Does wind matter in the growth response of beech poles to thinning?

Thiéry Constant, Joel Hans DONGMO KEUMO JIAZET, Jana Dlouha, Vivien Bonnesoeur, François Ningre, Etienne Farre, Meriem Fournier, Bruno Moulia

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Context : The forestry side

- Windstorms have a destructive effect on forests (Gardiner et al. 2009)
- Foresters were recently aware of the role of wind as a growth factor in forest production (Meng et al. 2006, Watt et al. 2010, Dean et al. 2013),
- For managing a stand, the main foresters' tool is thinning
- But… wind exposure of a tree is also modified by thinning as light environment, competition for water supply and nutrients

- Which is the importance of natural mechanical stimulations in the increase of growth resulting from thinning ?

Context : Recent work published by Nicoll et al. 2019

forests

MDPI

Article

Changes in Spruce Growth and Biomass Allocation Following Thinning and Guying Treatments

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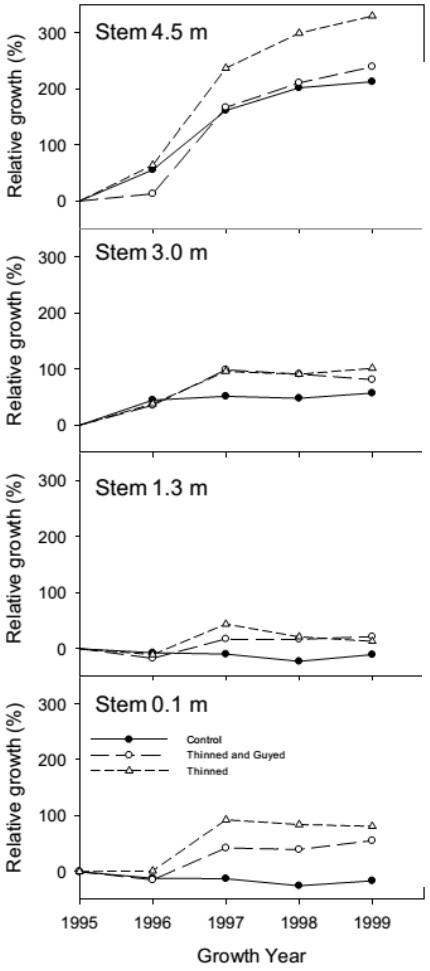
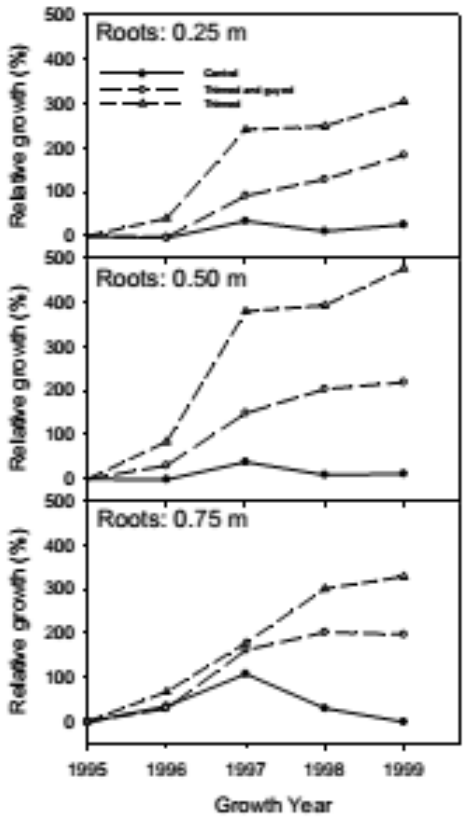
check for updates

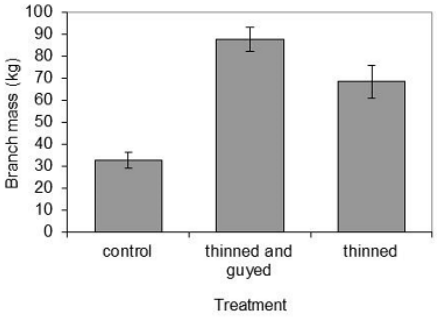
Stem Radial Growth



Root Radial Growth

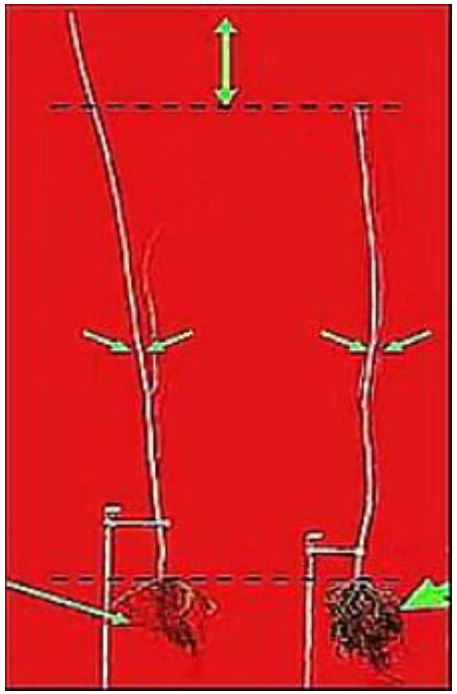


Branch Biomass



Context : The biological side

- Thigmomorphogenesis has been demonstrated as a powerful mean for acclimation of trees to wind regimes
- Bending strains are the stimuli sensed by plant (Coutand et Moulia 2000) and the S3M model formulates the mechano-perception process (Coutand et Moulia 2000 , Moulia et al., 2011, 2015)
- Most of studies were performed under controlled environment and mainly with seedlings.



Coutand PS 2010

- Can we transpose the gained knowledge in a forestry context for understanding the role of wind in the growth response of trees after thinning ?

The Wind-Thin* Project

- Project began in 2012 within a French project Forwind (2012-2016) in collaboration with PIAF (Clermont-Ferrand) – ONF-RDI (Nancy)
- A stand acclimated to its wind regime (i.e. no silvicultural intervention since 10 years)
- Beech (*Fagus sylvatica L.*)
- Forêt de Haye" ~ 10000 ha close to Nancy mainly broadleaves on a limestone plateau
- Stand used for a1ststudy (Bonnesoeur et al . 2016)

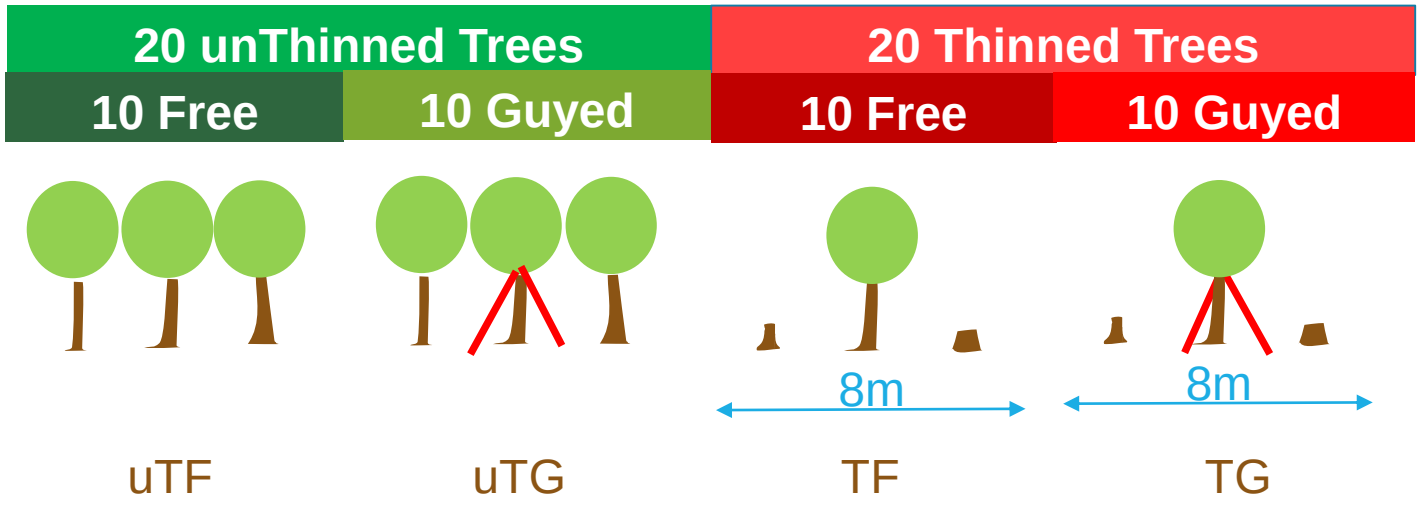
The Wind-Thin experiment

- Location : Haye forest close to Nancy (France)

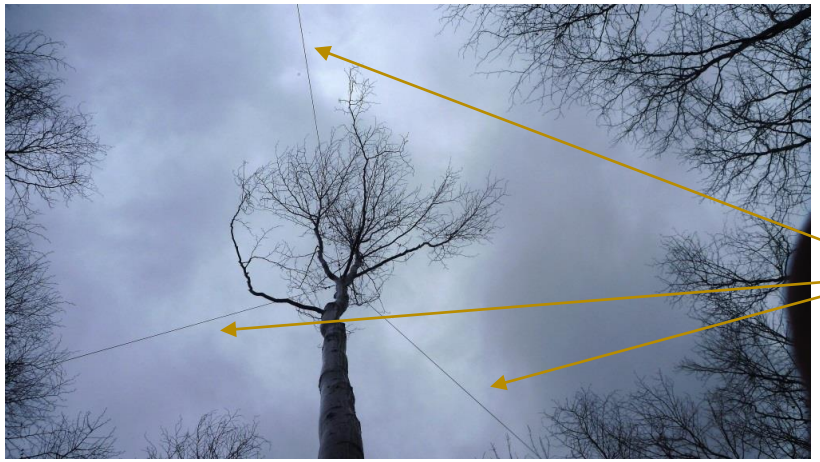
© Frank Fife/ AFP

The Wind-Thin experiment : Design

- Start in 2015.
- DBH ~13 cm, Ho ~ 13 m, RDI = 0.87, Age ~30 years, Limestone plateau,
- 40 Beech poles divided into 4 treatments
  (guyed or free to sway) X (control or thinned trees)
- Each group representing the range of sizes within the stand



The Wind-Thin experiment

	Unthinned	Thinned
Free to sway		
Guyed		

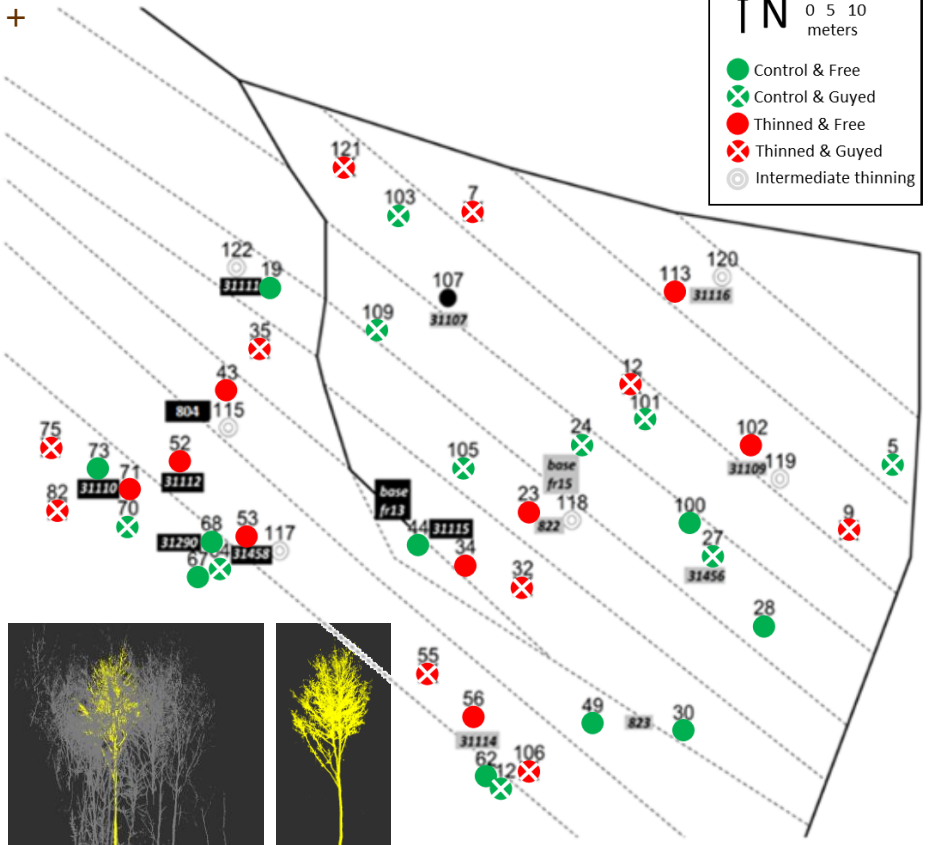
3 steel cables

The Wind-Thin Experiment : monitoring

Band Dendrometers +
Point Dendrometers

Strain Sensors

Close to breast height



2014 /2016 / 2018
3D T-Lidar data
and
spatialized inventory of the neighbours

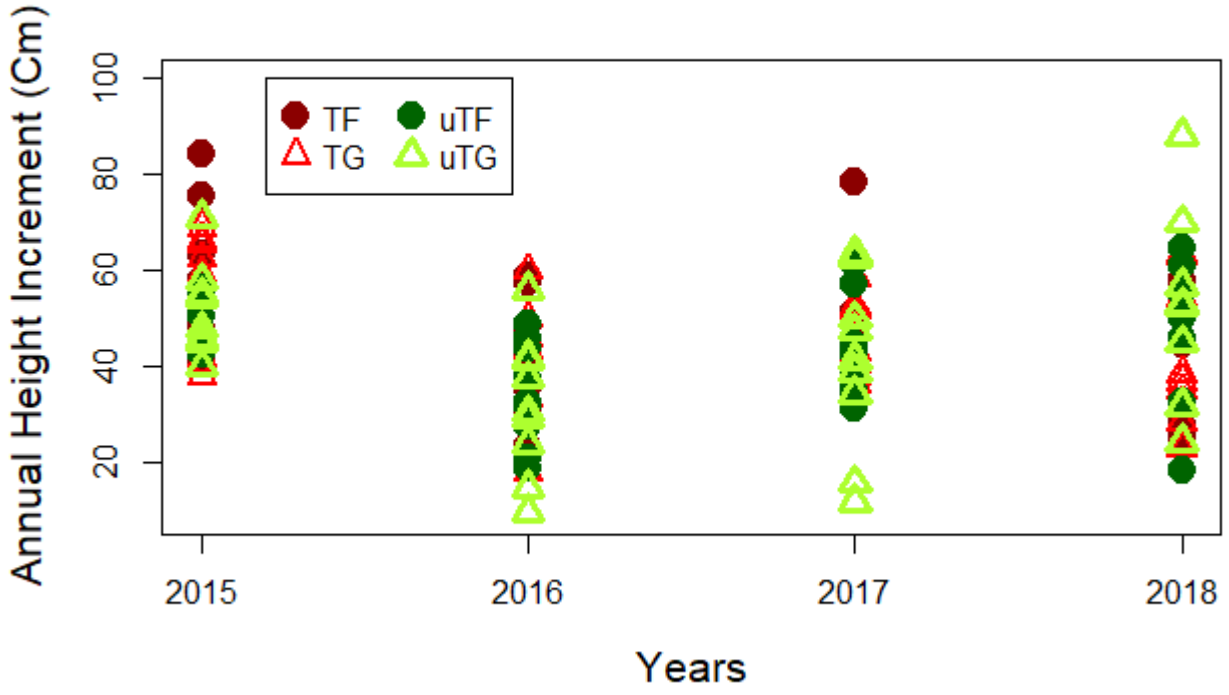
20m Meteorological Mast

Annual LAI measurements and
soil characterization to calculate water-balance

The Wind-Thin Experiment : final characterization

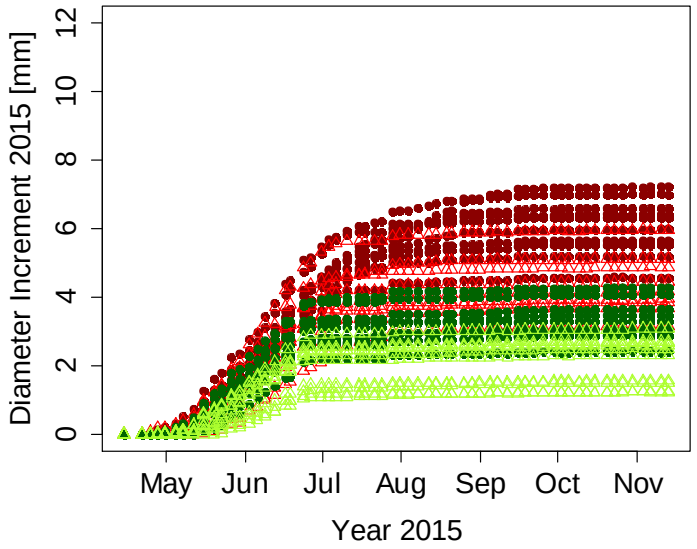
- T-Lidar measurements
- Biomass distribution
- Pulling tests (Cf. Joel's presentation)
- Root systems and soil characterizations
- Wood samples
  - Mechanical properties, density, MFA
  - Stem analysis
  - Grain angle
  - refined analyis of radial growth anisotropy

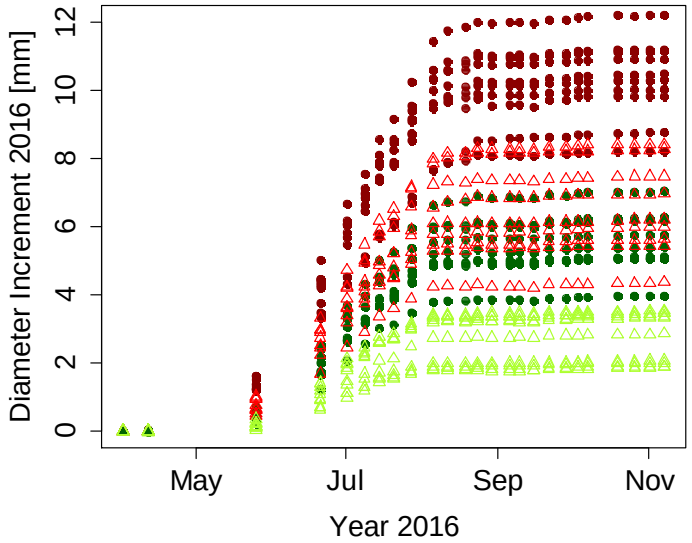
Annual Height Increment

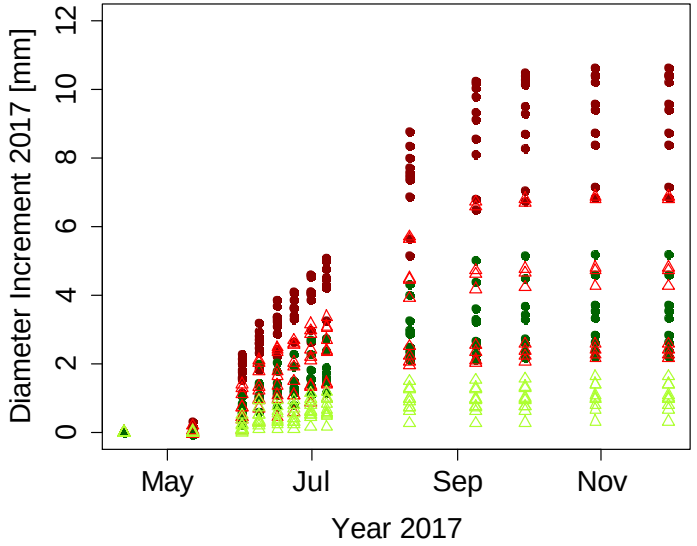


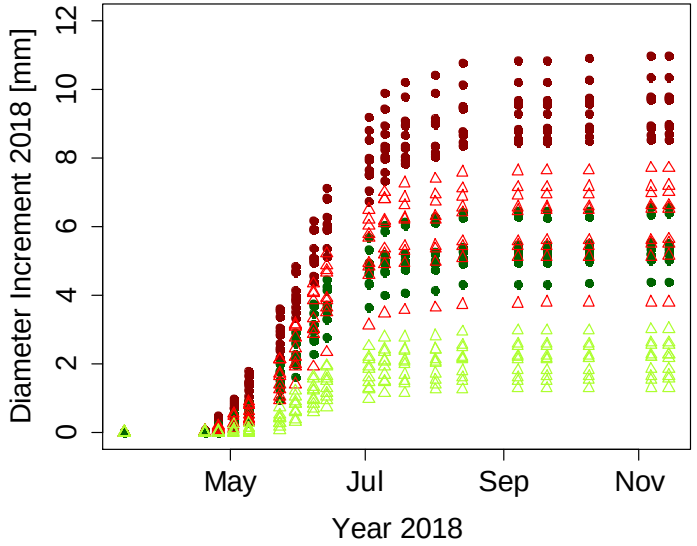
- Measured retrospectively after felling
- No significant differences between
  - Treatments
  - Years
- Results contradictory to previous findings…?
  - Apical control less prononced for beech than for conifers or poplar in young stages?
  - Height of guying is ~1/2 H_T and hence the differences of branches motion due to wind for a tree guyed or not is not perceptible by the tree

Measured Diameter Increments

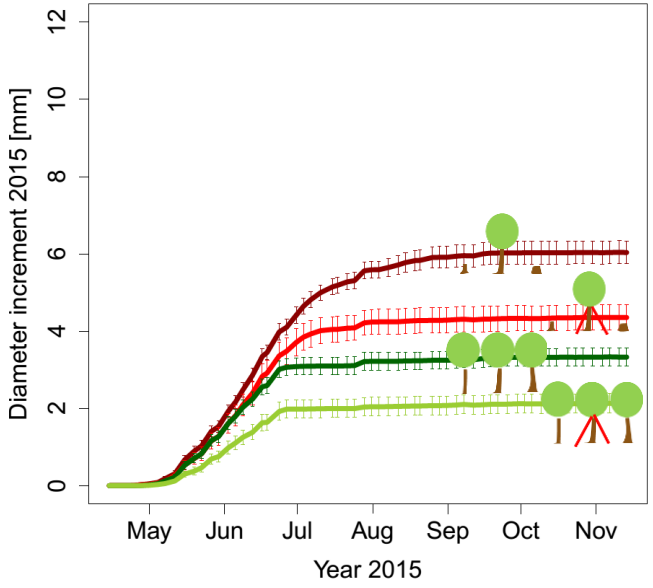


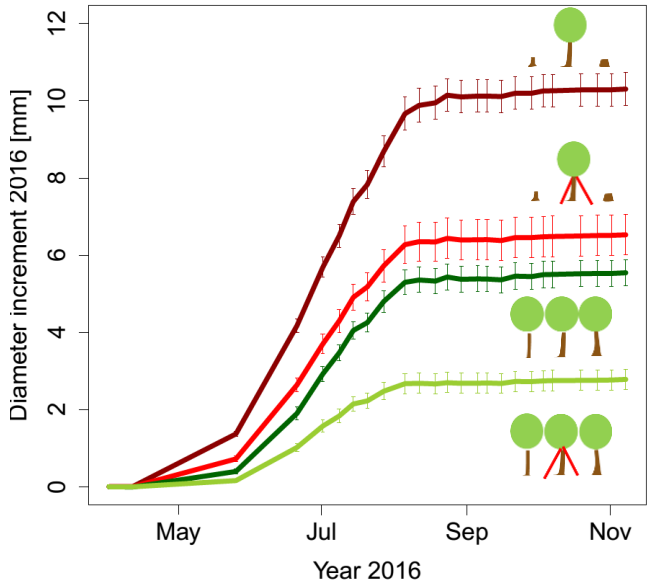


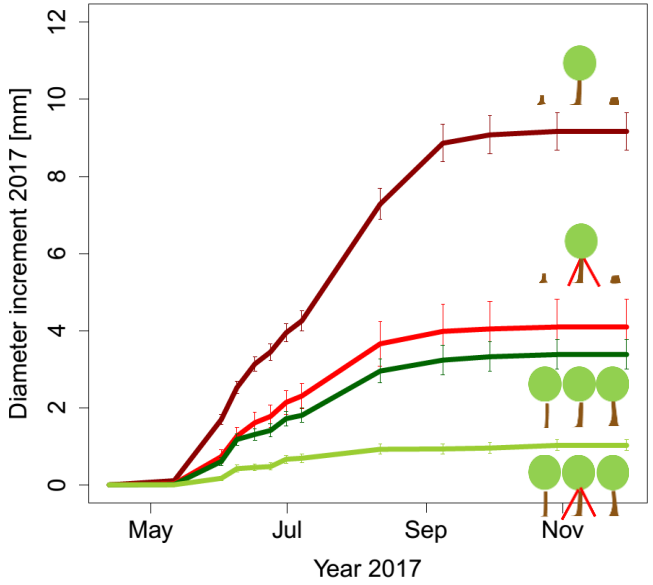


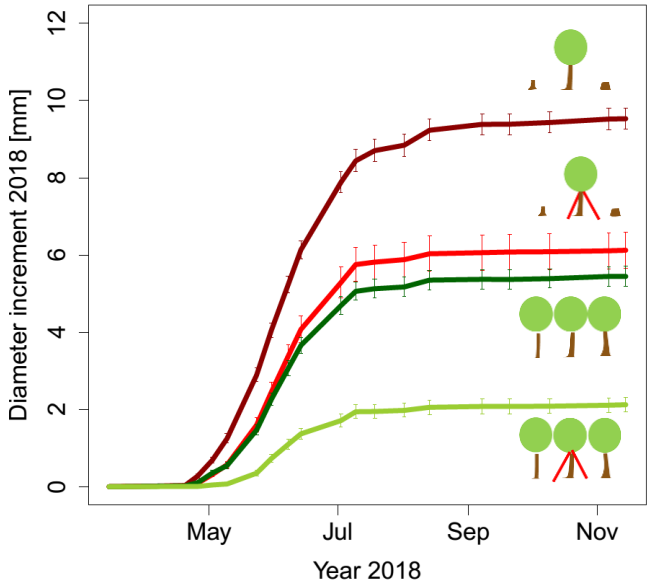


- From band dendrometers
- By year
- By treatment
- By tree





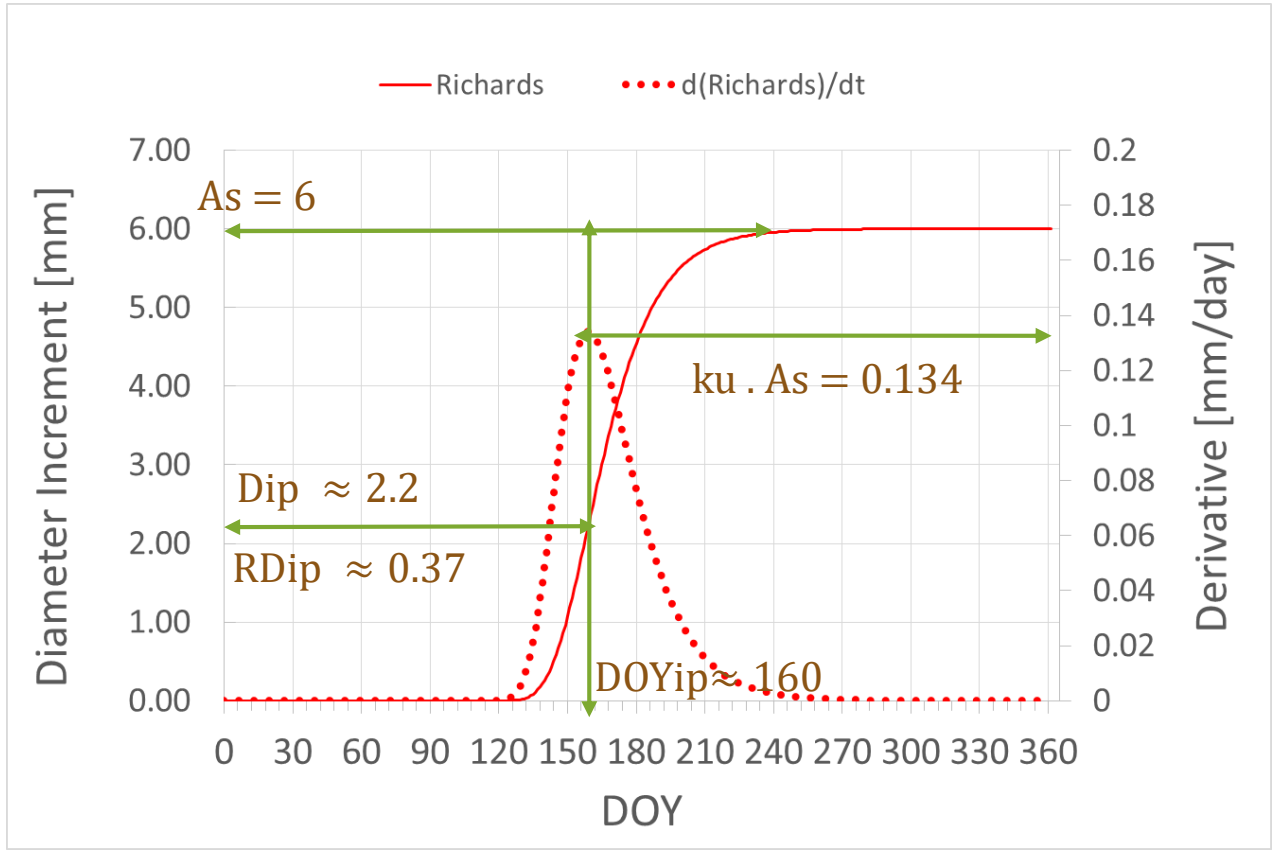




Averaged Values with CI95

- By date and Treatment

Methods : Richards's Model Parameters



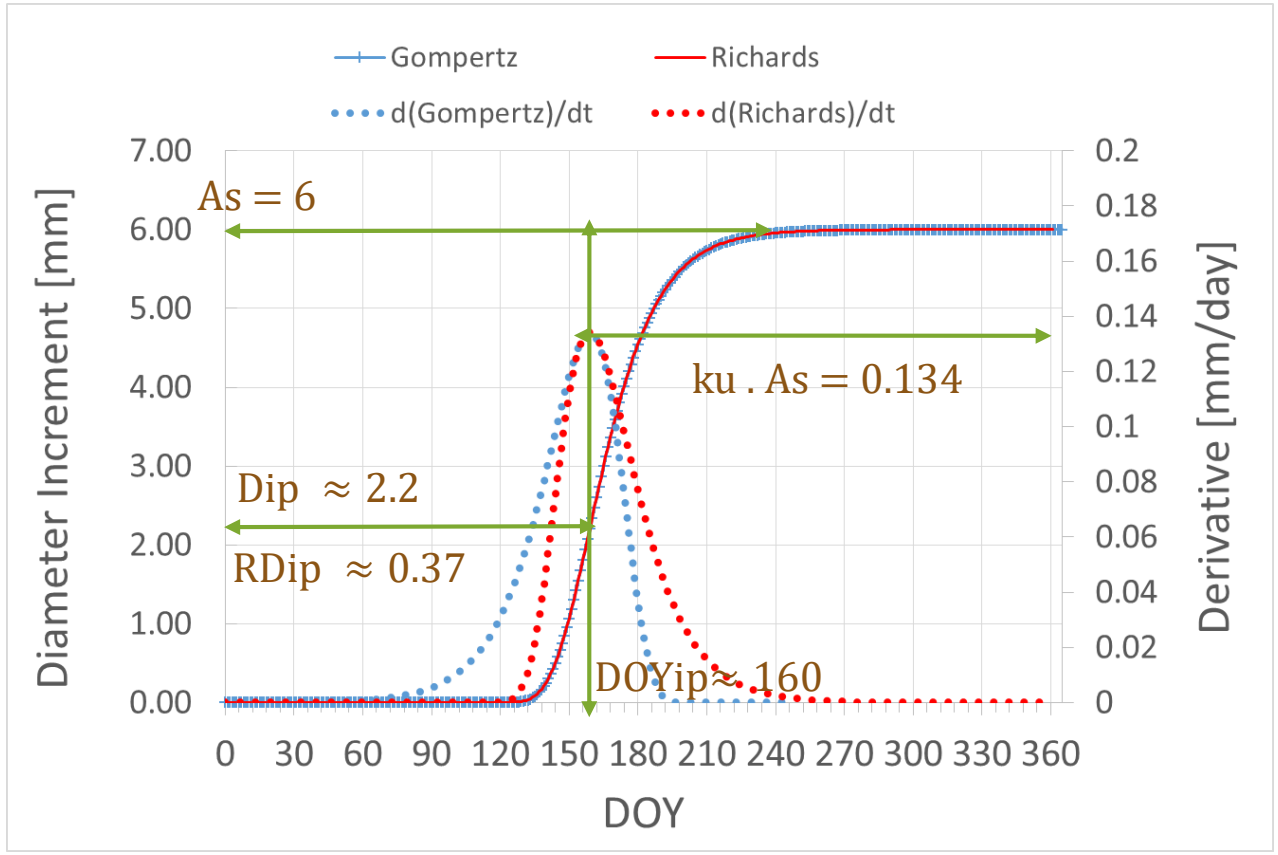
- Sigmoidal model with 4 Parameters
- Uniform parameterization [Tjørve & Tjørve 2010]
- As : Upper Asymtote [mm]
- ku : Maximum Relative Growth Rate [%/day]
- DOYip : Day of Inflection Point (IP)
- d → $RDip$ = Proportion of As at IP

$$RDip = d^{\frac{d}{1-d}}$$

- Pros : joins the upper asymptote gradually
- Cons.: Risk of no convergence with 4 parameters

  -> Gompertz's Model (3 parameters)

Richards's Model Parameters



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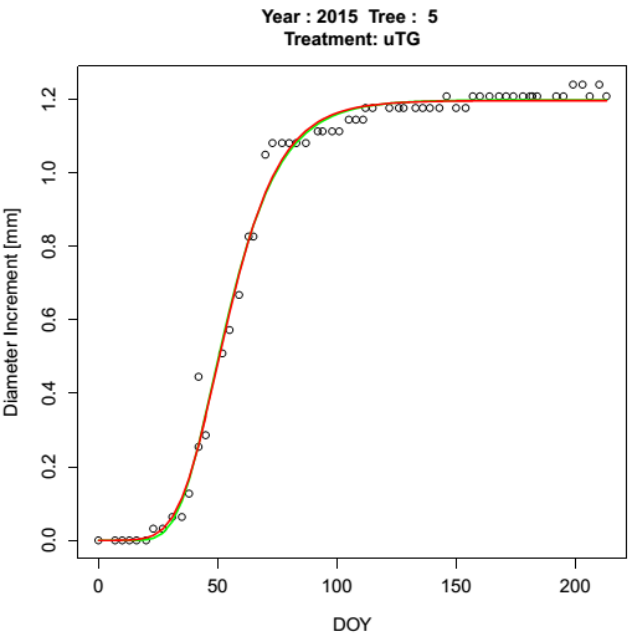
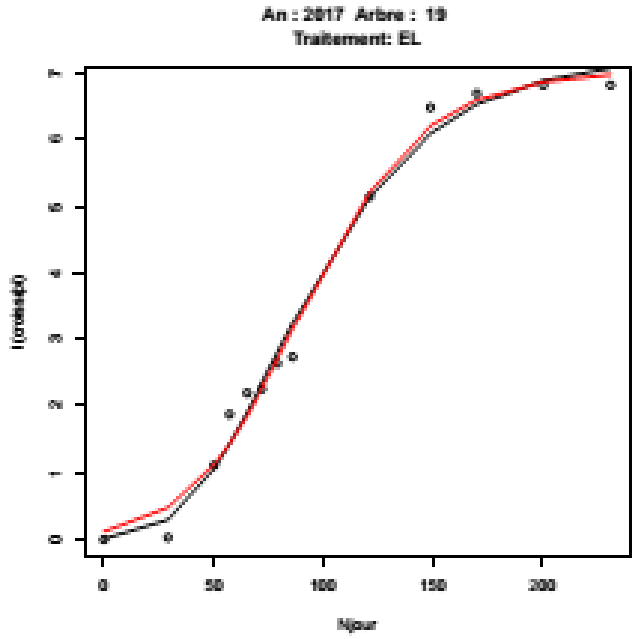
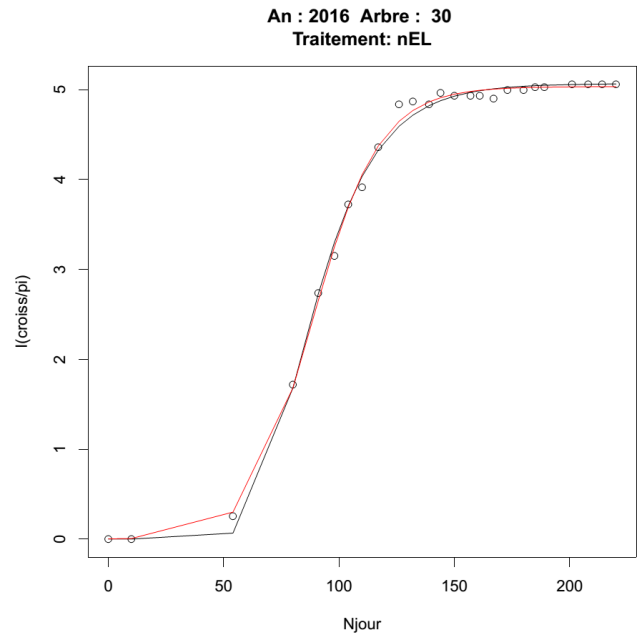
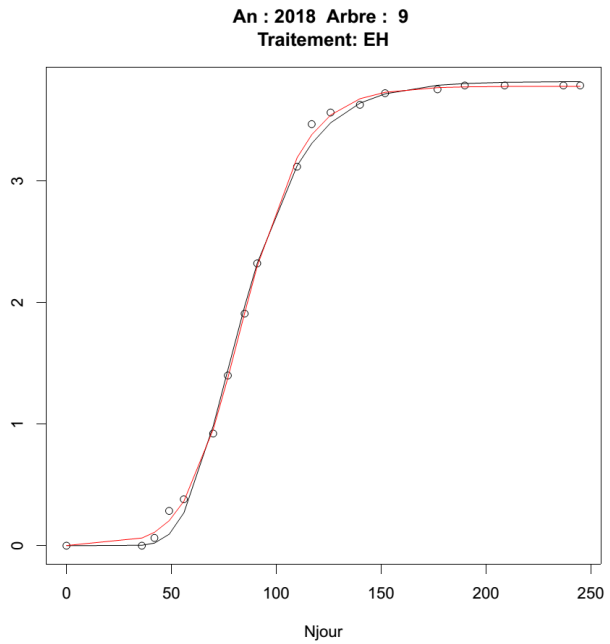
Some examples of the fitting between Gompertz and Richards (Red)

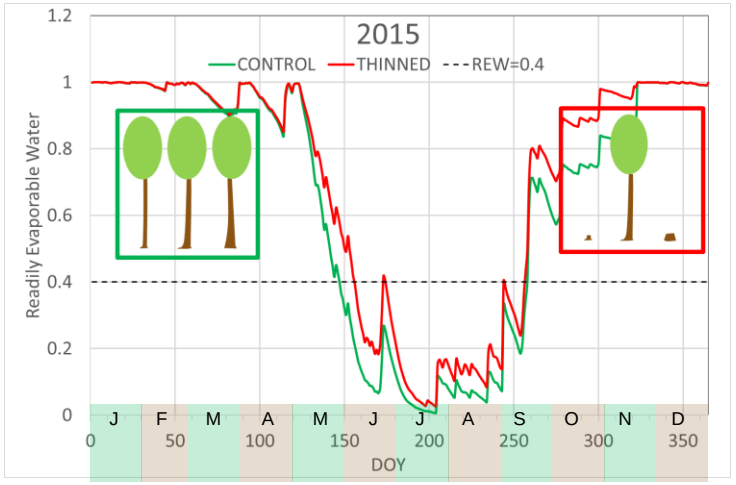


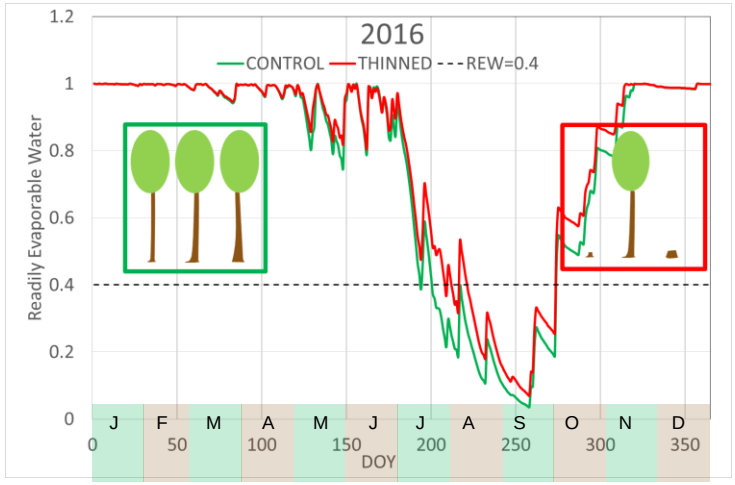


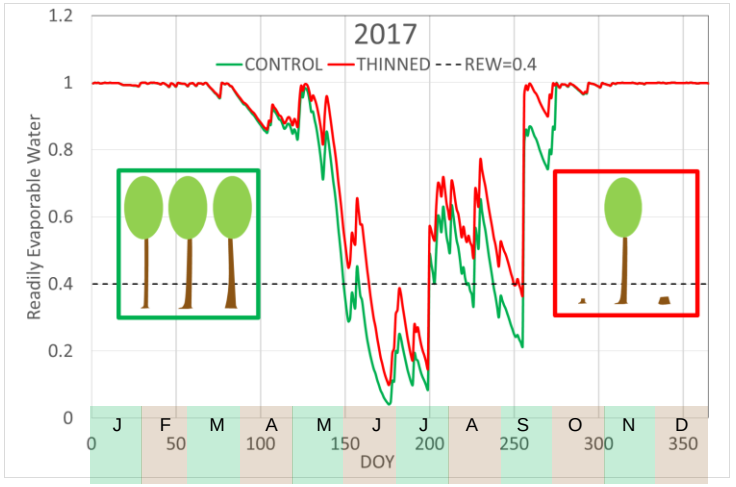


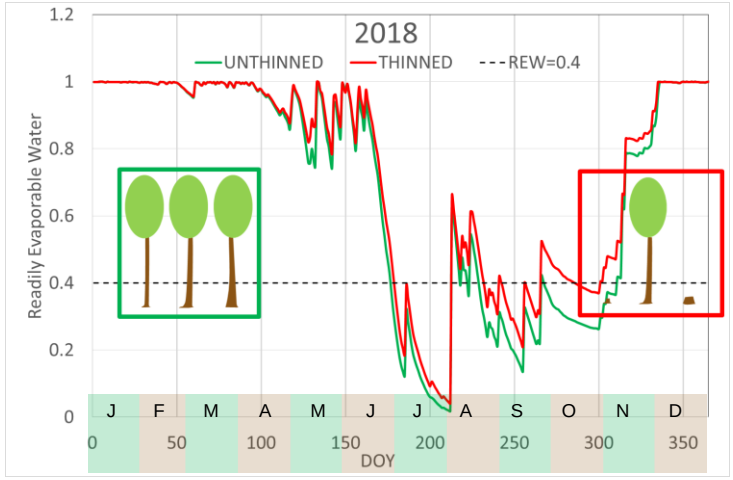


Which ranking between years for the tree growth potential (~ no water stress) ?





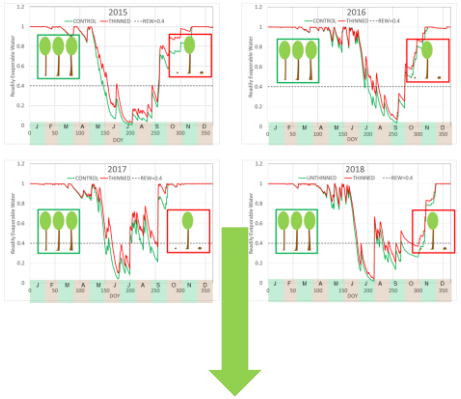




- Daily Water Balance computation by BILJOU © https://appgeodb.nancy.inra.fr/biljou/en
- Result = Daily Readily Evaporable Water
- REW < 0.4 => Water Stress
- Start of water stress is year dependent
- Unthinned trees (LAI~7) more stressed than thinned trees (LAI ~5) and earlier but we don't want to be so detailed in our ranking

Which ranking between years for the tree growth potential (~ no water stress) ?

- Criterion : Number of days / per month without stress

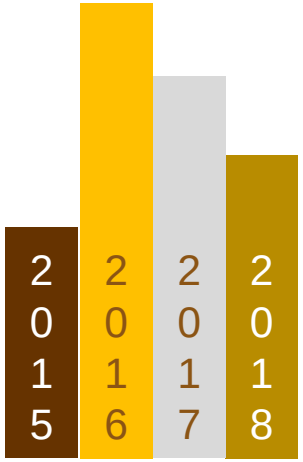


REW > 0.4

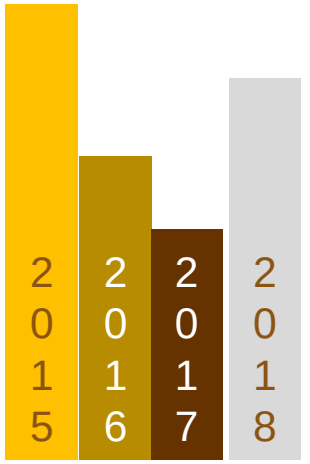
Number of days per month without water stress

	May	June	July	August	September
2015	27	0	0	0	16
2016	31	30	17	0	1
2017	29	2	13	21	18
2018	31	25	0	14	2

Podium
Water Availabity

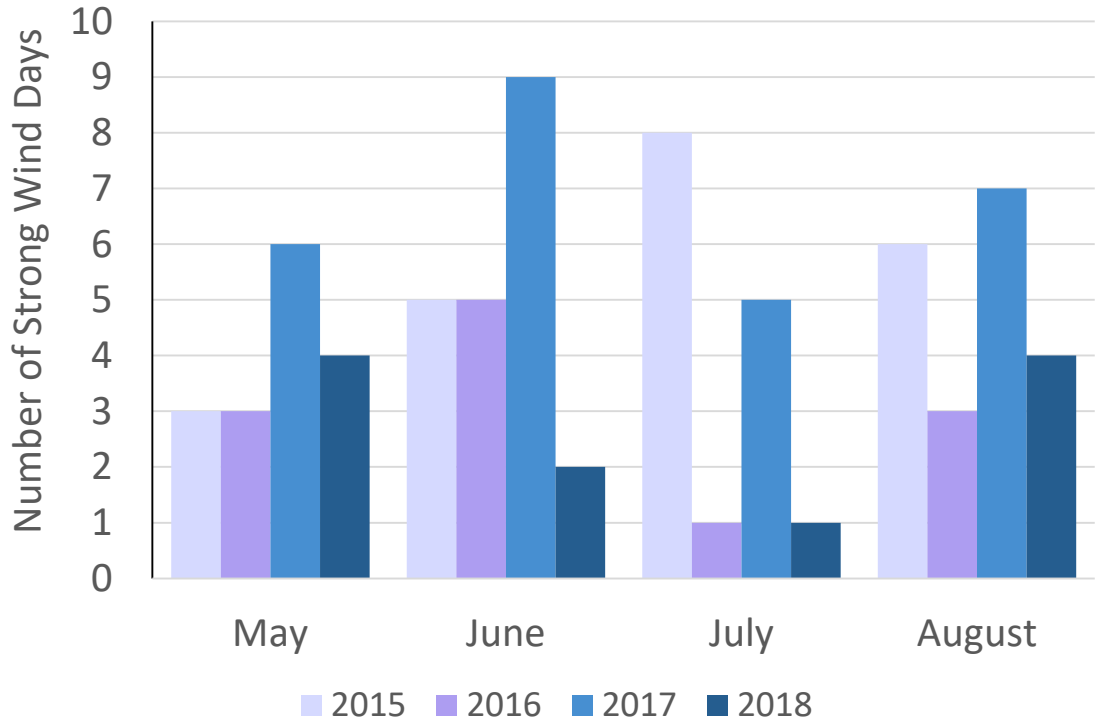


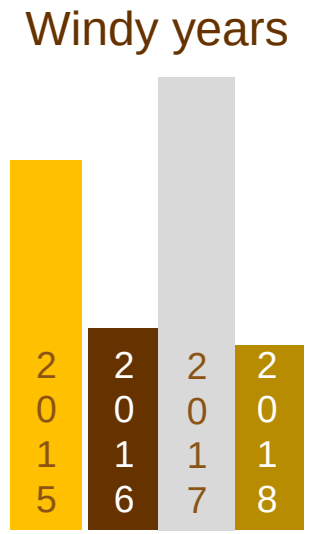
Shortest
Growth Period

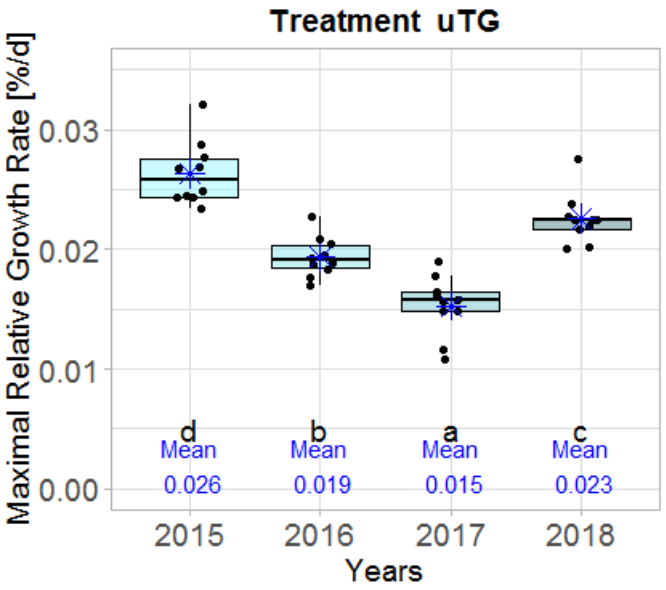


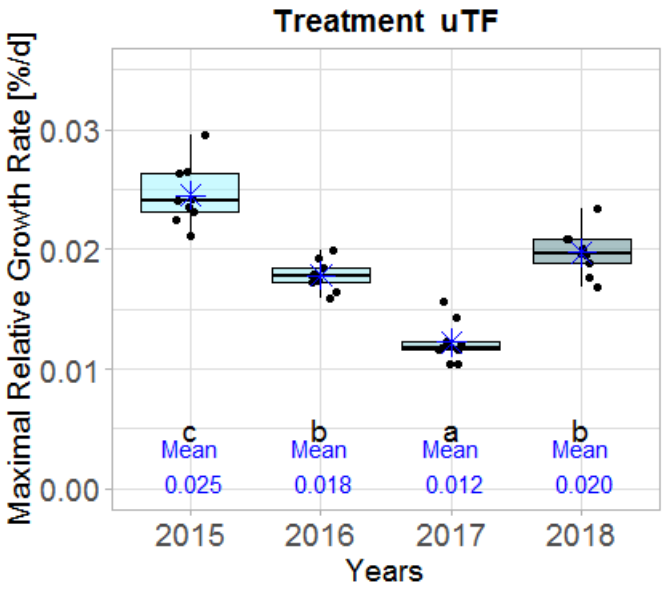
Which ranking between years for a potential thigmomorphogenetic effect ?

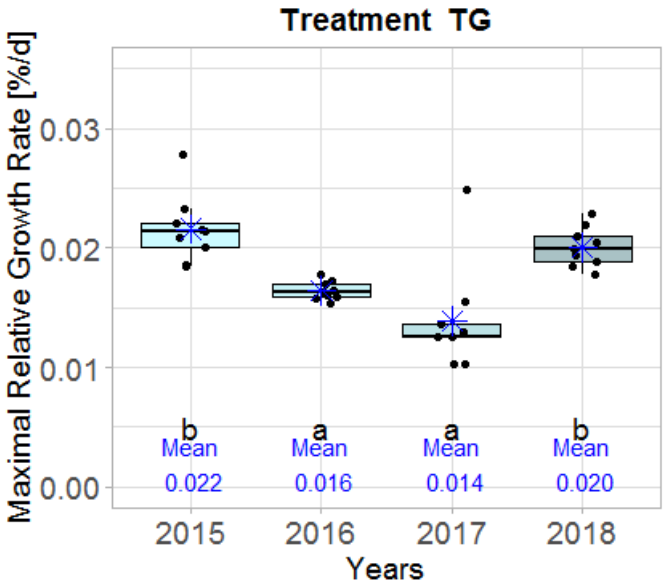
- Criterion : Number of days with strong wind (> 50 km/h) between May and August

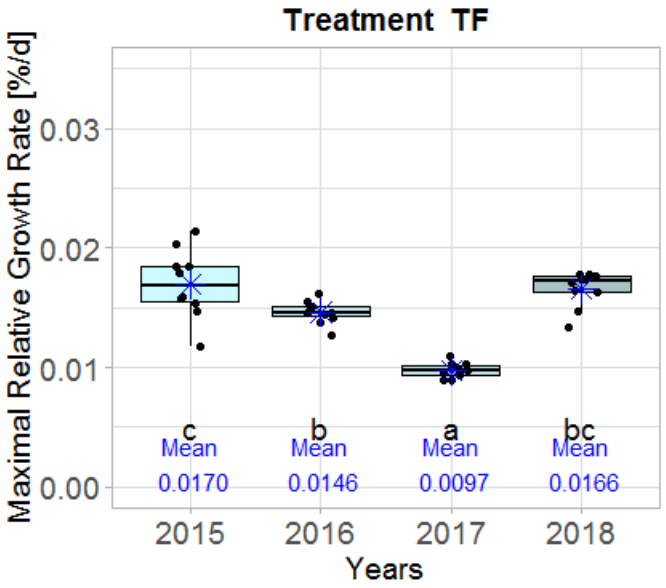










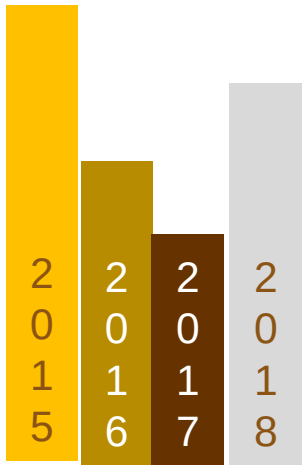


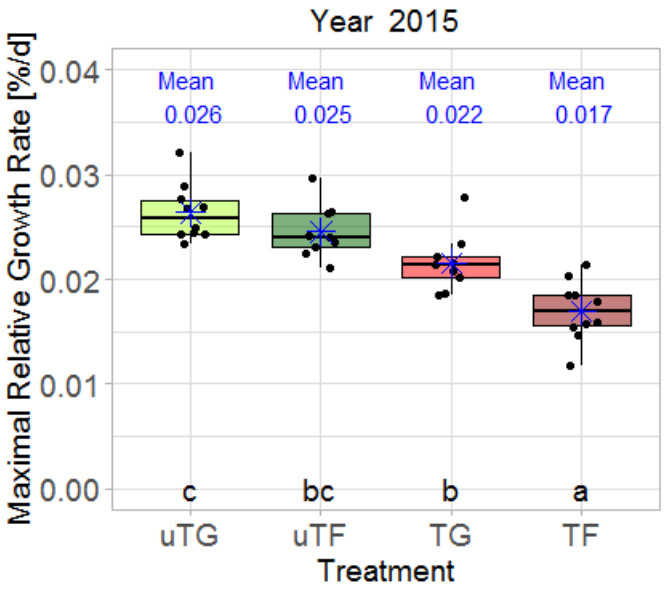
Maximum Relative Growth Rate

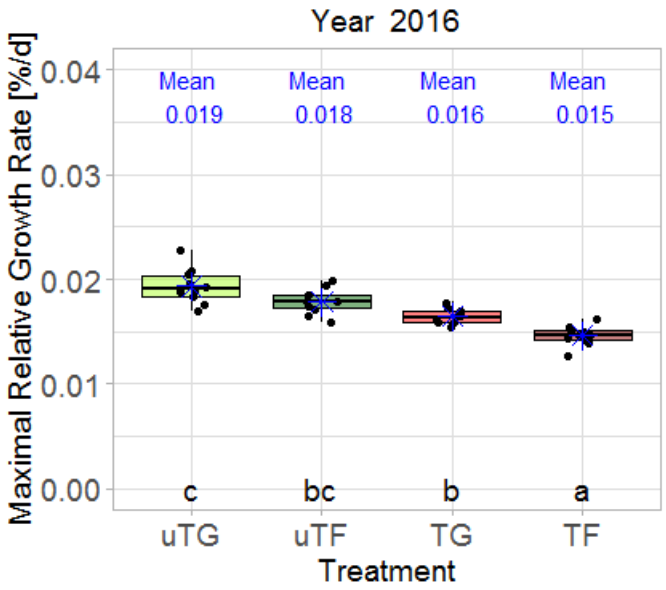
Differences between year by treatment

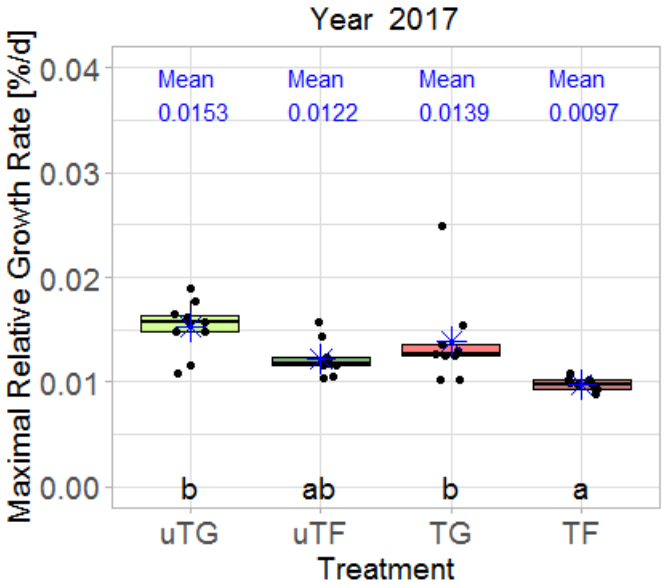
- Range [0.012; 0.026] %/day
- the differences of means are often significant
  - uTG Nb = 4
  - uTF Nb = 3
  - TG Nb = 3
  - TF Nb = 3
  - 2015 ≥ 2018 ≥ 2016 ≥ 2017
- Same ordering than

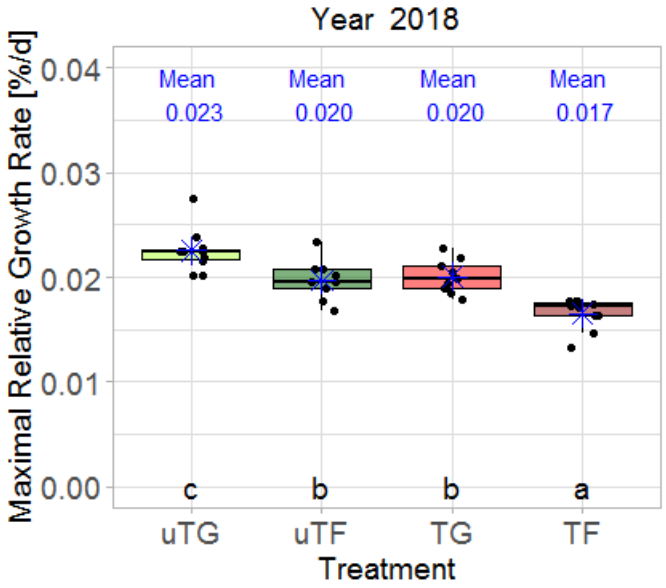
Shortest Growth Period







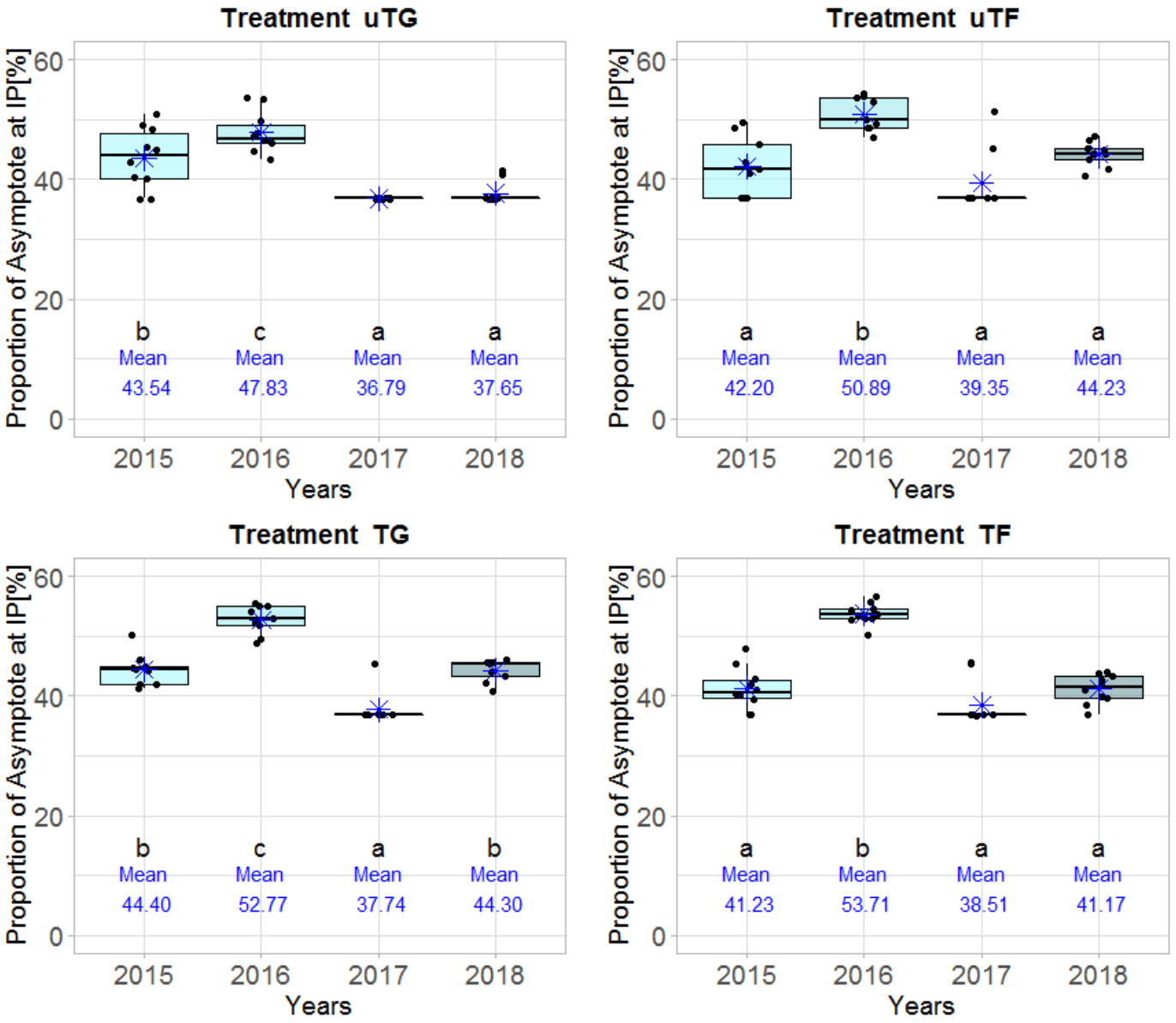




Maximum Relative Growth Rate

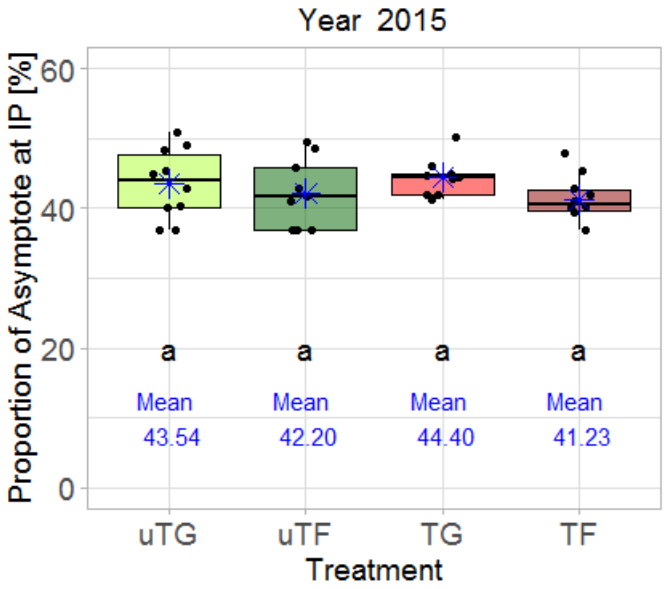
Differences between treatments by year

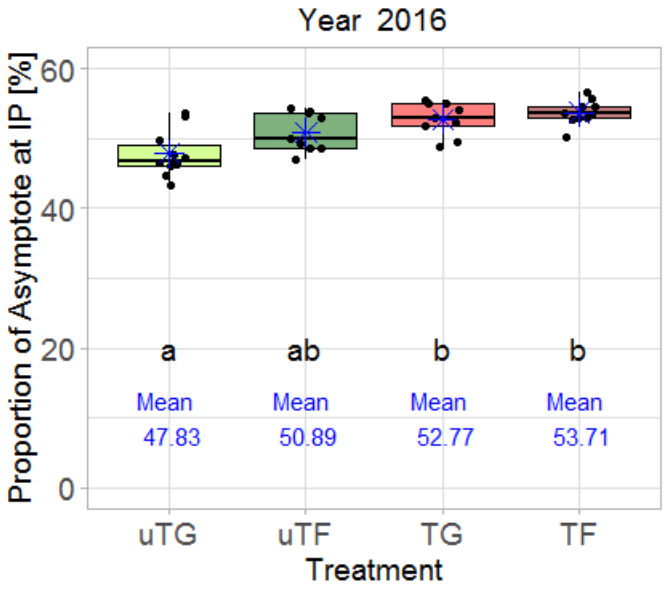
- uTG ≥ uTF ≥ TG > TF
- No differences between uTF and TG for all years

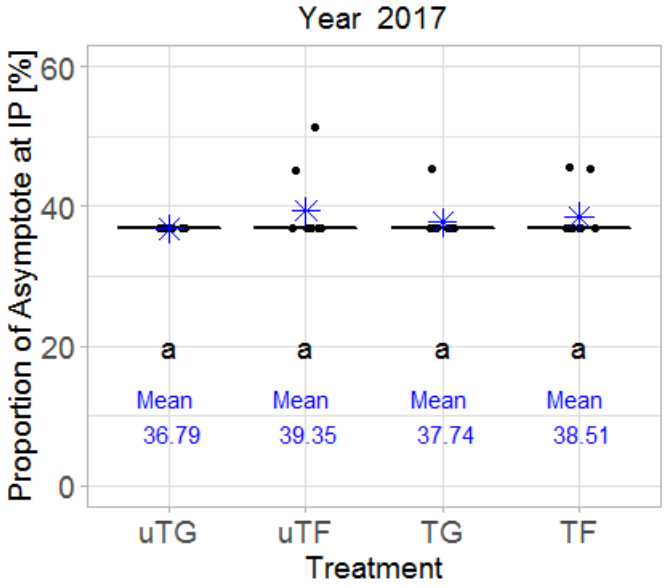


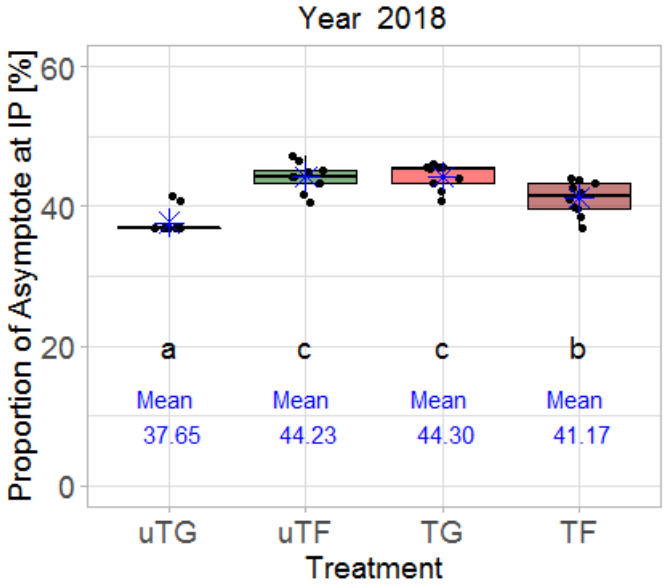
Relative position of inflection points
Differences between years by treatment

- Range [37; 54] %/day
- 2016 is the highest value and the difference is significant in all treatments with the other years
- the difference between the other years is poor especially for Free trees, and it is less clear for Guyed trees





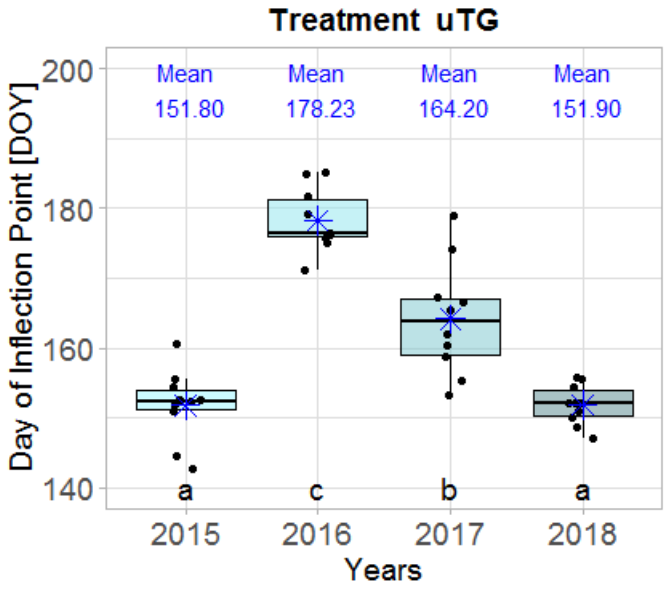


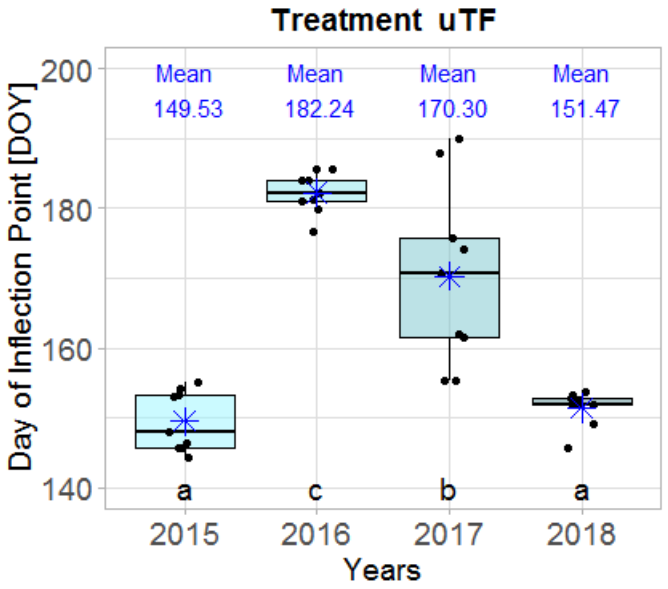


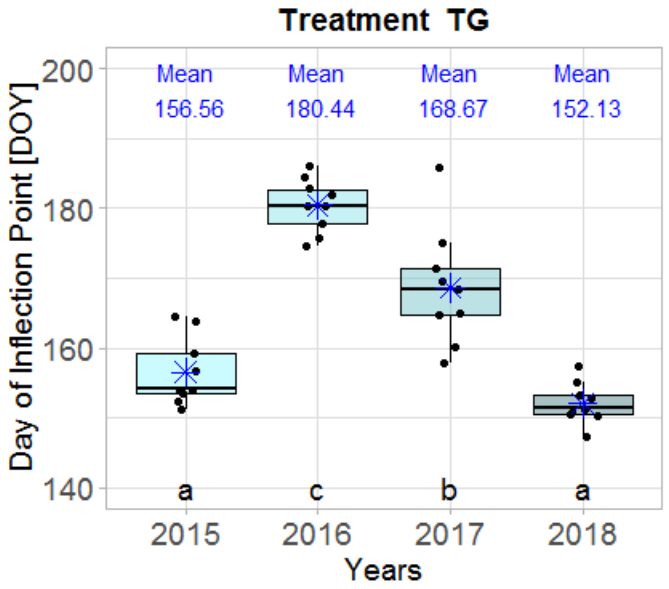
Relative position of inflection point

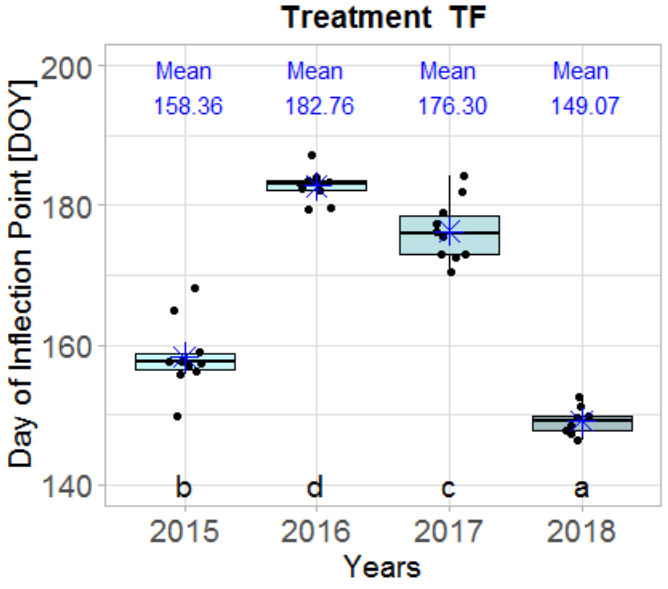
Differences between treatments by year

- Some differences between the treatments but it is very narrow
- No clear trend
- No significant difference in 2015 and 2017
- No difference between uTF and TG









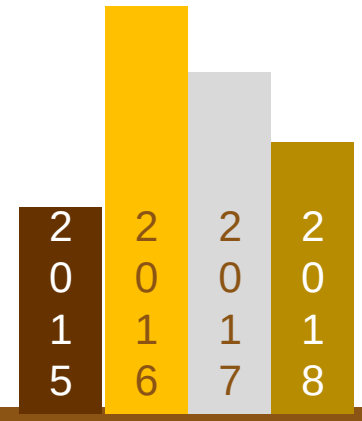
Day of inflection point

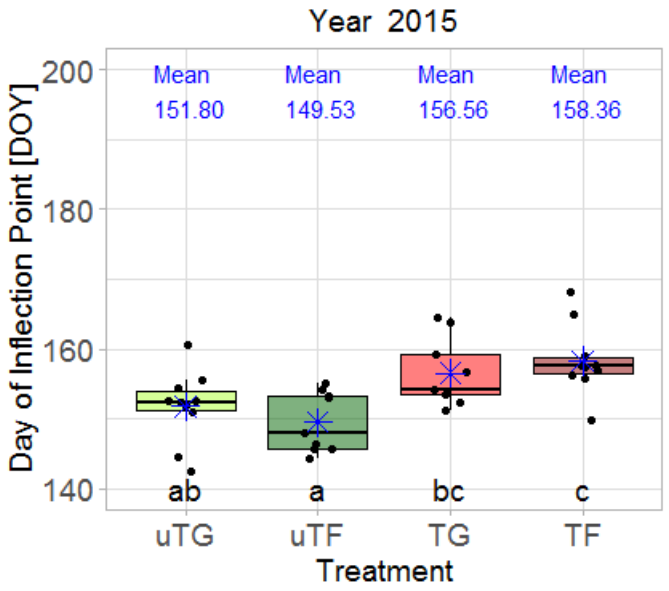
Differences between years by treatment

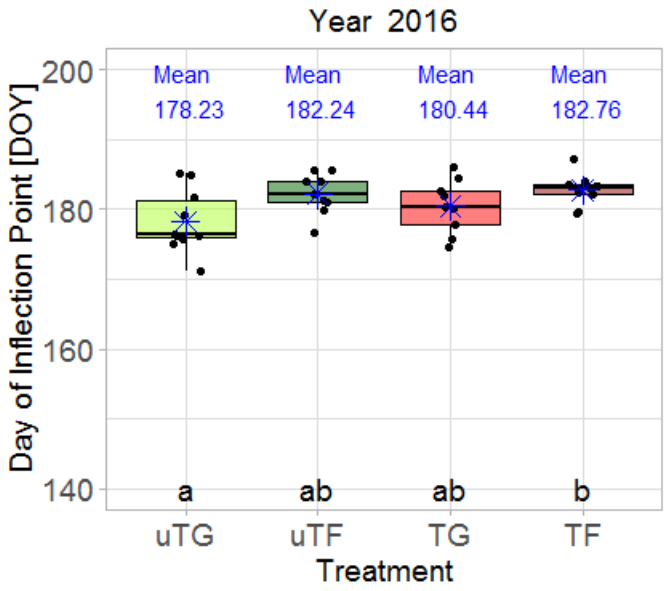
- range [149; 183] DOY
- The variation of the mean day between years has the same pattern between each treatment with some changes in 2015 and 2018.

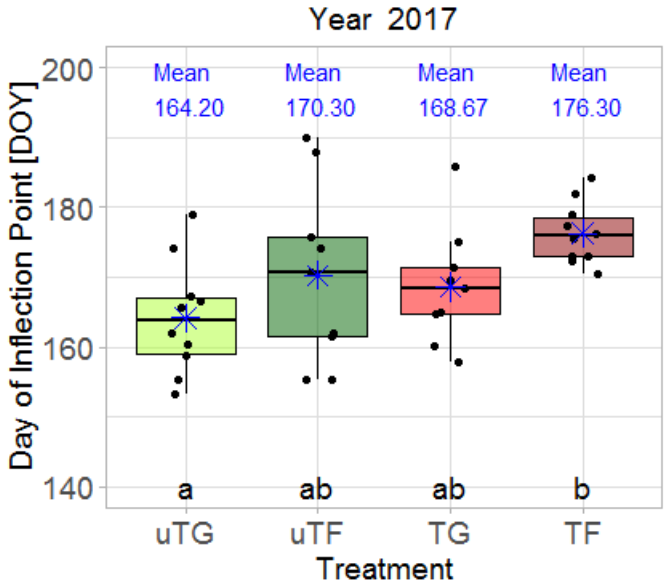
Water Availability

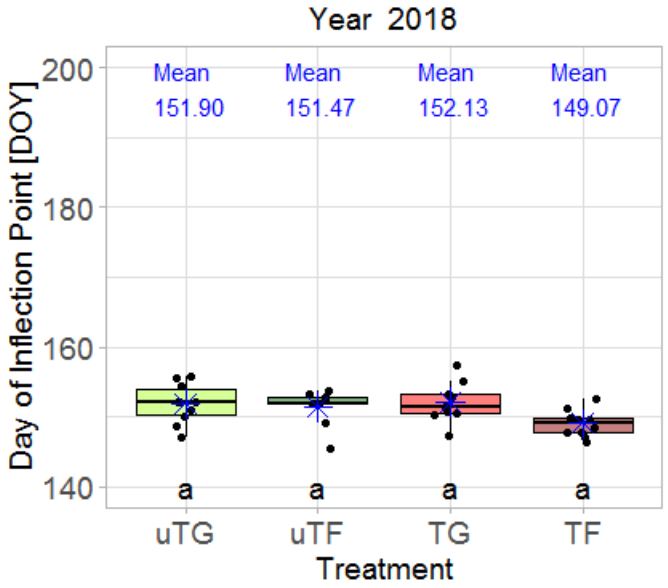
- 2016 > 2017 > 2017 ≥ 2018
- Probably driven by :







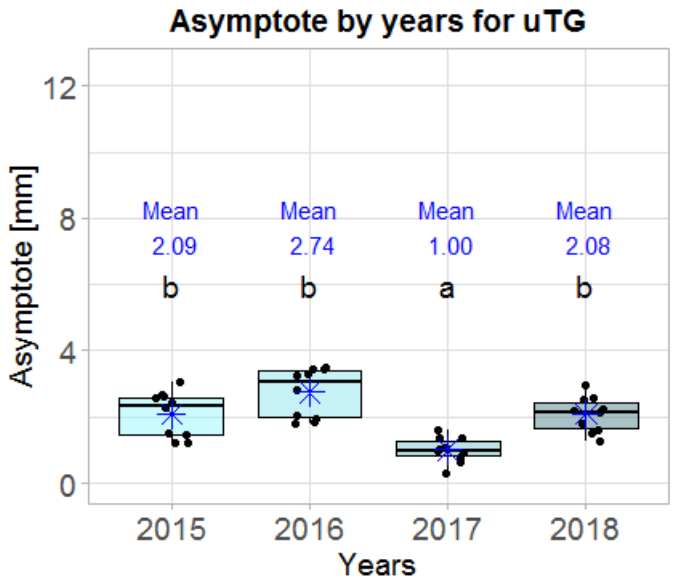


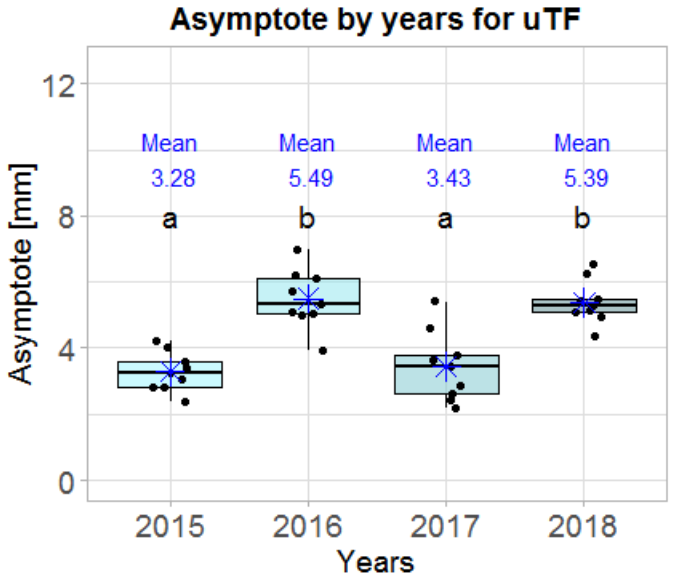


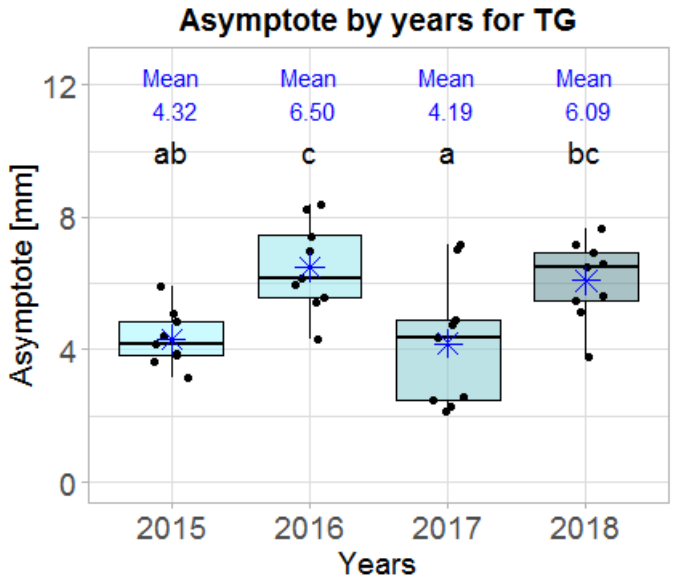
Day of inflection point

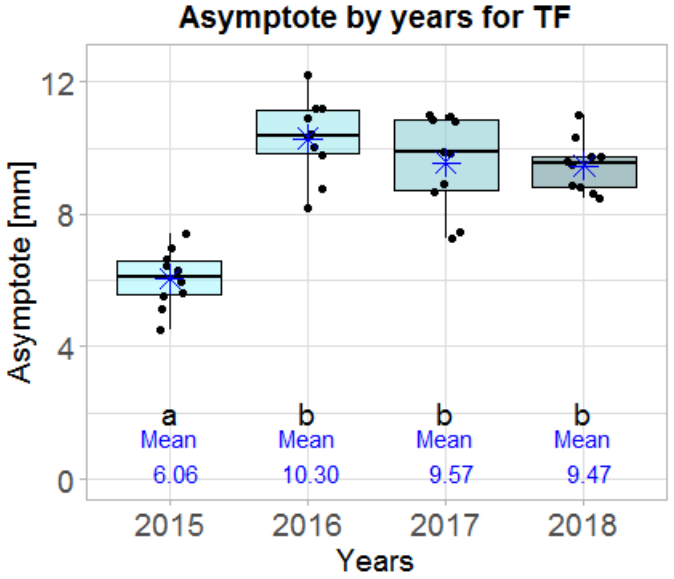
Differences between treatments by year

- within a same year the differences for the day of inflection are less than 10 days
- No significant difference between unthinned trees, and between thinned trees
- No difference between uTF and TG except in 2015.







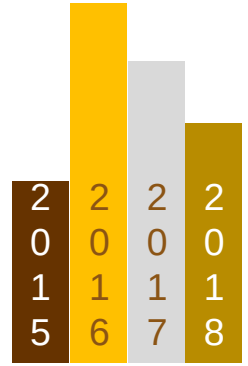


Asymptotic Value

Differences between years by treatment

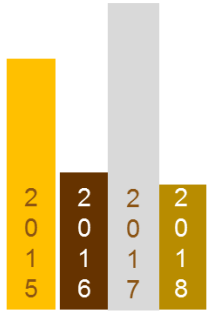
- Range [1;10] mm
- No similar ranking with

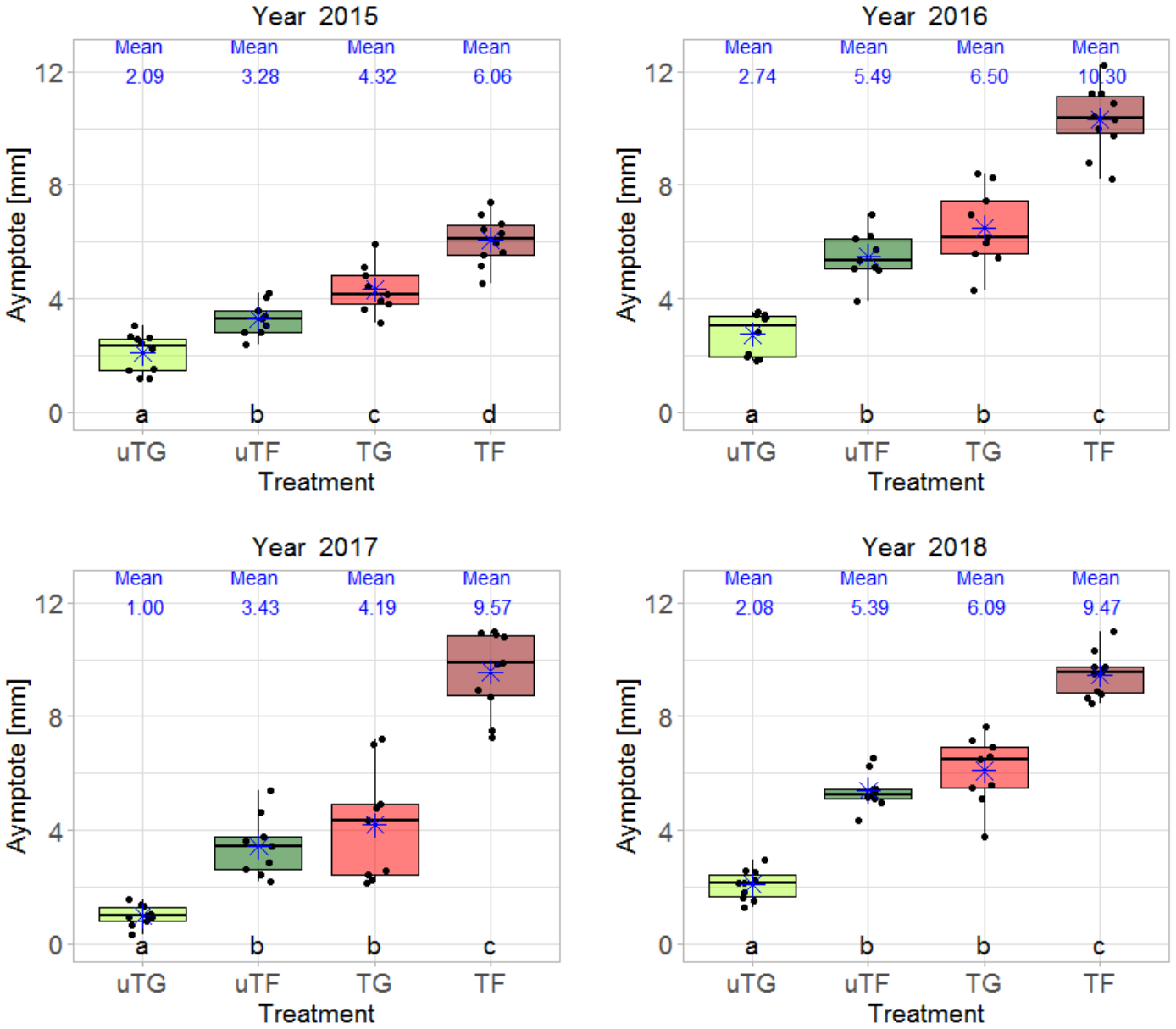
Water Availability



- For TF variation between years is different from others mainly due to a shift to the top for 2017 which doesn't exist for uTF : Thigmomorphogenis?

Windy years



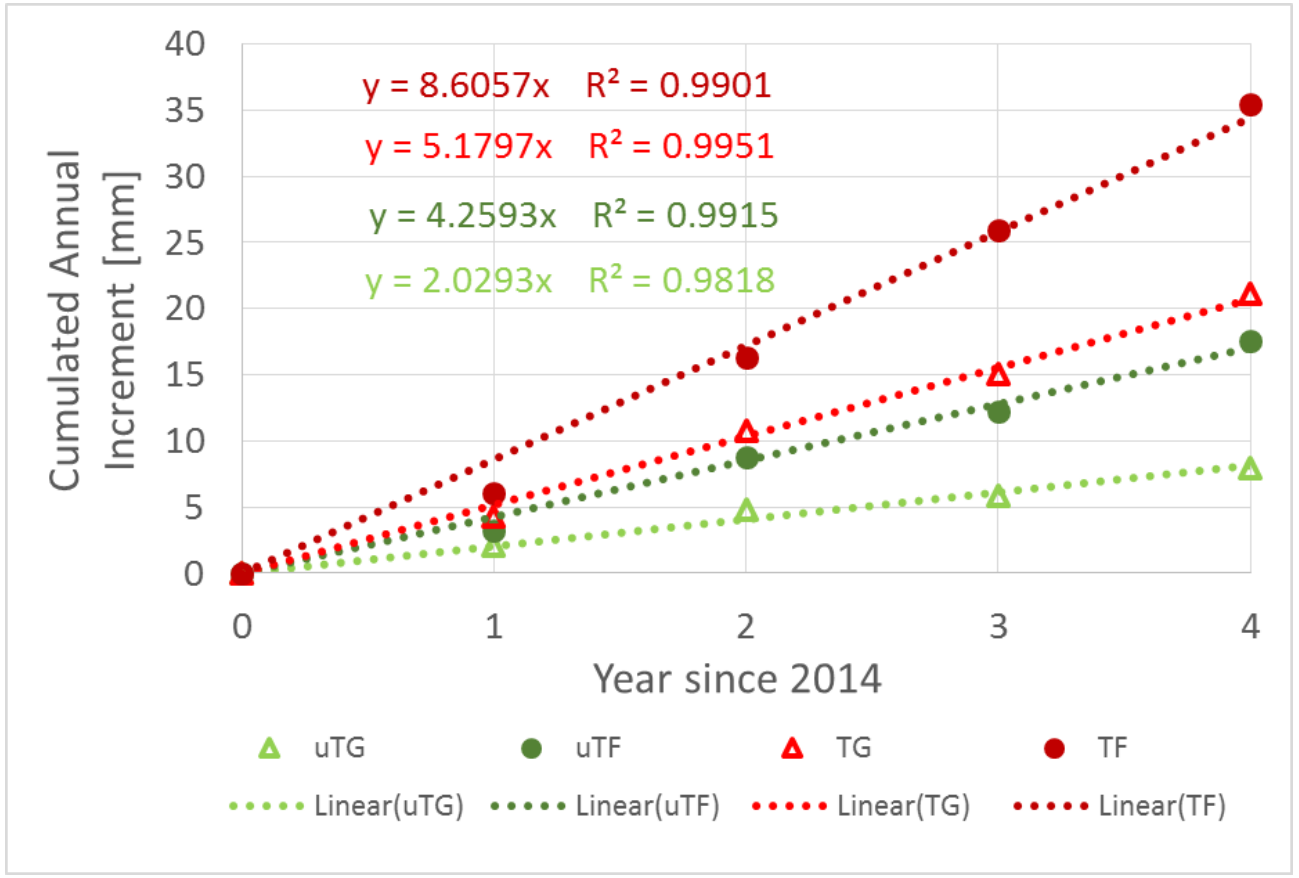


Asymptotic Value

Differences between treatments by year

- TF > TG >=uTF > uTG
- in 2015 significant differences between all treatments
- No differences between uTF and TG for 2016-2017-2018

Comparison of diametral growth rates between treatments



	dD/dt [mm/year]	x Ref_{UTF}
TF	8.6	2.0
TG	5.2	1.2
uTF	4.3	1.0
uTG	2.0	0.5

Conclusions

- Wind plays a major role in the growth response of beech poles to thinning
- Without the mechanical stimuli due to wind, the effect of thinning quasi vanishes
- The growth response in 2015, first year of the experiment, seems different, but this year was drier than the others so it will be difficult to disentangle the effects
- No effect on the height growth was detected
- The strong winds (>50 km/h) regime during the growing period plays a significant role in the regulation of radial growth. To confirm this an analysis of the growth rate at a refined time scale could be possible

Aknowledgements for funding and support.