GLUP

Carbohydrate Reserves of Poles

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Context — In forest systems where canopy disturbance is common (most managed forests, natural forests in areas of regular disturbance), the ability of trees to respond quickly to canopy opening determines their ability to reach the top canopy (Harcombe et al., 2002, Kwit and Platt, 2003). It is an essential element of the competitiveness of trees relative to their immediate neighbours, whose individual characteristics are extremely contrasted in uneven-aged and mixed stands. Characterizing the response of trees to competition release and understanding the processes that determine growth recovery is a preliminary step in predicting the relative competitiveness of individuals and, in mixed forests, the co-occurring species (Landis et al. 2005).

Objectives — The initial scientific objectives for GLUP were to test (1) whether the carbon distribution between growth and storage functions is changed between long-standing dominated trees (control) and trees released from competition (thinned) and (2) whether beech and the sessile oak, two species with contrasted shade tolerance and contrasted ecophysiological functioning, respond differently to the sudden opening of the canopy. From operational point of view, the question is to understand the limits of response to late and local competition release for these two social species of major economic interest in France and, more locally, in Lorraine.

The second hypothesis could not be approached, as the National Forest Office did not allow us to harvest the oaks for the duration of the project.

Approach — Two uneven-aged and mixed stands among silvicultural experiments aiming at studying the response to competition release (height about 10 m under the canopy) were studied in Bride Forest (57) and in Ageville forest (52). The beech poles studied at Ageville are younger (70 years old) and with a higher height to diameter ratio than those of Bride (ages ranging from40 to 110 years). The competition release of the beech poles occurred during the winter of 2007-2008. At Ageville, 14 control and 10 thinning poles were sampled for joint analysis of radial growth and total non-structural carbohydrates (TNC). At Bride, 21 control poles and 21 thinned poles were sampled. All sample trees were felled seven years after canopy opening. For each tree, successive height annual increments on the main axis were estimated by using the annual growth units. In parallel, a disk was collected at 1.30 m height from each tree, ring width, from pith to bark, was measured in four perpendicular radii. The TNC reserves content were measured on wood cores taken from the base of the stem in October 2014, the date of maximum TNC concentrations. Each core was cut into three segments of 0-2 cm below the bark, 2-4 cm, then 4- to the pith. An enzymatic assay was carried out for the starch concentrations and a colorimetric assay (van Handl, 1968) for the soluble sugar concentrations, expressed in% of dry matter. TNC included starch and soluble sugars, i.e. the total carbohydrates available for the tree functioning.

Key results — The results are presented according to three specific hypotheses tested during the project:

1. Dominated beech poles from the understorey maintain total non-structural carbohydrate that allow surviving and reacting to thinning. Total non-structural carbohydrate (TNC), starch and soluble sugars concentrations are 2.6% DM, 1.5% DM and 1.1% DM, respectively, for control poles, slightly lower than reported by previous studies (Gérard and Bréda, 2014). On these control poles, a typical radial distribution of TNC is decreasing from recent rings to the pith. The poles from Ageville forest has significantly lower starch and soluble sugar as well as TNC contents than those from Bride, and two control poles showed extremely low starch concentration (<0.5% DM), too low to sustain the metabolism and defence necessary for immediate survival.

2. The release of the competition increases the growth and storage functions in the stem compared to control poles. Concentrations of starch, soluble sugars and total carbohydrates are not different between control or thinned trees. Tree allometry is modified in thinned trees: trees allocating more diameter growth than to height growth during the first years after canopy release. The amounts of TNC per tree are significantly higher because of a trunk biomass increased by thinning.

3. Releasing local competition by thinning increases the carbon partitioning to the growth function. The carbon partitioning was estimated as the ratio of stem radial increment since treatment (seven last rings) and a proxy of total carbohydrate (concentration x basal area). The variance of the carbon partitioning among poles is explained ($r^2 = 0.6$) by a positive effect of thinning ($p = 0.0001$), a negative effect of tree age ($p = 0.0022$) and a positive effect of length relative crown ($p = 0.0001$).

Main conclusions including key points of *discussion* — The competition release of beech poles (shade tolerant species) increases the carbon uptake of trees allowing both an increase in the stem radial growth and the maintenance of total non-structural carbohydrate concentrations similar to the control poles (no dilution effect, compensation of increased growth and maintenance respiration). This ability to maintain stable starch concentrations regardless of the level of competition age, status, constraints experienced is consistent with the observations in MEPIB-DEATH project. The individuals with a higher height to diameter ratio, with less developed crowns or the older ones seem less able to maintain this conservative balance.

Future perspectives —As the National Forestry Office did not authorize to harvest poles oaks, similar analyses could not be performed on oak. This is unfortunate since our goals was to see if the local competition release would impact differently the reaction of the two contrasting species in terms of shade tolerance. The study of oak behaviours remains relevant.

Valorisation —

GERARD B., BRÉDA N. (2014) Radial distribution of carbohydrate reserves in the trunk of declining European beech trees (*Fagus sylvatica* L.). *Annals of Forest Sciences* 71, 675-682.

HARCOMBE P.A., BILL C.J., FULTON M., GLITZENSTEIN J.S., MARKS P.L., ELSIK I.S. *(*2002) Stand dynamics over 18 years in a southern mixed hardwood forest, Texas, USA. *Journal of Ecology* 90, 947-957.

KWIT C., PLATT W.J. (2003) Disturbance history influences regeneration of non-pioneer understory trees. *Ecology* 84, 2575-258.

LANDIS R.M., PEART D.R. (2005) Early performance predicts canopy attainment across life histories in subalpine forest trees. *Ecology* 86, 63-72.

VAN HANDEL E (1968) Direct microdetermination of sucrose. Anal Biochem 22 (2): 280-283.