



Species interactions dynamics in fast growing poplar and alder forestry and agroforestry systems: from leaf to tree.

Priault Pierrick, Thomas Anaïs, Piutti Séverine, Dallé Erwin, Marron Nicolas



Forestry plantations

Increasing demand for renewable energy sources, including **biomass**

+

Increasing demand for more **sustainable production systems**



Increase of agroforestry practices *but* little experience in management of tree component

Mainly woody biomass

Short rotation plantation of fast-growing species



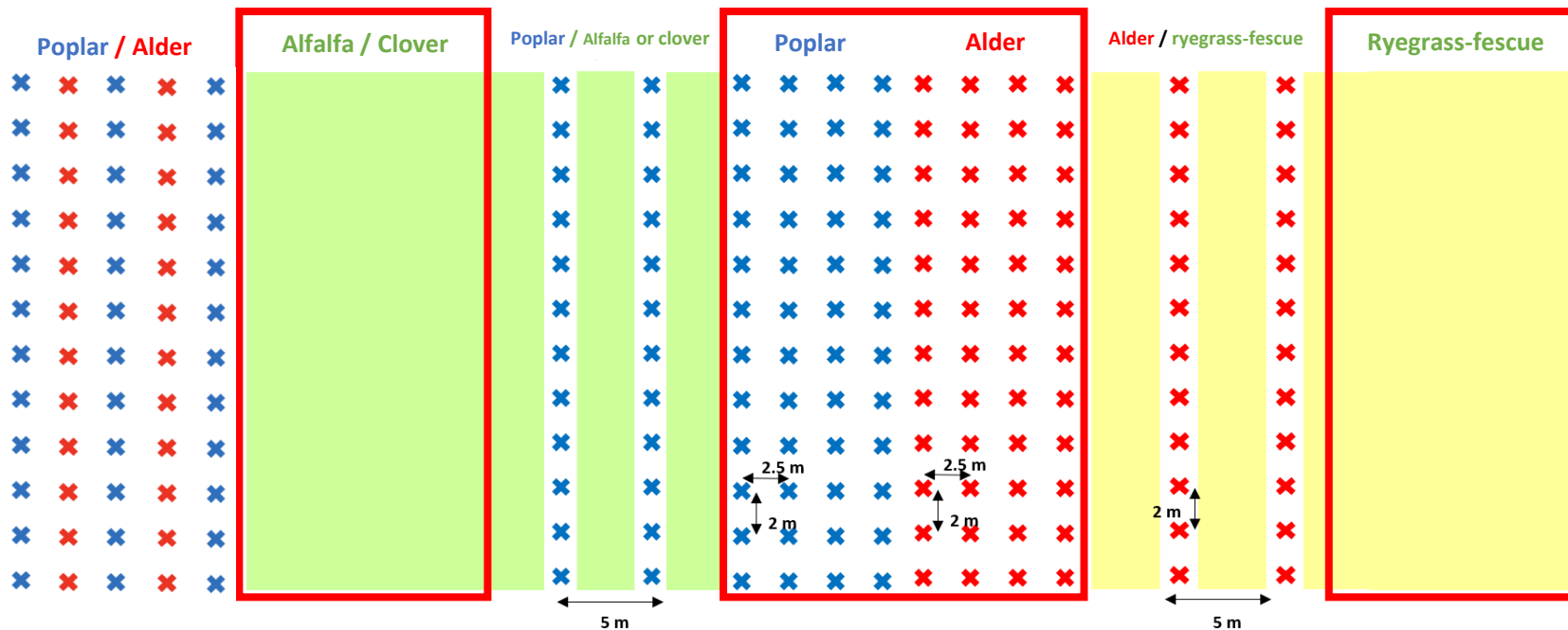
Poplars (2000 trees/ha)

What are the effects of the association of species on tree performances in temperate agroforestry systems?

Objective: Compare growth performances of fast-growing trees (poplar, alder) in **AF** and in forest mixture (**FM**) or monoculture (**MONO**).

Experimental forestry and agroforestry plantation of La Bouzule (Nancy, France)

- Poplar (*Populus deltoides* x *Populus nigra*)
- Alder (*Alnus glutinosa*)
- Alfalfa (*Medicago sativa*, 2014-2018), clover (*Trifolium pratense*, 2018-2022)
- Succession wheat (*Triticum aestivum*), Triticale and temporary grassland (ryegrass, fescue)



Alder - Monoculture





Experimental forestry and agroforestry plantation of La Bouzule (NE France)

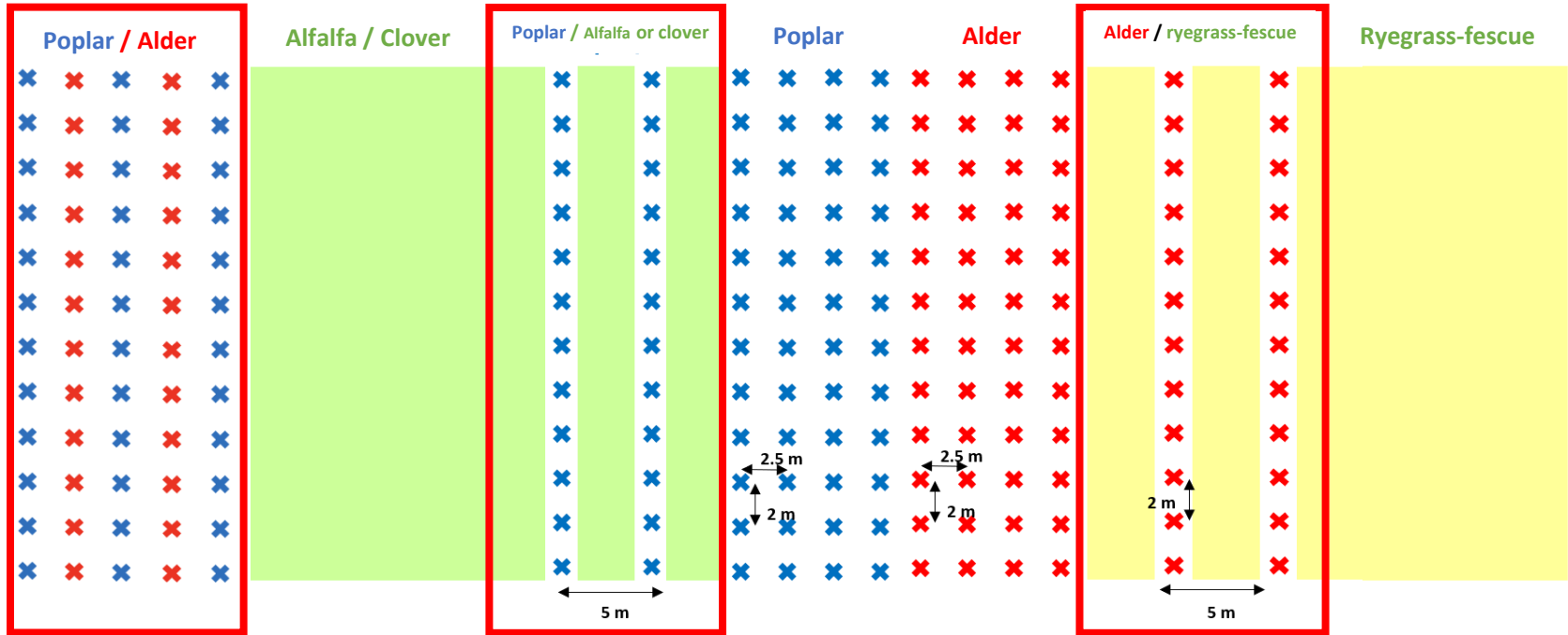
- Poplar (*Populus deltoides* x *Populus nigra*)

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Date + nombre d'arbres

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Poplar – agroforestry system(mixture with alfalfa then clover)



Alder – agroforestry system (mixture with temporary grassland)



What are the effects of the association of species on tree performances in temperate agroforestry systems?

Objective: Compare growth performances of fast-growing trees (poplar, alder) in **AF** and in forest mixture (**FM**) or monoculture (**MONO**).

Hypotheses: Trees with better growth performances in AF than in FM or MONO due to:

- (1) a *reduced competition* between species
- (2) a *facilitation* effect due to the presence of N₂-fixing species

Methods – Tree growth performances

Measurements on all trees (end of each growing season) and on 60 trees per species and per treatment during the growing season

Diameter

At breast height
using a digital
caliper



Height

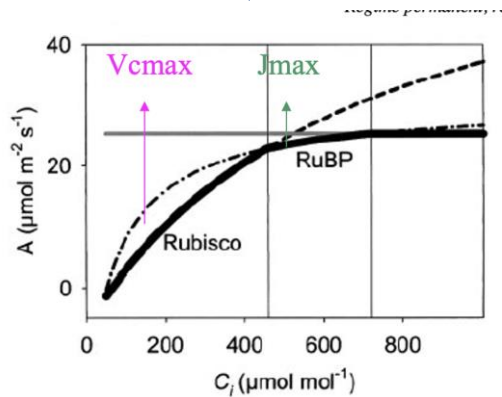
From the base to the
last bud of the tallest
stem



Methods – Leaf photosynthetic capacities

CO₂ response curves

Farquhar photosynthetic model



V_{cmax}: maximal carboxylation rate of RubisCO

J_{max}: maximum electron transport rate



Infra red gas analyser

CO₂ and H₂O gas exchanges

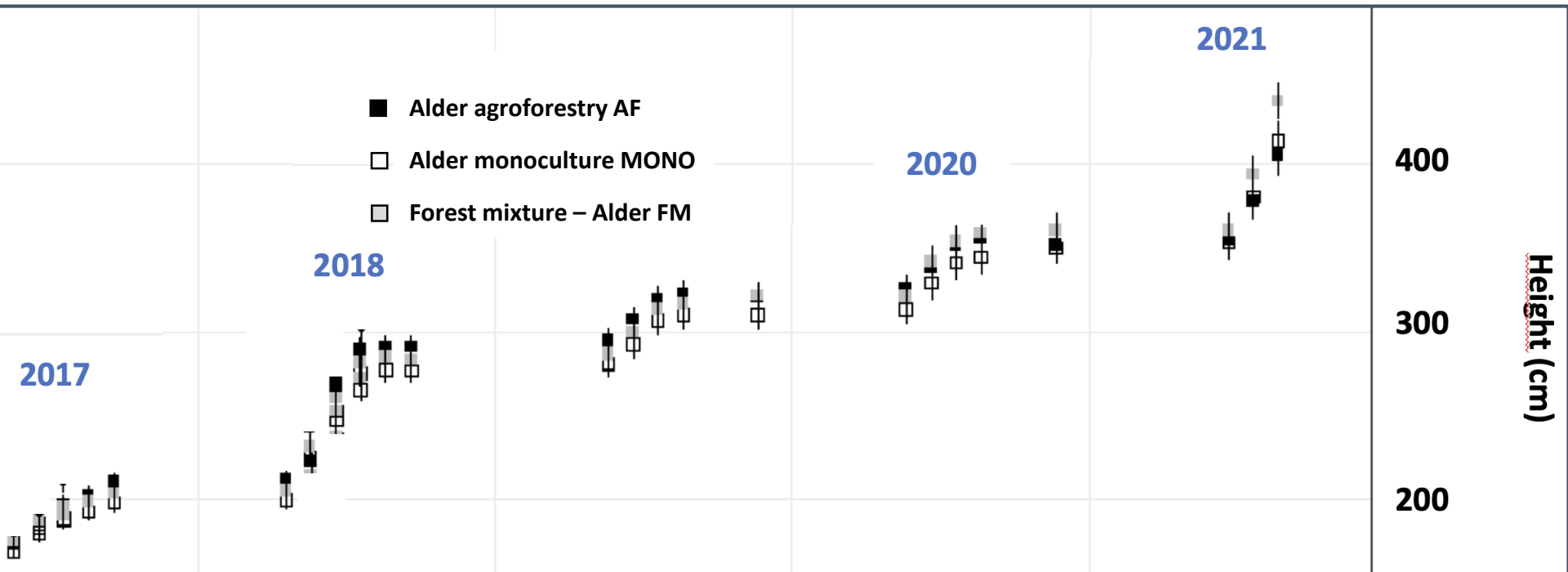
- Net carbon assimilation
- Intercellular CO₂ concentration

Light leaves

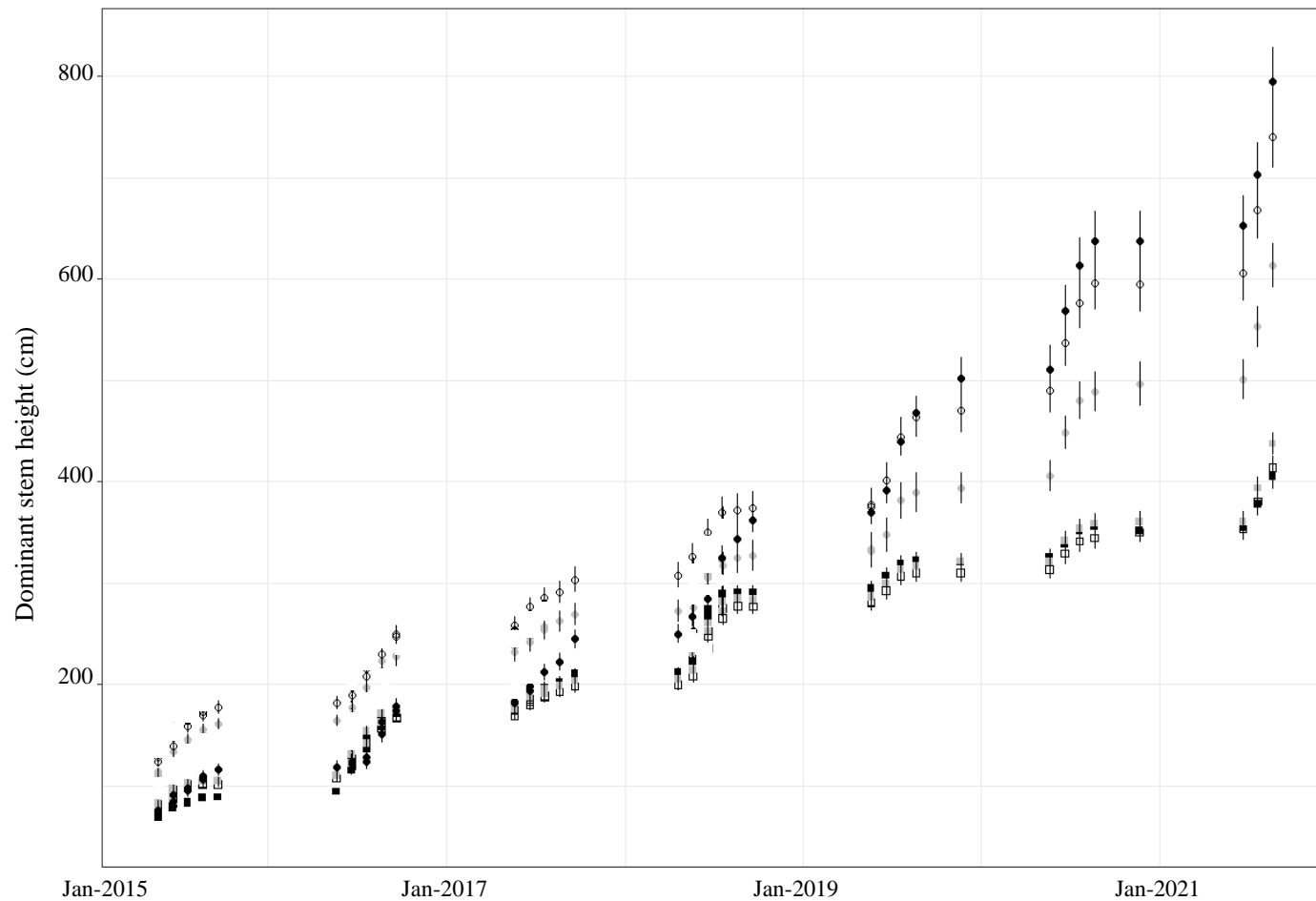
June – Sept 2020

*12 trees per species
and per treatment*



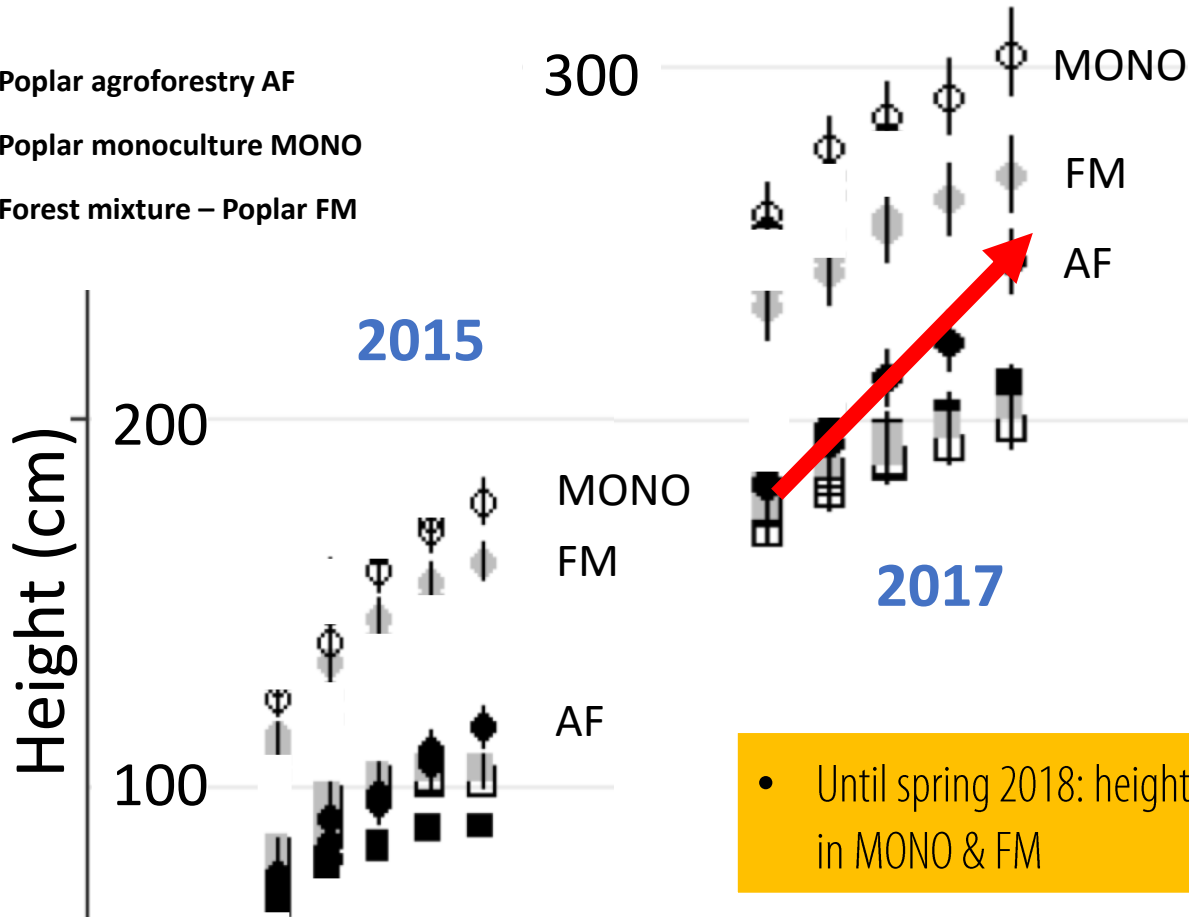


For alders, agroforestry practices didn't impact growth performances after 7^{1/2} years.

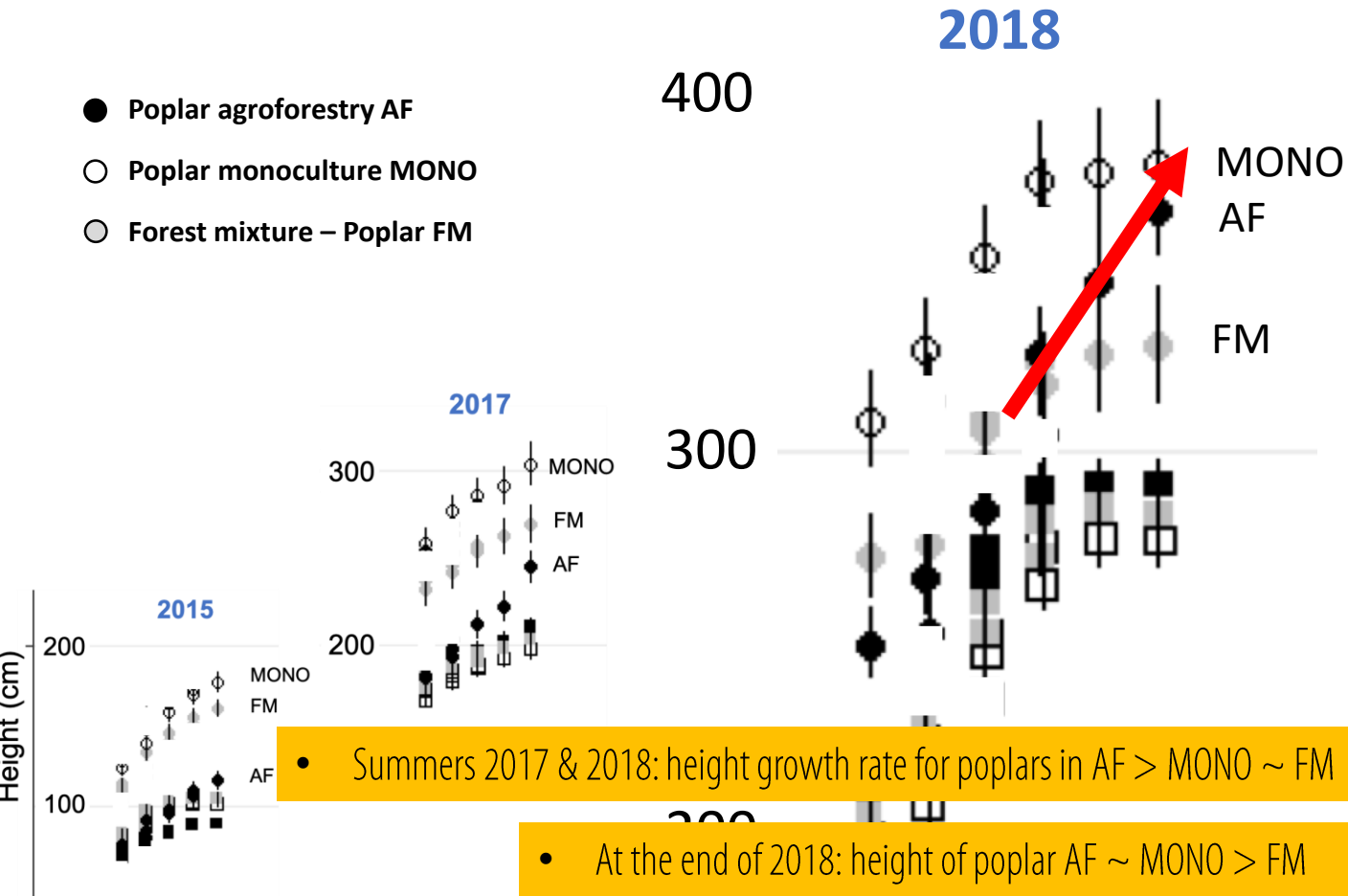


Results – Tree growth performances

- Poplar agroforestry AF
- Poplar monoculture MONO
- Forest mixture – Poplar FM

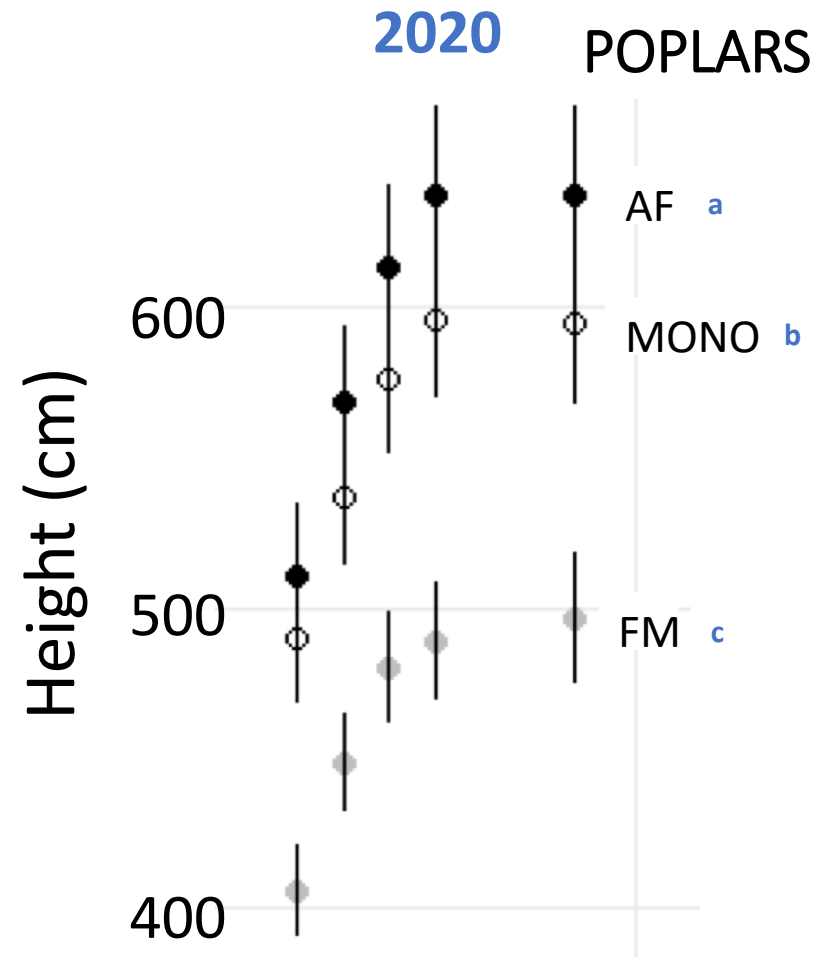
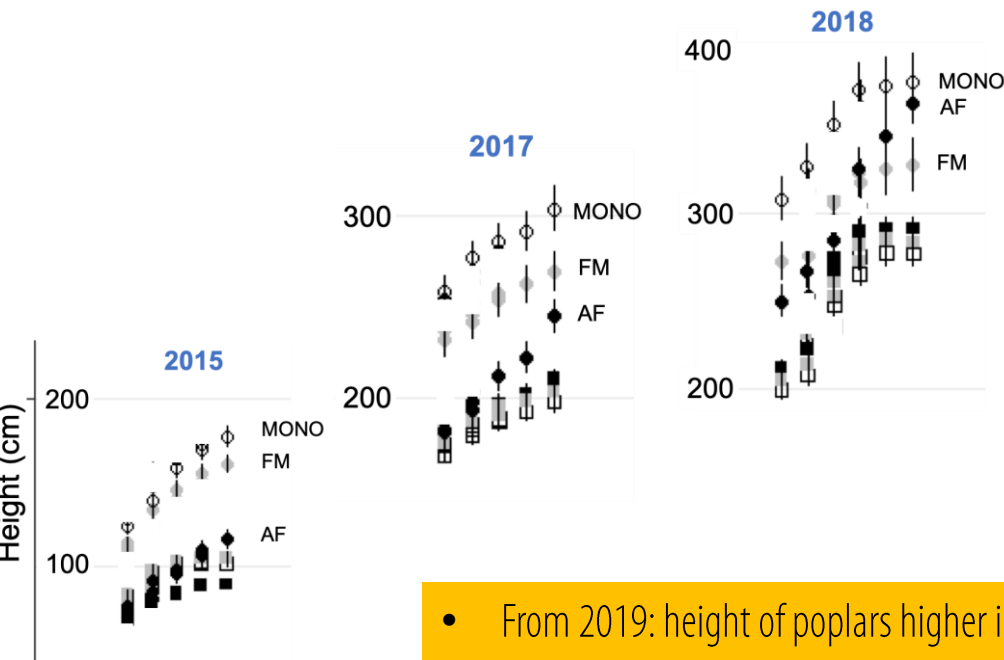


• Until spring 2018: height of AF poplar < poplar in MONO & FM

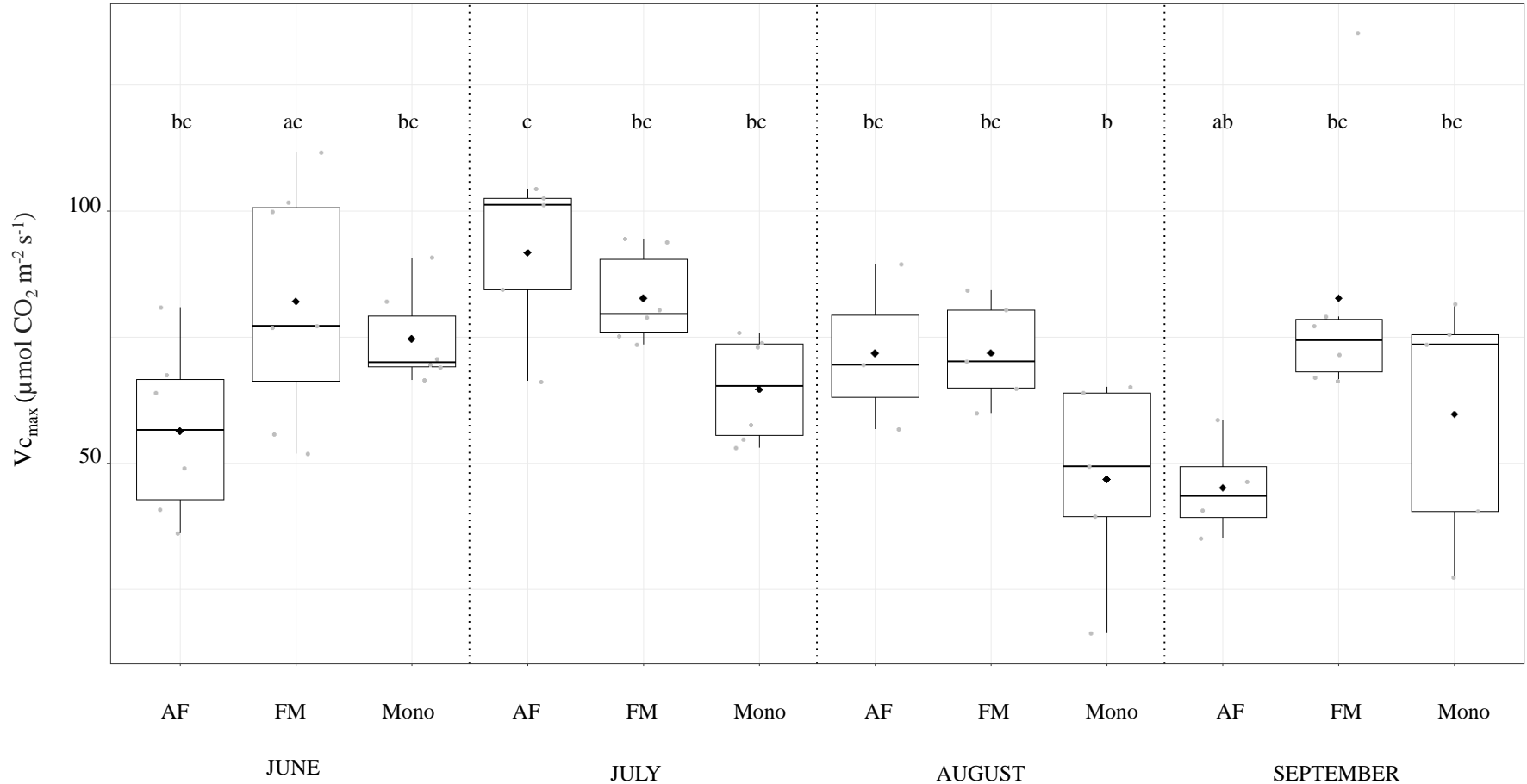


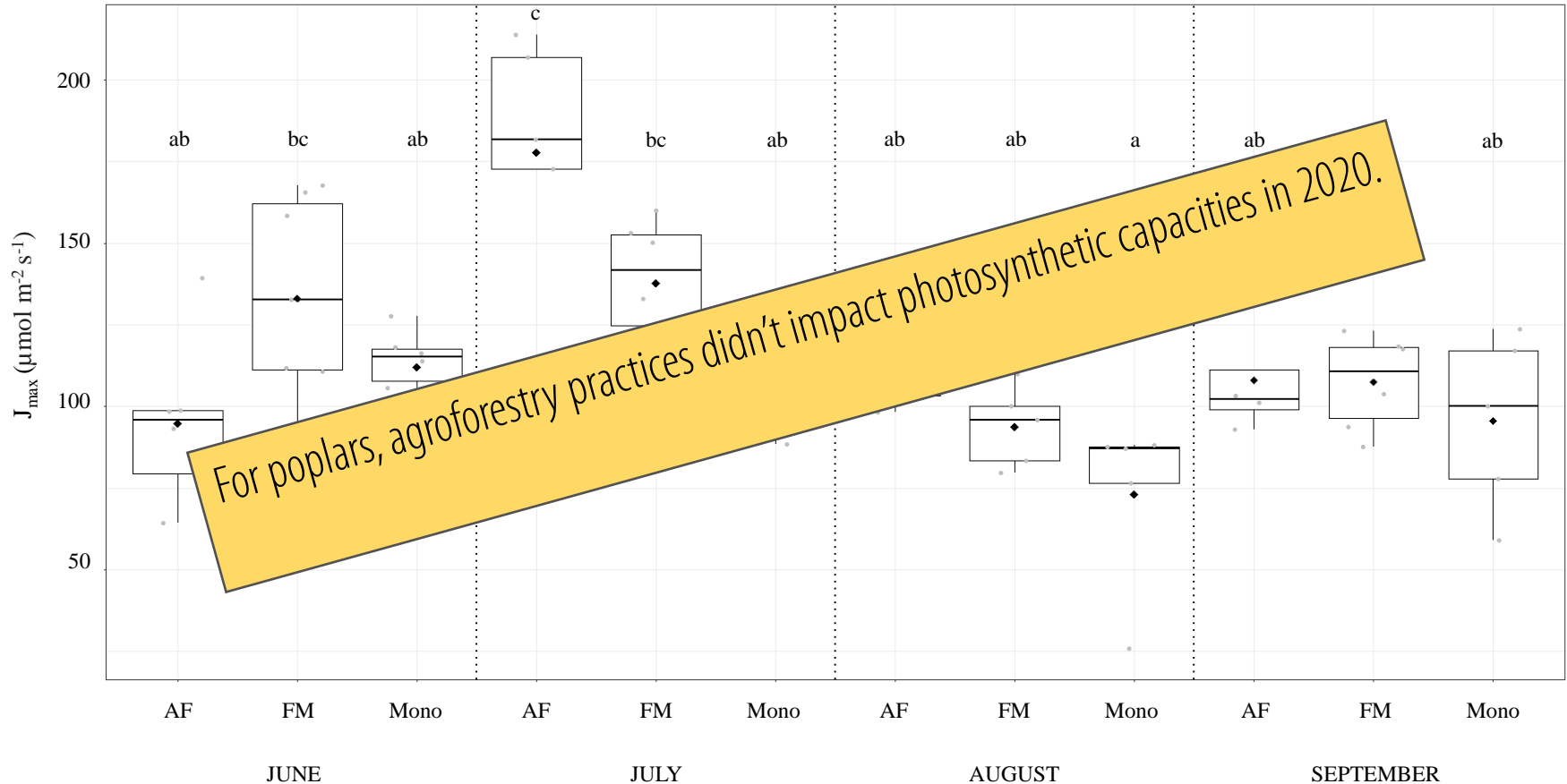
Results – Tree growth performances

- Poplar agroforestry AF
- Poplar monoculture MONO
- ◐ Forest mixture – Poplar FM



- From 2019: height of poplars higher in AF than in monoculture





Discussion – Species interactions driving poplar growth performances

1

2014 – 2018

Poplars in AF showed lower height than poplars in monoculture or forest mixture.

COMPETITION

2

2018-2020

Poplars in AF had higher height growth than poplars in monoculture or forest mixture.

POSITIVE INTERACTIONS > COMPETITION

Higher soil mineral nitrogen content in 2018

Not associated with increased photosynthetic performances of poplar AF leaves (nor with increased leaf area per tree)

Lower tree density -> possible reduction in competition for light (crown dimensions and architecture)

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2020-2021

Poplars in AF had similar height than poplars in monoculture or forest mixture.

POSITIVE INTERACTIONS ~ COMPETITION



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Growth dynamics of fast-growing tree species in mixed forestry and agroforestry plantations

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See also:

Posters A11 & A15 – session A1-2

Video 726129163 – session A

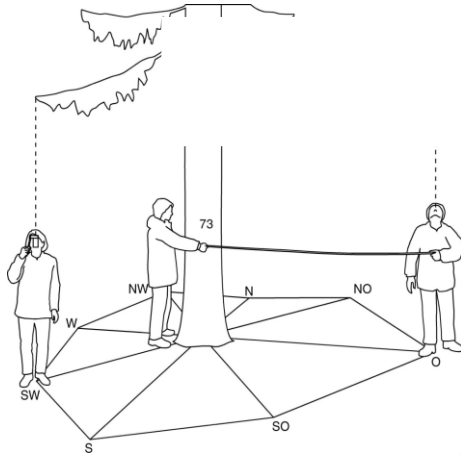
Thank you for your attention

Results – Tree growth performances

		H/DBH ratio (m.cm ⁻¹)		
		2017	2018	2019
Poplar	Monoculture	1.75 ± 0.03	2.07 ± 0.1 ^b	1.53 ± 0.04 ^b
	Agroforestry	2.26 ± 0.08 ^a	1.66 ± 0.04 ^a	1.25 ± 0.03 ^a
Alder	Monoculture	2.19 ± 0.04 ^b	1.79 ± 0.03 ^a	1.49 ± 0.02 ^b
	Agroforestry	2.16 ± 0.05 ^b	1.61 ± 0.03 ^a	1.36 ± 0.02 ^a

- 2017: poplars in AF with a higher H/DBH than in monoculture
- From 2018: ↓ of H/DBH → poplars in AF with a lower ratio than in monoculture

CROWN ARCHITECTURE

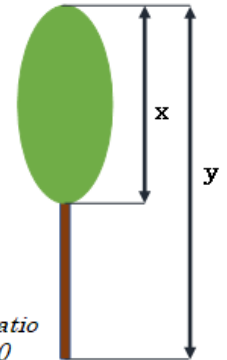
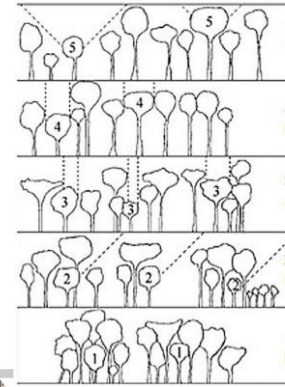


Crown dimensions
(Crown volume, Crown projection area)



Light interception index

(Dawkins, 1958; Verryckt et al., 2022)



Live Crown Ratio
 $LCR = (x/y) \cdot 100$

(Crown volume, tree pruning)

PHENOLOGY – growing season length

Bud burst



Bud set and senescence

