- The tool displays the average sole-cropping yields, which you can adjust if needed based on your own experience or field data.

4 SIMULATION

- Run the simulation to predict the annual crop yields and quality, and the timber yields.
- The results are displayed visually and compared with a conventional sole-cropping agricultural system.

5 ECONOMIC VALUATION

- The tool calculates the financial impact of crop losses and timber production.
- The results show the net economic effect of the alley-cropping practice over a 10-year period.

6 REPORT

- You can export the data as a clear report containing graphs and tables.

SCIENTIFIC BASIS

TREE SPECIES

SAPLING 1.0 was initially developed for two tree species that are typical in an agroforestry context, namely poplar (*Populus × canadensis*) and walnut (*Juglans regia*). In addition, the tool includes a so-called 'standard tree', for which the model parameters are based on the average of 19 tree species:

sycamore maple (*Acer pseudoplatanus*), black alder (*Alnus glutinosa*), horse chestnut (*Aesculus hippocastanum*), hazel (*Corylus avellana*), ash (*Fraxinus excelsior*), walnut (*Juglans regia*), apple (*Malus domestica*), poplar (*Populus × canadensis*), wild cherry (*Prunus avium*), pear (*Pyrus communis*), sessile oak (*Quercus petraea*), pedunculate oak (*Quercus robur*), black locust (*Robinia pseudoacacia*), willow (*Salix* sp.), rowan (*Sorbus aucuparia*), wild service tree (*Sorbus torminalis*), small-leaved lime (*Tilia cordata*), large-leaved lime (*Tilia platyphyllos*), and elm (*Ulmus* sp.).

Further expansion of the tool is currently limited by the availability of reliable height growth curves under agroforestry-specific conditions, characterized by relatively open planting designs and often nutrient-rich environments. For diameter at breast height and wood biomass, models are available for 19 tree species; the values for the standard tree represent the average of these species-specific datasets. Height growth models are currently being further developed for additional species, which will enable the explicit integration of more tree species into SAPLING in the future.

TREE MODELS

HEIGHT MODELS

BIOMASS MODELS

To calculate the (temporal evolution of) tree biomass, we use allometric relationships based on the diameter at breast height (DBH). This is done in two steps: (1) predicting the development of DBH as a function of time, and (2) calculating biomass based on the estimated DBH.

Diameter at Breast Height

For 19 tree species, DBH is modelled as a function of time. The relationship between DBH and age is species-specific and was estimated based on several sources: Van Den Berge et al. (2021) for hedgerow trees in Flanders; Lukaszkiewicz & Kosmala (2008) for urban trees in Poland; Monteiro et al. (2017) for urban trees in Great Britain; and Carton (2022) and Pardon (2018) for poplar in Flanders (see Table 1).

From each of these studies, the raw data (DBH as a function of age) were extracted. A logistic function (Eq. 1) was subsequently fitted to each individual dataset. This type of relationship is commonly used in ecology to approximate tree growth dynamics.

$$DBH = \frac{a}{e^{b-ct}} \quad \text{[Equation 1]}$$

where *a*, *b*, and *c* are species-specific model parameters and *t* represents the tree age (in years). The model parameters were estimated for each tree species and study by minimizing the Root Mean Square Error (RMSE). For tree species for which no relationship was available in the literature, growth rates were approximated by comparison with other species for which growth relationships were available. When two or more growth functions were available for a given species, the curve that best reflected growth under open-grown conditions (e.g., urban trees) was selected (see Table 1).

For each tree on the plot and at each time step, the model calculates DBH based on the corresponding equations. These DBH values are subsequently used as input for the biomass model.

Table 1: Diameter at Breast Height (DBH) [cm] as a function of age (t) [years] for the different agroforestry tree species.

Tree species	Growth rate	Equation	Source
Acer pseudoplatanus	Fast	= 61/(1+exp(2-0.059*t))	Monteiro et al. (2017)
Alnus glutinosa	Fast	= 728/(1+exp(4.62-0.035*t))	Van De Berge et al. (2021)
Aesculus hippocastanum	Medium	= 52.8/(1+exp(2.02-0.069*t))	Lukaszkiewicz & Kosmala (2008)
Corylus avellana	Medium	= 89.9/(1+exp(2.28-0.04*t))	Lukaszkiewicz & Kosmala (2008)
Fraxinus excelsior	Fast	= 68.7/(1+exp(2.7-0.072*t))	Lukaszkiewicz & Kosmala (2008)
Juglans regia	Medium	= 89.9/(1+exp(2.28-0.04*t))	Lukaszkiewicz & Kosmala (2008)
Malus domestica	Medium	= 89.9/(1+exp(2.28-0.04*t))	Lukaszkiewicz & Kosmala (2008)
Populus × canadensis	Very fast	= 65.6/(1+exp(2.12-0.187*t))	Carton et al. (2022)
Prunus avium	Fast	= 89.9/(1+exp(2.28-0.04*t))	Lukaszkiewicz & Kosmala (2008)
Pyrus communis	Medium	= 89.9/(1+exp(2.28-0.04*t))	Lukaszkiewicz & Kosmala (2008)
Quercus petraea	Slow	= 60.2/(1+exp(2-0.061*t))	Van De Berge et al. (2021)
Quercus robur	Slow	= 60.2/(1+exp(2-0.061*t))	Van De Berge et al. (2021)
Robinia pseudoacacia	Fast	= 1452.5/(1+exp(5.66-0.041*t))	Van De Berge et al. (2021)
Salix sp.	Fast	= 1452.5/(1+exp(5.66-0.041*t))	Van De Berge et al. (2021)
Sorbus aucuparia	Medium	= 89.9/(1+exp(2.28-0.04*t))	Lukaszkiewicz & Kosmala (2008)
Sorbus torminalis	Medium	= 89.9/(1+exp(2.28-0.04*t))	Lukaszkiewicz & Kosmala (2008)
Tilia cordata	Medium	= 89.9/(1+exp(2.28-0.04*t))	Lukaszkiewicz & Kosmala (2008)
Tilia platyphyllos	Medium	= 89.9/(1+exp(2.28-0.04*t))	Lukaszkiewicz & Kosmala (2008)
Ulmus sp.	Fast	= 61/(1+exp(2-0.059*t))	Monteiro et al. (2017)

Biomass

To quantify the aboveground woody biomass of the different trees on the plot, allometric relationships based on DBH were used. These relationships were derived for each tree species from literature: Shafer et al. (2019) provided biomass equations for trees in food forests, McPherson et al. (2016) provided volume equations for urban trees in the USA, and Hjelm & Johansson (2012) provided volume equations for poplars in Sweden. When no allometric relationship was available, we used data from species with comparable growth rates. (see Table 2). When only an allometric relationship for aboveground volume was available, wood density was obtained from the Global Wood Density Database (Zanne et al., 2009). Multiplying wood density by volume then allows calculation of total aboveground biomass. Figure 1 illustrates the increase of aboveground biomass in function of time.

Table 2: Allometric relationships for aboveground biomass [kg] based on diameter at breast height (DBH) [cm] for the 19 tree species. The equations were derived from the literature for the corresponding tree species in an urban forest or food forest context.

Tree species	Equation	Source
Acer pseudoplatanus	= (520/1000)*(0.0019421*DBH^1.785)	McPherson et al. (2016)

Alnus glutinosa	= 0.00079*DBH^2.28546	Shafer et al. (2019)
Aesculus hippocastanum	= (580/1000)*(0.0002431*DBH^2.415)	McPherson et al. (2016)
Corylus avellana	= exp(-2.2118+2.4133*ln(DBH))	Shafer et al. (2019)
Fraxinus excelsior	= (530/1000)*(0.0005885*DBH^2.206)	McPherson et al. (2016)
Juglans regia	= exp(-2.2118+2.4133*ln(DBH))	Shafer et al. (2019)
Malus domestica	= exp(-2.2118+2.4133*ln(DBH))	Shafer et al. (2019)
Populus × canadensis	= (370/1000)*(exp(0.3285*ln(dbh)^2.2502))	Hjelm & Johansson (2012)
Prunus avium	= exp(-2.2118+2.4133*ln(DBH))	Shafer et al. (2019)
Pyrus communis	= exp(-2.2118+2.4133*ln(DBH)))	Shafer et al. (2019)
Quercus petraea	= (580/1000)*(0.0002431*DBH^2.415)	McPherson et al. (2016)
Quercus robur	= (580/1000)*(0.0002431*DBH^2.415)	McPherson et al. (2016)
Robinia pseudoacacia	= 4.13741*DBH^2.17752	McPherson et al. (2016)
Salix sp.	= 0.454*10^(0.8856+2.0552*log(2.54*DBH))	Shafer et al. (2019)
Sorbus aucuparia	= exp(-2.2118+2.4133*ln(DBH))	Shafer et al. (2019)
Sorbus torminalis	= exp(-2.2118+2.4133*ln(DBH))	Shafer et al. (2019)
Tilia cordata	= exp(-2.6788+2.4542*ln(DBH))	Shafer et al. (2019)
Tilia platyphyllos	= exp(-2.6788+2.4542*ln(DBH))	Shafer et al. (2019)
Ulmus sp.	= (460/1000)*(0.0018*DBH^1.869)	McPherson et al. (2016)

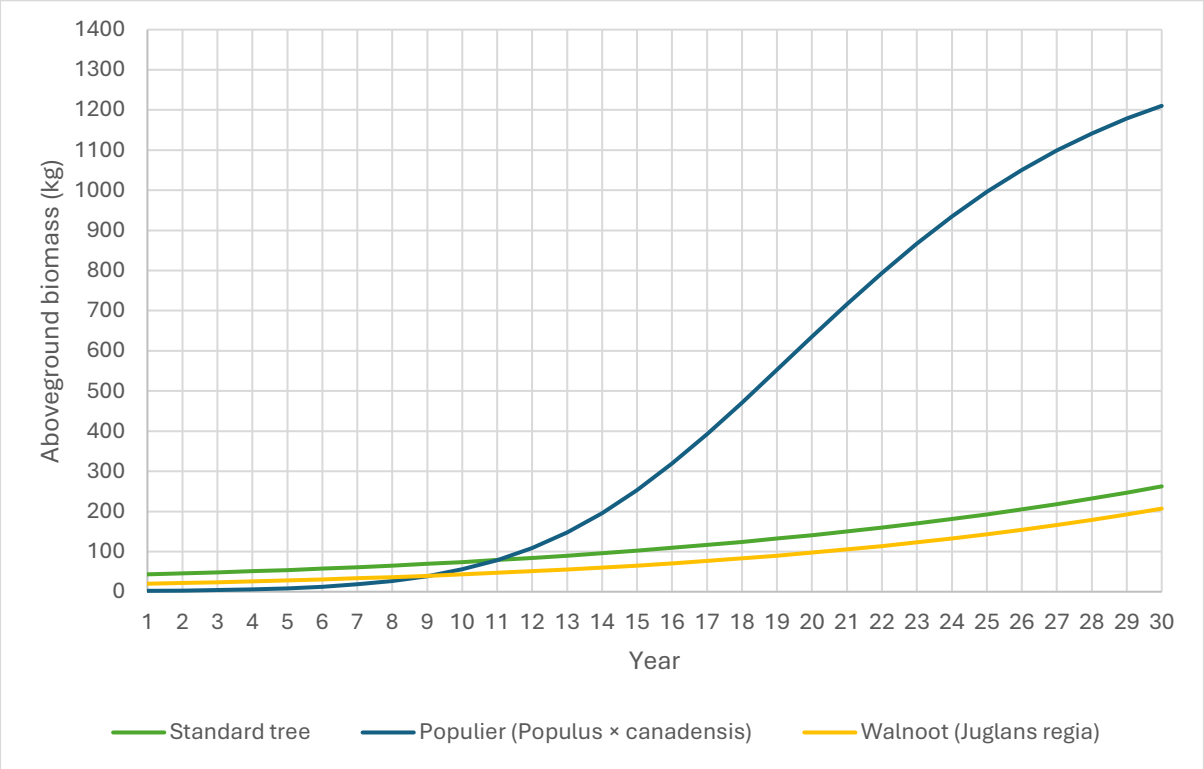


Figure 1: Aboveground tree biomass [kg] over time according to the allometric relationships for the standard tree, poplar, and walnut (Hjelm & Johansson, 2012; Shafer et al., 2019).

WOOD VOLUME DISTRIBUTION

For further analysis, the total biomass [kg] after 10 years was converted to wood volume [m^3] based on species-specific wood densities (Zanne et al., 2009). This conversion is necessary for the economic valuation (see Economic Valuation).

The woody component of the alley-cropping system provides several end products. Because the proportions of quality timber, biomass, and non-harvestable residual fractions differ among tree species, the simulation uses a standard distribution of total wood volume per species across these categories (see Table 1).

Table 3: Preliminary species-specific distribution of wood volume [m^3] across quality timber and biomass fractions.

Tree species	High-quality wood volume (%)	Extra biomassa volume (%)
Juglans regia		
Populus × canadensis	69	21
Prunus avium	61	31
Standard	65	26

CROPS

CROPS

SAPLING is developed for five commonly cultivated arable crops in Flanders: **silage maize, grain maize, winter wheat, winter barley, and potato**. This selection is based on available empirical data and scientific evidence (Pardon et al., 2018; 2025). In future versions of the tool, the list of supported crops will be further expanded as new empirical data become available. If a user wishes to analyze a crop that is not yet included in the list, they may select a comparable crop from the existing selection to obtain an indicative estimate.

QUALITY PARAMETERS

For each of the five crops currently included in SAPLING, several quality parameters are available. Depending on the specific crop, these include **crude protein content (%), starch content (%), organic matter digestibility (%), dry matter content (%), and/or thousand-kernel weight (g)**. The impact of tree presence on these parameters is based on data from the study by Pardon et al. (2025).

Table 4: Overview of crop quality parameters modeled in SAPLING.

Crop	Quality parameter
Silage maize	Crude protein content (%), starch content (%), organic matter digestibility (%), dry matter content (%)
Grain maize	Dry matter content (%)
Winter wheat	Thousand-kernel weight (g), dry matter content (%)
Winter barley	Crude protein content (%), dry matter content (%)
Potato	dry matter content (%)

MEAN CROP YIELD AND MOISTURE CONTENT

Within SAPLING, the crop yield of an alley-cropping system is compared with that of a sole-cropping system (the cultivation of a single crop without the presence of trees) under conventional management. The reference values for average yields are obtained from STATBEL Land- en tuinbouwbedrijven - landbouwgegevens (see Table 5). These reference values, expressed in tons of product per hectare, are converted to tons of dry matter (DM) per hectare by multiplying by the DM content (1 – moisture content). The moisture contents used are based on the following sources: the WUR datasheet for silage maize, the ILVO variety overview for grain maize, the FEGRA reception standards for winter wheat and winter barley, and the VLAM product datasheet for potato. The corresponding values are presented in Table 5.

Table 5: Average crop yields according to STATBEL (2023) and crop moisture contents in the SAPLING tool.

Crop	Average crop yield (ton dry matter/ha)	Moisture content
Silage maize	16.9	65%
Grain maize	9.4	15%
Winter wheat	7.8	15.5%
Winter barley	7.3	15.5%
Potato	8.9	79%

CROP YIELD AND QUALITY MODELS

In the model, crop yield and quality in alley-cropping systems are determined as a function of **H**, which is the ratio of the distance to the trees to the tree height (H = distance/tree height) (Eq. 2). The variable H combines two important factors: the distance to the trees and their height, both of which influence crop growth through shading, root competition, and changes in the microclimate. For illustration: H = 0.5 means that the distance to the trees is half the tree height; H = 2 means that the distance is twice the tree height.

For each crop in the rotation (silage maize, grain maize, potato, winter barley and winter wheat), the crop yield and associated quality parameters are modelled using a **linear mixed-effects model** of the form:

$$\boldsymbol{Y = a + b * log_2(H)} \qquad \text{[Equation 2]}$$

where *Y* represents the crop yield (ton dry matter per hectare) or a crop quality parameter. The parameters *a* and *b* are crop-specific and differ depending on whether the model concerns yield or

quality variables (see Table 6). The $\log_2$ transformation ensures that the influence of the tree row is strongest at low H values and levels off at greater distances. The models and model parameters were derived from field data of Flemish alley-cropping systems (Pardon et al., 2025).

In SAPLING, these models are applied to a 10-year rotation. For each year, the yield and the associated crop quality parameters are calculated as a function of H. Figure 2 shows, for each crop, the relationship between H and the crop yield [tons DM/ha]. The logarithmic function illustrates that crop yield decreases at lower H values and levels off at higher H values; a similar pattern applies to the crop quality parameters. The H values at which crop yield in alley-cropping equals the average yield in sole-cropping are 4.0 for silage maize, 1.8 for grain maize, 2.9 for winter wheat, 1.5 for winter barley, and 0.25 for potato. At H values below these thresholds, yield decreases relative to sole cropping, whereas at higher H values, yield increases.

Table 6: Crop-specific model parameters (a and b) of the linear mixed model (Equation 2) according to Pardon et al. (2025).

	Crop	Parameter a	Parameter b
Crop yield (ton DM/ha)	Silage maize	14.133	1.366
	Grain maize	8.4	1.195
	Winter wheat	7.067	0.485
	Winter barley	7.2	0.181
	Potato	10.358	0.721
Crude protein content (%)	Silage maize	7.846	0.051
	Winter barley	12.042	0.041
Thousand-kernel weight (g)	Winter wheat	11.474	0.147
Organic matter digestibility (%)	Silage maize	75.222	-0.439
Starch content (%)	Silage maize	31.05	0.019
Dry matter content (%)	Silage maize	34.228	0.119
	Grain maize	65.903	0.418
	Winter wheat	87.288	0.142
	Winter barley	89.775	0.21
	Potato	22.822	-0.27

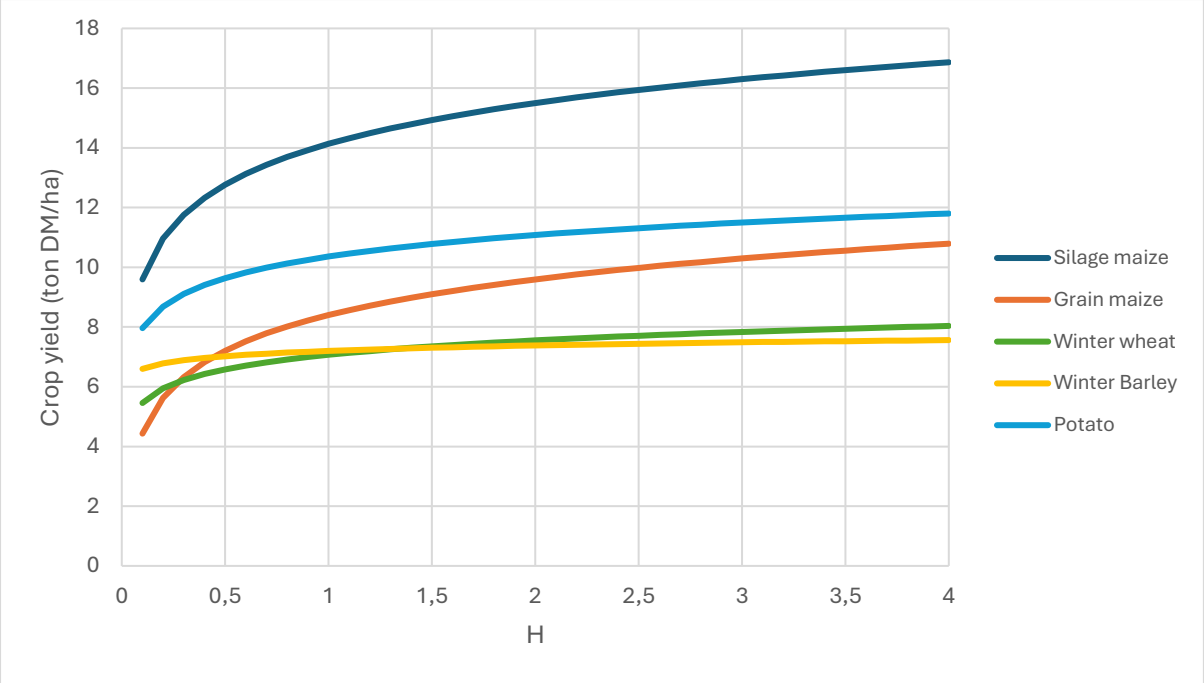


Figure 2: Crop yield [tons DM/ha] as a function of H (distance to the tree row/tree height) for the different crops in the SAPLING tool. The relationships were determined using the logarithmic curve $[yield = a + b * log_2(H)]$ according to the study by Pardon et al. (2025).

Key assumptions and limitations

The models are primarily based on field data from alley-cropping systems with young to mid-aged trees (up to approximately 10 years old). For this reason, the application of the model is explicitly limited to the first ten years after establishment of the alley-cropping system. The reliability of results beyond this period is uncertain, as changes in crown architecture, growth direction, and the ratio between crown volume and tree height may alter the nature and strength of tree–crop interactions.

In addition, the validity of the models is restricted to the range of H values observed in the underlying field data (see Table 7). Extrapolation beyond this range is associated with increased uncertainty. To limit this uncertainty, the tool applies boundary conditions for the maximum distance between tree rows, thereby avoiding extremely high H values and the associated uncertain model outcomes.

Table 7: Range of H observed in the sampled fields and measurement plots for each crop.

Crop	H range
Silage maize	0,12 – 14,62
Grain maize	0,33 – 3,04
Winter wheat	0,17 – 8,20
Winter barley	0,10 – 12,90
Potato	0,40 – 6,56

In SAPLING, a comparison is made between the tool-modelled yields for conventional alley-cropping systems and the average yield values for conventional sole-cropping systems. These average yield values serve as a reference framework and are representative of Belgian growing conditions. Regional differences in soil type, climatic conditions, and management practices are not explicitly accounted for. To address this limitation, the tool allows users to adjust the default average yield values to reflect farm-specific or field-specific conditions.

Note: specifically for potato, field measurements from above-average production years (2017 and 2021) lead to a slight overestimation of the average potato yield in an agroforestry context in the models.

ECONOMIC VALUATION

In SAPLING, the economic assessment compares the timber revenues and crop losses associated with the transition from sole-cropping systems to alley-cropping systems. The woody component in the alley-cropping system is valued based on the timber volume after ten years, subdivided into biomass, high-quality timber, and an unused fraction. The market prices for these timber products are presented in Table 8 and are based on the information sheet Timber revenues from agroforestry.

In addition to the revenues from the woody component, potential revenue losses in crop yield must also be considered. The difference in crop yield between alley-cropping and sole-cropping is calculated using the crop models and the average yield values presented in Table 5. The market prices of the crops are shown in Table 9.

In the first years after establishing an alley-cropping system, net income may temporarily decline. This is due to (i) the loss of cultivated area caused by the presence of tree rows and (ii) reduced yield and/or quality levels of crops located close to the trees. These negative effects are partly compensated for by increased yields at greater distances from the trees. This increase is linked to favorable microclimatic conditions, such as reduced wind exposure, higher soil moisture levels, and more stable temperatures. The effects of trees on crop quality remain limited and are of minor economic relevance during the first decade after establishment.

This analysis focuses on the first ten years following the transition to alley-cropping, a period in which the trees are still young, and biomass accumulation is limited (Figure 1). In this initial phase, the woody component provides little to no marketable output, meaning that the economic impact is primarily determined by changes in crop yield in the vicinity of the trees. As shown in Figure 1, tree biomass increases substantially after this first decade, which is accompanied by a rise in the commercial value of the woody component. As a result, the system may generate a positive net economic return in the longer term.

Table 8: Market prices [€/m³] for timber volume, subdivided into biomass and high-quality timber.

Wood species	Timber component	Price per volume wood [€/m³]
Poplar (*Populus × canadensis*)	Biomass	17.5
	High-quality	278.48

Table 9: Market prices [€/ton of product] for the five crops: silage maize, grain maize, winter wheat, winter barley and potatoes.

Crop	Price (€) per ton product
Silage maize	101
Grain maize	171
Winter wheat	215
Winter barley	216
Potato	153

INDICATIVE VALIDATION

To evaluate the performance of the SAPLING tool, an indicative validation was carried out. Yield data from two plots within the existing dataset were compared with the yields predicted by the tool based on the developed models. These models estimate crop yield as a function of the distance to the tree row and tree height in alley cropping systems.

For each crop, the percentage deviation between the measured yield and the yield predicted by SAPLING was calculated. The results show an error margin of approximately 16–21% for most crops, namely grain maize (17%), winter wheat (21%), winter barley (16%), and potato (16%). A larger deviation was observed for silage maize (approximately 47%).

Since this evaluation used data originating from the same dataset that was used for model development, this analysis should be considered an indicative validation rather than a full independent validation. Further validation with independent field data is required to confirm the accuracy and robustness of the tool.

FURTHER EXPANSION OF SAPLING

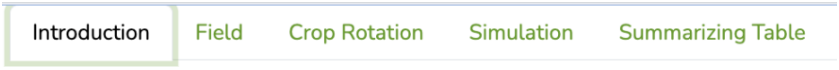
To facilitate future modifications by programmers or developers who may wish to extend the script, specific markers have been included throughout the code. These markers indicate where changes can be made to integrate additional tree species or crop species into the tool.

To add new tree species, users can search for the marker “Other tree species” in the script using the search function (e.g., Ctrl + F). At each of these locations, a short explanation is provided describing the required modifications. By implementing the necessary changes both in the SAPLING Shiny script and in the script containing the functions, a new tree species can be successfully integrated into the tool.

Similarly, to add new crop species, users can search for the marker “Other crops”. These sections indicate where adjustments are required in the code to include additional crops.

PRACTICAL USER GUIDE

To get started, click ‘Get started’. You will automatically be directed to the first tab, ‘Field’. Using the tabs at the top of the tool, you can easily navigate between the different sections.



STEP 1: DESIGN THE ALLEY-CROPPING FIELD (FIELD TAB)

DESIGN MODE

There are two ways to design tree rows in this tool.

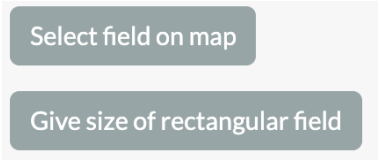
The **Try-out mode** automatically generates vertically oriented tree rows based on the spacing parameters you select. This offers a quick way to explore different field layouts. In this mode, the distance between each pair of tree rows remains constant.

The **Professional mode** gives you full control. You can click directly on the field to place the tree rows exactly where you want them. This allows you to replicate your field layout as accurately as possible and, for example, vary the spacing between different rows.

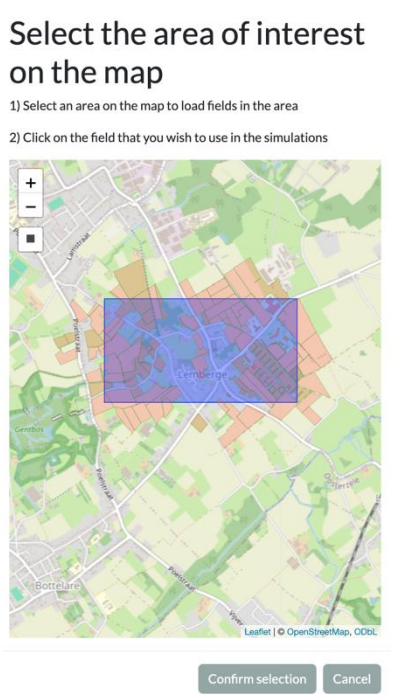
Choose the mode that best fits your workflow: rapid exploration or precise, customised field design.

FIELD DIMENSIONS

You can choose between designing an alley-cropping system on a virtual **rectangular field** (‘Give size of rectangular field’) or selecting an **actual field in Flanders** on the map (‘Select field on map’).

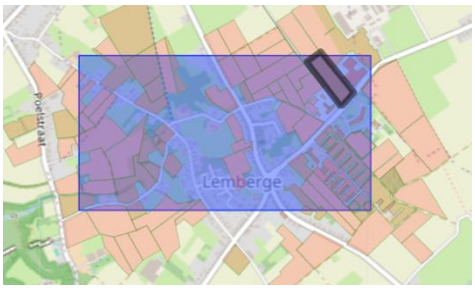


OPTION 1: BUTTON “SELECT FIELD ON MAP”



Select a field on the map.

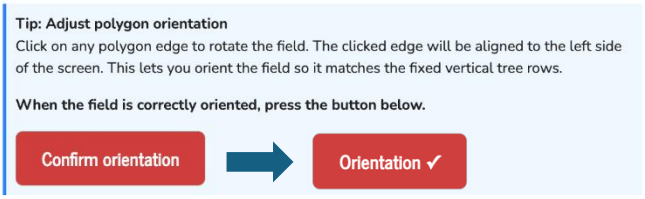
- You can move the map by clicking and dragging.
- Use + to zoom in and – to zoom out.
- Click the square icon ▣ and draw a box around the desired area on the map. The available fields will appear in orange. Important: zoom in sufficiently and keep the selected area reasonably small to ensure accurate field selection and avoid long loading times.
- Click the desired field to select it.
- Confirm your selection by clicking the ‘Confirm selection’ button.



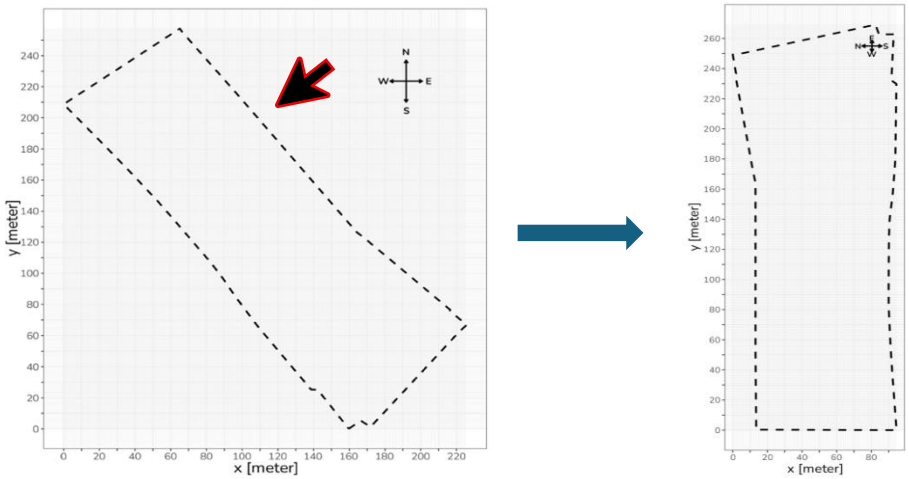
After completing this step (option 1), the selected field is automatically displayed within the tool’s grid. This forms the basis for the subsequent steps.

Adjust field orientation

Click any side (dashed line) of the field to rotate it. The selected side will be aligned with the left side of the screen. This allows you to orient the field so that it matches the fixed vertical tree rows that will be added in the next steps.

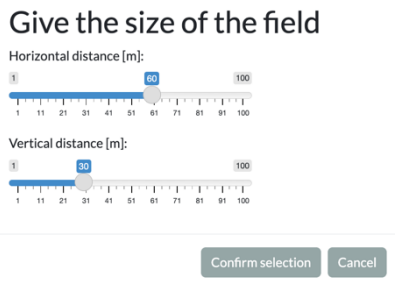


When the field is correctly oriented, click the ‘Confirm orientation’ button. Your new orientation will be confirmed with a ✓.



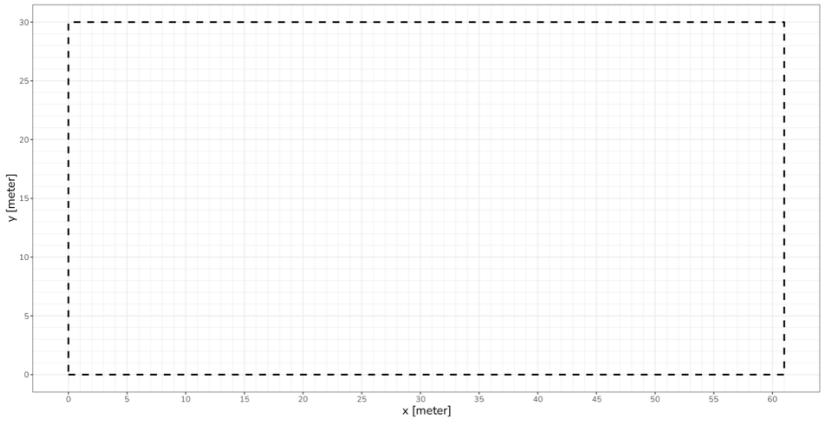
OPTION 2: BUTTON "GIVE SIZE OF RECTANGULAR FIELD"

Select a rectangular field with user-defined dimensions.



- Move the slider under **'Horizontal distance (m)'** to set the desired horizontal length.
- Move the slider under **'Vertical distance (m)'** to set the desired vertical length.
- Confirm your selection by clicking the **'Confirm selection'** button.

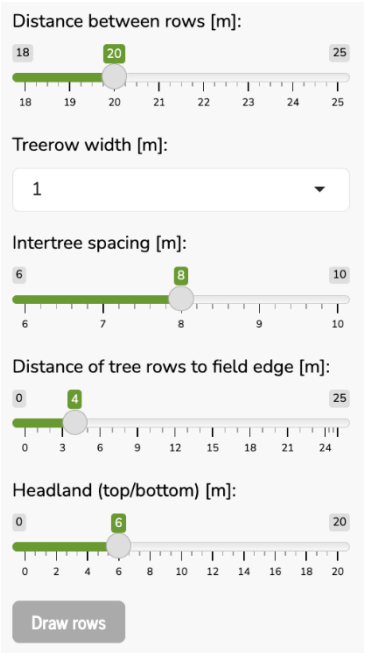
After completing this step (option 2), the selected field is automatically displayed within the tool's grid. This forms the basis for the subsequent steps



PLACING TREE ROWS

TRY OUT MODE

Inputs for configuring tree rows:



Distance between rows (m) – slider: set the spacing between the tree rows.

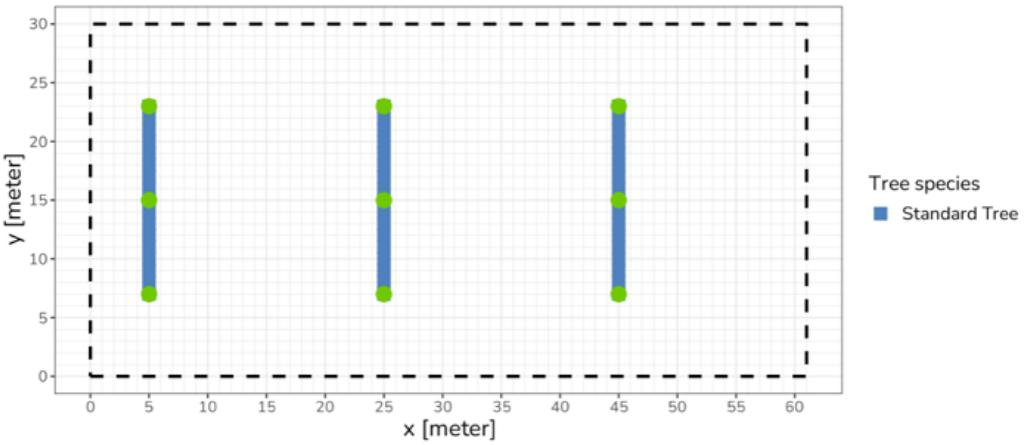
Tree row width (m) – dropdown menu (3 options): choose the width of the tree row.

Intertree spacing (m) – slider: define the distance between individual trees within a row.

Distance of tree rows to field edge (m) – slider: set the distance between the tree rows and the left/right field boundary.

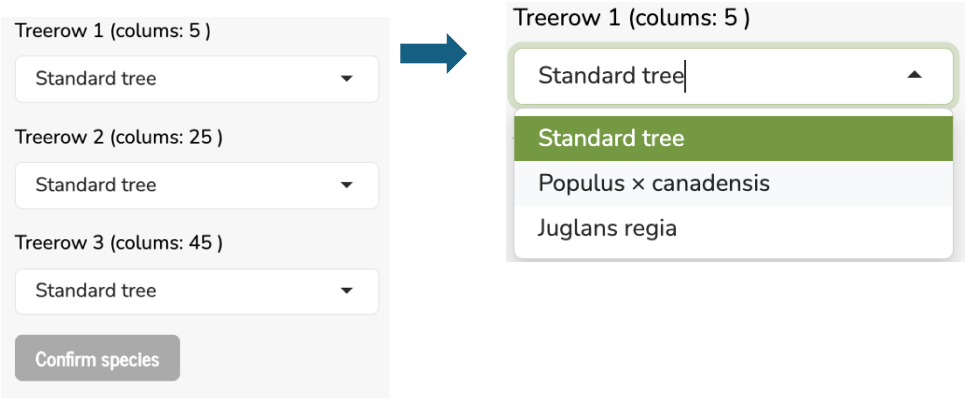
Headland (m) – slider: determine the width of the headland (top and bottom of the tree row).

Confirm your settings by clicking the **'Draw rows'** button. Below you can see the result for a rectangular field. The green dots illustrate the number of trees planted in each row. Note: In Try-out mode, the spacing between all rows (and between the trees within each row) will always remain constant.

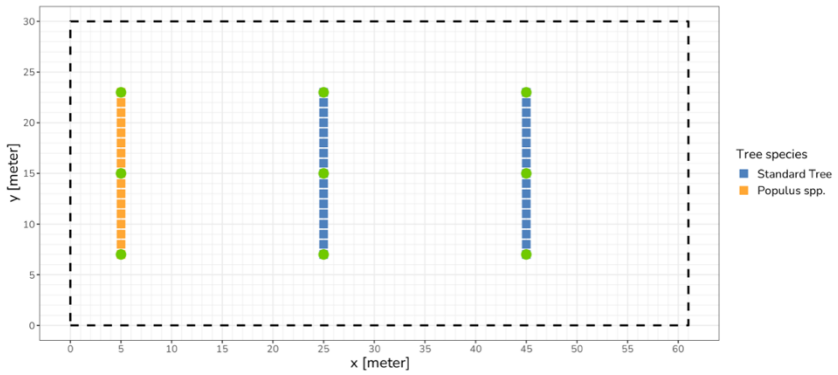


Selecting a tree species for each tree row

In the dropdown menu, you can select a tree species for each row. Use the selection arrow to open the list of available species. If, in practice, multiple species are planted within the same row, it is best to choose the tallest-growing species. After selecting the desired species, click **'Confirm species'**.

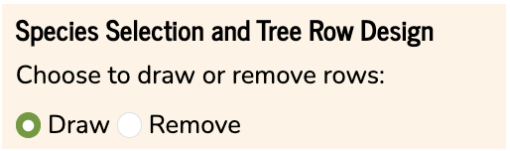


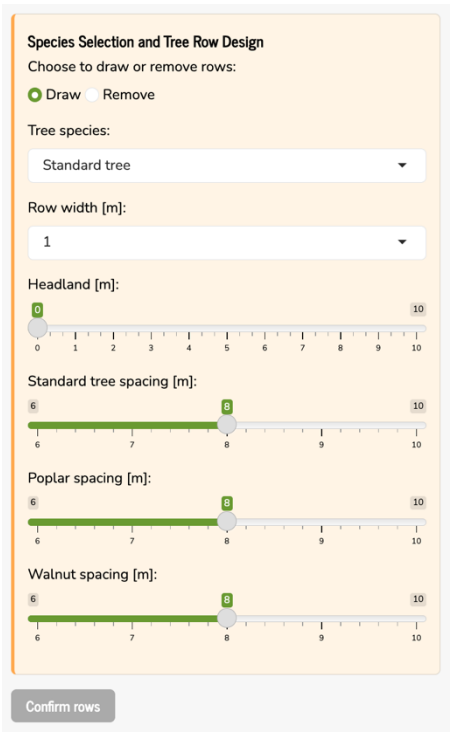
"The result of the previous steps is now displayed: the design of your alley-cropping system is shown, including the planned tree rows and the selected tree species.



PROFESSIONAL MODE

In the Professional mode, you again have the choice between a rectangular field ('Give size of rectangular field') or a field in Flanders selected on the map ('Select field on map'). For this guide, we continue with a rectangular field, but the same procedure applies for both modes.

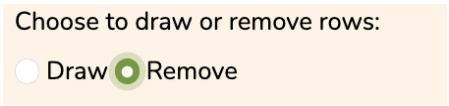




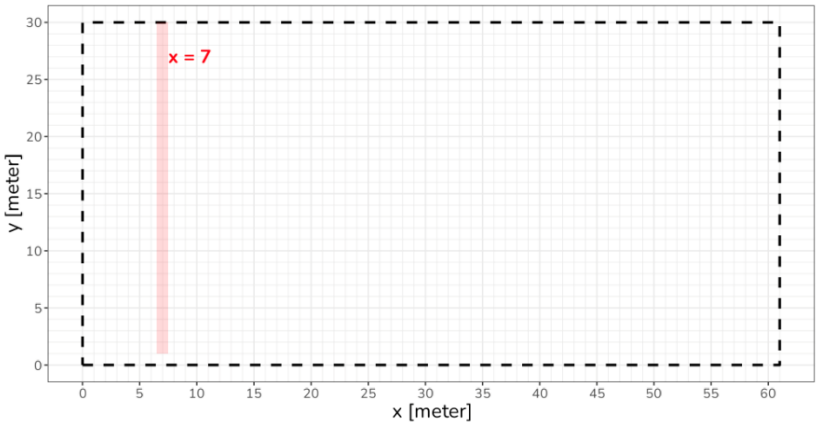
To draw a tree row, always start by selecting the **'Draw' mode**. First choose the tree species; this is important because the properties of the tree row are linked to this choice. Then set the row width, the distance to the top and bottom of the field (the headland), and the intertree spacing for that species. Click on the map to draw the tree row; the properties that are currently selected will be applied to that row.

If you want to draw a new row with different properties, adjust the settings and click on a new location. Each click creates a row with the properties active at that moment.

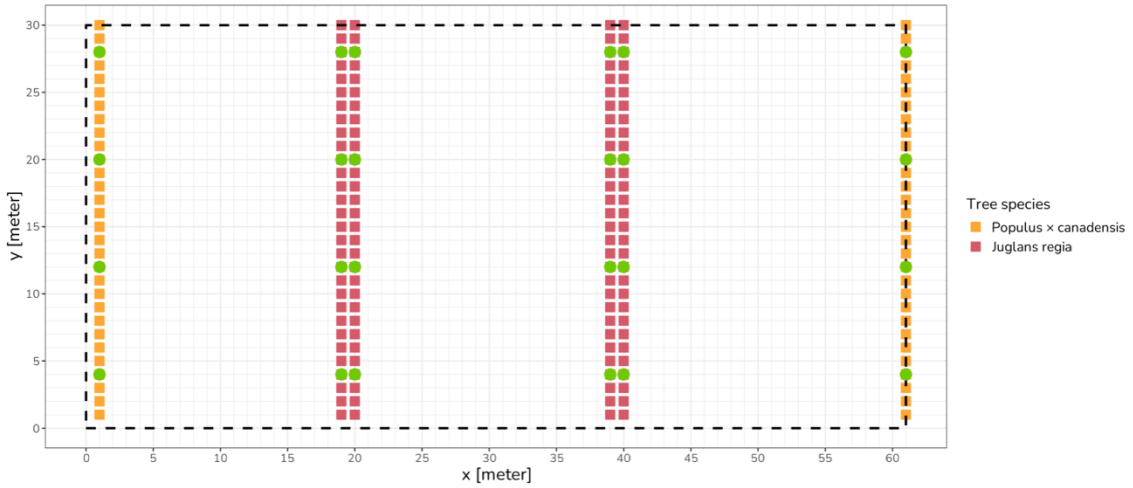
If you have drawn a row incorrectly or want to remove one, switch to the '**Remove' mode** and click the corresponding tree rows to delete them.



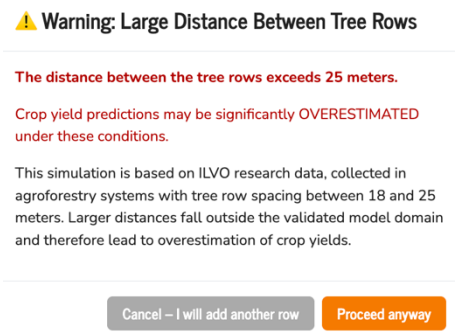
When selecting a tree row to draw, the map shows you the exact location where the row will be placed. The preview follows your cursor, allowing you to position the row with precision.



When you are satisfied with your design, click **'Confirm Rows'** to save all drawn rows and finalize the layout.



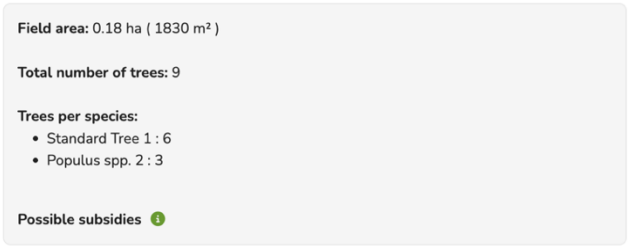
When the distance between tree rows exceeds a certain threshold (25 m), a warning will appear. You can choose to adjust the configuration or continue with the current design. If you proceed, keep in mind that the models used may overestimate crop yields under these conditions.



For the next steps, we continue working with the design created in the Try-out mode.

FIELD OVERVIEW AND SUBSIDIES

After designing your field, you receive a concise overview of the total area and the number of trees per species. This information shows which (Flemish) subsidies you may be eligible for.

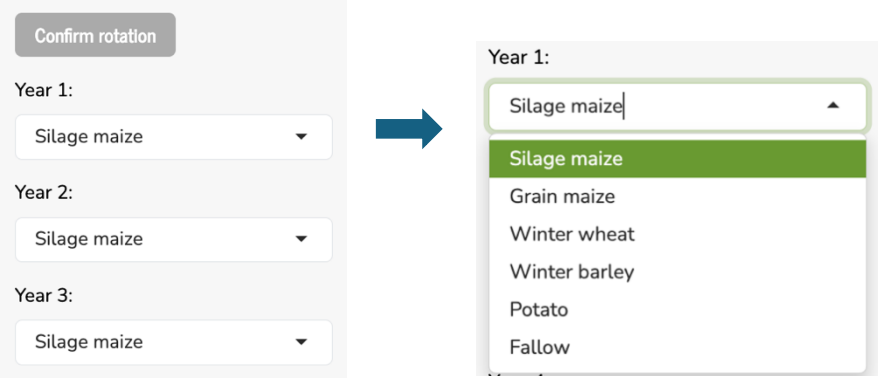


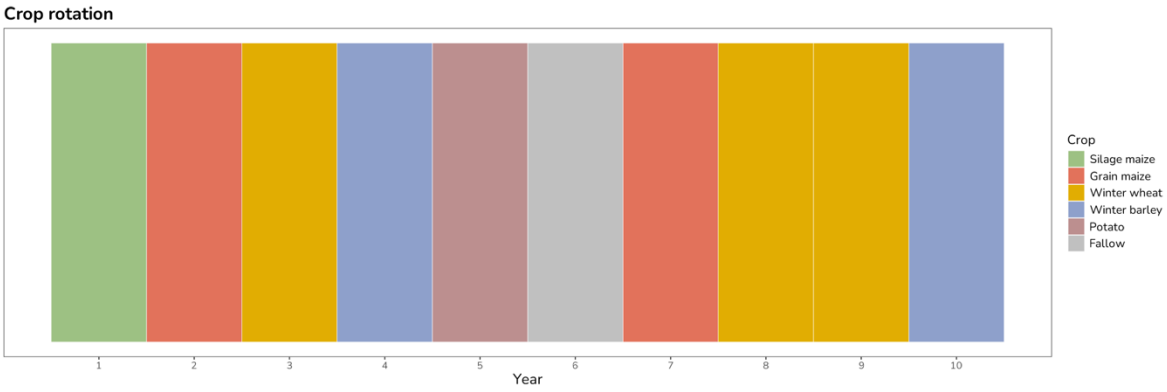
By clicking the info button, you can access the relevant subsidy information. The following link also provides additional details on CAP subsidies for the planting and maintenance of agroforestry systems (Flemish regulations). The Flemish Agency for Agriculture and Fisheries sets clear conditions for these subsidies. These conditions can also be found via this this link (BLS) and this link (BLO).

STEP 2: CROP ROTATION (CROP ROTATION TAB)

SET-UP A 10-YEAR CROP ROTATION

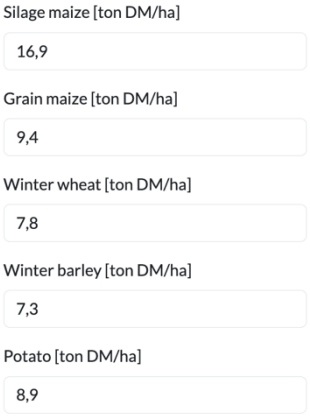
You can choose from five available crops or leave the field fallow. For each year, select the desired crop from the dropdown menu and confirm the rotation by clicking **'Confirm rotation'**. A visual overview of the chosen rotation will then be displayed. Do you use different crops in practice? Then try to select the crop that most closely matches your intended choice in terms of growth and yield (e.g., choose winter wheat if you would normally grow oats).





AVERAGE CROP YIELD IN SOLE-CROPPING

For each crop, the yield in tons DM/ha is automatically filled in based on the **standard yield values** from the STATBEL data. You can manually adjust these values by clicking in the field and entering a new value that better fits your simulation or your specific plot.



STEP 3: SIMULATION (TABBLAD SIMULATION)

After designing your field and defining the crop rotation, you can start the simulation. Click **'simulate alley-cropping system'** to begin.

If you have skipped a previous step, a notification will appear indicating what is missing, allowing you to correct it before the simulation starts.

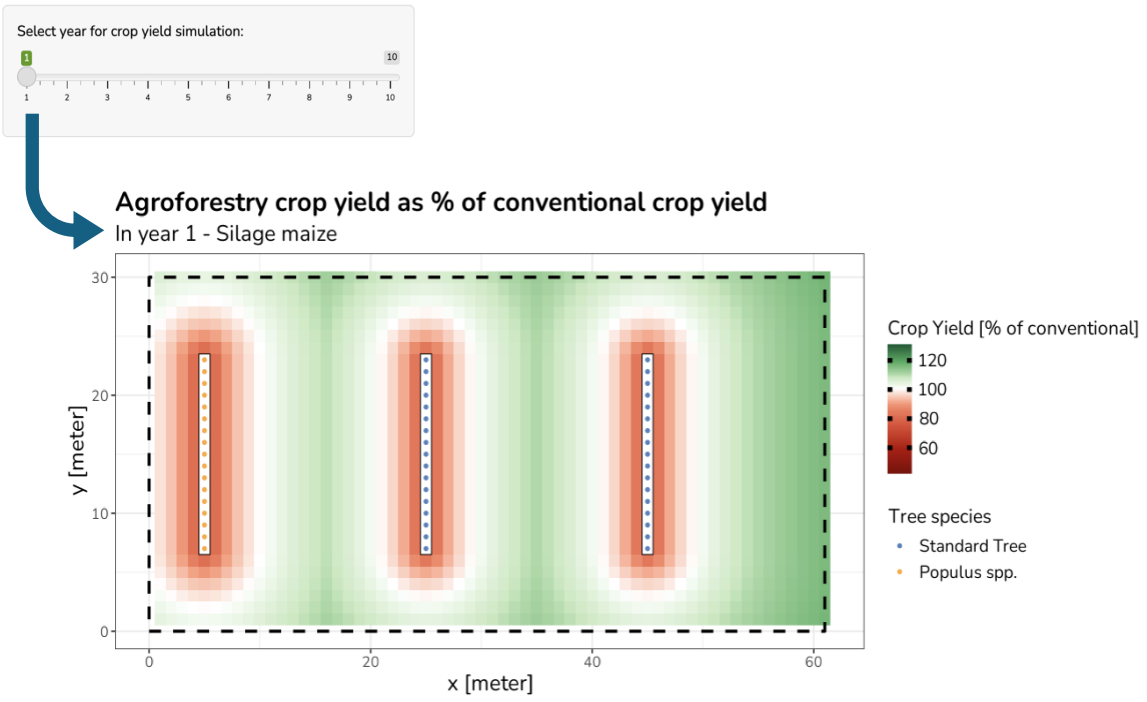
The results are displayed in three separate tabs:

- **Alley-cropping Yield** – annual yields for each crop and tree species
- **Quality Parameters** – yearly quality indicators per crop
- **Economic Output** – economic valuation of timber and crop production

RESULTS SIMULATION

1. CROP AND TIMBER YIELDS FOR A 10-YEAR ROTATION IN AN ALLEY-CROPPING SYSTEM

The **crop yield (tons DM/ha) is displayed per year for the entire field**. This allows you to immediately see how the tree rows influence crop performance. Using the slider **'Select year for crop simulation'**, you can view each year individually. The color gradient compares the alley-cropping yield with the average yield of sole-cropping systems: white represents 100% (equal), red shades indicate lower yields (darker = lower), and green shades indicate higher yields (darker = higher).

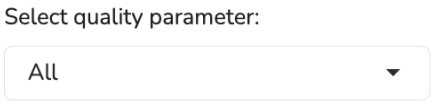


For the other outputs, you will see the following from top to bottom:

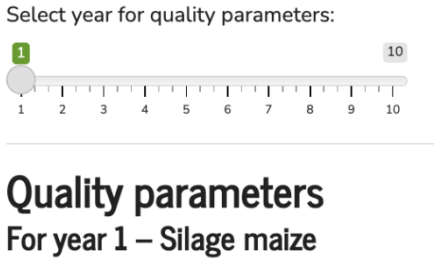
- A **bar plot showing the annual crop yields** in the alley-cropping system, alongside the average sole-cropping yields for comparison, for all 10 years.
- A **bar plot displaying the cumulative crop losses** in the alley-cropping system over the 10-year rotation.
- A **bar plot showing the cumulative timber yields** for the different species, with the total wood volume presented in year 10.
- A **summary table**: simulated crop yield in the alley-cropping system (tons DM/field and tons DM/ha), average crop yield in a sole-cropping system (tons DM/ha), the difference (tons DM/ha), and the alley-cropping crop yields expressed as a percentage of the average sole-cropping yields.

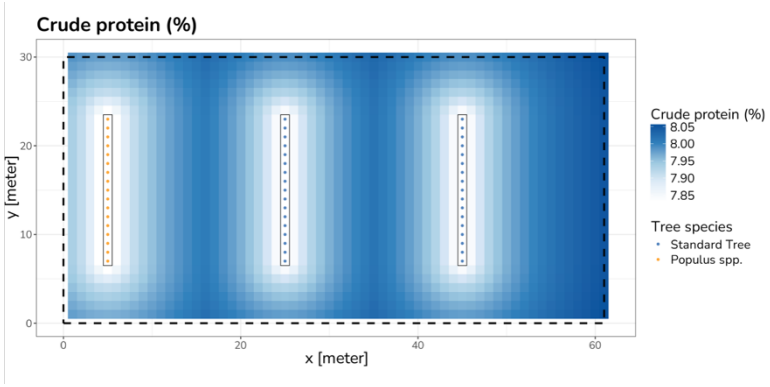
2. QUALITY PARAMETERS

On the left side of the tab, a **clear table summarizes the quality parameters of the field for each year**. For every year in the rotation and for each parameter, the table displays the minimum, maximum, and average values. Using the **'select quality parameter'** menu, you can also choose a specific parameter to view its evolution over the years.



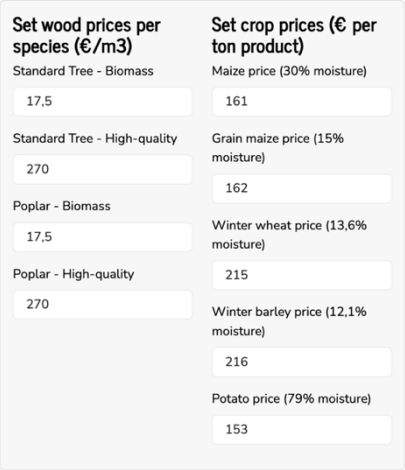
On the right side, the **quality parameters for a selected year** are displayed. You can choose the desired year using the **'select year for quality parameters'** slider. The values are shown using a color gradient, making differences within the field clearly visible. This visualization also highlights how the tree rows influence crop quality.



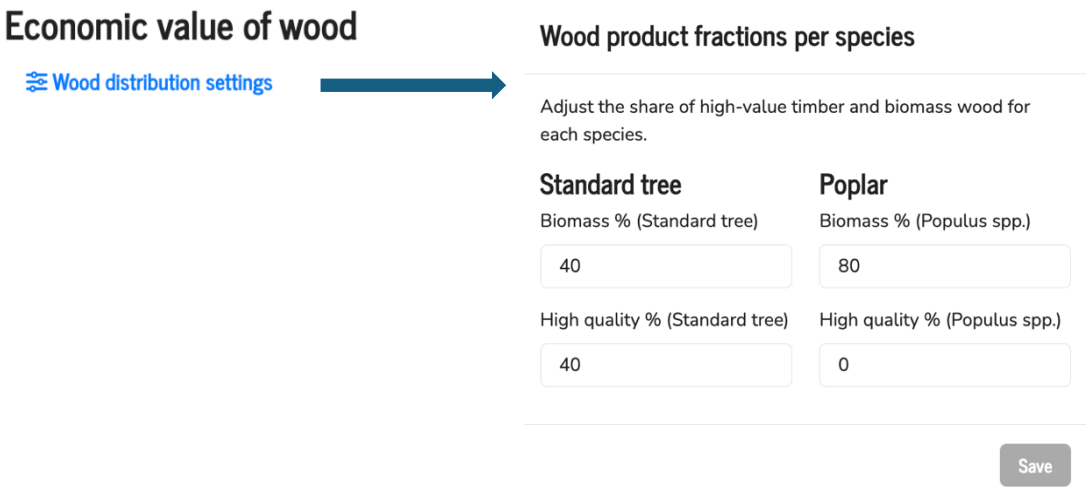


3. ECONOMIC VALUATION

You have the option to adjust the **market prices** for **timber production** (both biomass wood and high-quality timber) and **crop yields**. Default values are provided for both categories..



You can also adjust the **distribution of the timber volume across the different end products** or use the default values. When you click the 'Wood distribution settings' button, a pop-up window appears in which you can modify how the timber volume is allocated to the end products.



The first table shows the **total economic result for the field over a 10-year rotation** after the transition from a sole-cropping agricultural system to an alley-cropping agroforestry system. It provides an overview of the **total timber revenues, the crop losses, and the net result for the first 10 years**. The second and third tables present a detailed breakdown of the timber revenues and crop losses.

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