Simulation of growth and development of beech seedlings growing in different light environments using PIAF-1.

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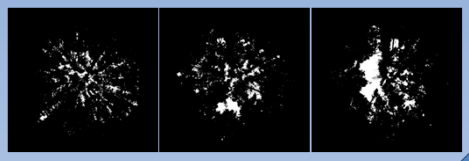
The European beech (*Fagus silvatica* L.) is a late-successional shade tolerant species. It is often cultivated and managed with the shelterwood system in Europe, meaning that its natural regeneration takes place in shade. Under low light conditions, seedling can grow slowly but their size must stay below a threshold where carbon gain and carbon balance remain positive. This is not so easy to determine experimentally. Carbon base model called PIAF-1 was introduced in FSPM conference in 2006. This model was first developed to be used with walnut seedling. The model can determine the growth, development, carbon gain and carbon balance in each organ of walnut seedling. In this study, we try to adapt PIAF-1 Model to be used in beech seedlings.

Two-year-old beech seedlings were planted in March 2007 in the understorey of natural Scots pine stands in Fontfreyde, Chaîne des puys, France. Some pine trees were cut to lighten the density and gave more light intensity on the understory. In summer 2009, nine beech seedlings were sampled under light availability ranging from 7 to 28% of incident light. Those seedlings will be used to determine the growth and development using PIAF-1 model. Those tree also use for parameterize in PIAF-1 model.



Gap fraction analysis + Meteorological data

Digitized data

Tree graph (MTGs)

Sugar, starch and Biomass measurements

Environmental parameters | **PIAF-1 tree architecture** | **Tree parameters**

PIAF-1 input files

PIAF-1 Model

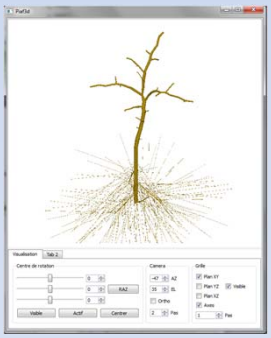
No.	Code	Dry weight (g)	Leaf area (cm^2)	Amount of light
1	P1_12	44.77	2563	10%
2	P1_32	53.58	3182	8%
3	P1_82	45.68	3403	7%
4	P2_05	75.51	4773	17%
5	P2_67	42.34	3260	13%
6	P2_75	40.28	2622	13%
7	P3-38	49.45	2823	28%
8	P3_57	92.46	5993	21%
9	P3_77	63.09	2696	24%

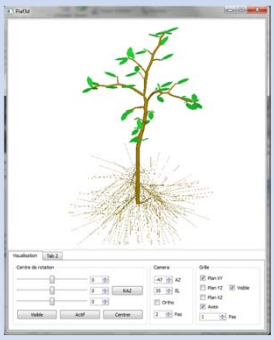
To acquire seedling architecture, aboveground parts of each seedling were 3D-digitized, including woody parts (growth units) and leaves using PiafDigit (Donès *et al.*, 2006). Then, seedlings were harvested in autumn and winter to quantify biomass , starch and sucrose contents of each organ of the above and below ground parts. Roots were separated into 3 classes: taproot, main lateral roots and fine roots. Those data were used to parameterize and initialize PIAF-1 tree input parameters. The digitized aboveground parts were converted from growth units within a MTGs file to be cylindrical segments bearing leaves in their true place and orientation that can be used in PIAF-1. Belowground parts were reconstructed based on diameter and length of each root class to sustain the same volume as the real seedling.

Meteorological input data (hourly light and temperature) were generated for each seedling based on recorded data from Fontfreyde meteorological station. Transmitted solar irradiance above the seedling was calculated from hemispherical photographs and the global radiation above the stand.

Result : PIAF-1 tree architecture inputs are totally different compare to MTGs system. Tools to convert MTGs file to be PIAF-1 tree architecture file has been developed. Seedling architecture was reduced to the time of January 2009 so that simulation can be done for the duration of one year. At the present stage, only one seedling has been converted, corrected and test run in PIAF-1. Potential growth, amount of storage, and reserve capacity of stem, leaf and root of each seedlings were analyzed and made as a tree parameters input file.

For the photosynthesis capability of beech, we used the results from Dreyer et al. (2001) as photosynthesis parameters. At the present time, beech phenology parameters are still developed, walnut seedling phenology parameters were used instead. Each input files were test and the protocol to create the files has been developed. The simulations on seedling P1_32 have been done. The whole tree carbon balance was shown (1), (2). The Carbon balance of the whole tree shows negative value. It means this seedling cannot survive. This negative value may come from the unmatched of growth parameters. It may also because we use many parameters those belong to walnut seedling. Comparing with beech seedling, walnut seedlings grow much faster and it was grown under different light environment.





Conclusion : Until present, PIAF-1 Model has the potential to simulate the growth and development of beech seedling. The model can simulate the amount of carbon demand, carbon gain and carbon reserves in each organ of the seedlings. But due to the showing of negative carbon balance, input parameters, especially the phenology of beech seedlings should be adjusted.