Latest public research on forage and turf and update on CLIMAGIE

Jean-Louis Durand, Lina Qadir Ahmed, Thierry Bariac, Romain Barillot, Philippe Barre, José Luis Blanco-Pastor, Didier Combes, Abraham Escobar-Gutierrez, Lucas Faverjon, Ela Frak, et al.

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INRA Research units: UR P^{3}F, UREP, EVA, CEFE

INRA Research divisions : Plant Biology and Breeding, Environment and Agronomy, Ecology of Forests, Grasslands and Waters

ISF

Nice 5 June 2019

INRA SCIENCE & IMPACT

INRA
for sown grasslands improvement

- 4 laboratories (Lusignan, Montpellier, Caen, Clermont Ferrand)
- 50 permanent staff, 40 more temporary
  - →equivalent to private sector (GNIS 2019)
- Pluridisciplinary : Plant Ecophysiology, Ecology, Genetics and breeding
- Open science
- *CLIMAGIE: Adapt grasslands to climate change: breeding and ecological intensification.* http://www6.inra.fr/climagie

INRA SCIENCE & IMPACT

I. The importance of sown grasslands in France
II. Adapt grasslands to climate change
III. The challenge of breeding for multi-species grasslands
IV. Conclusions

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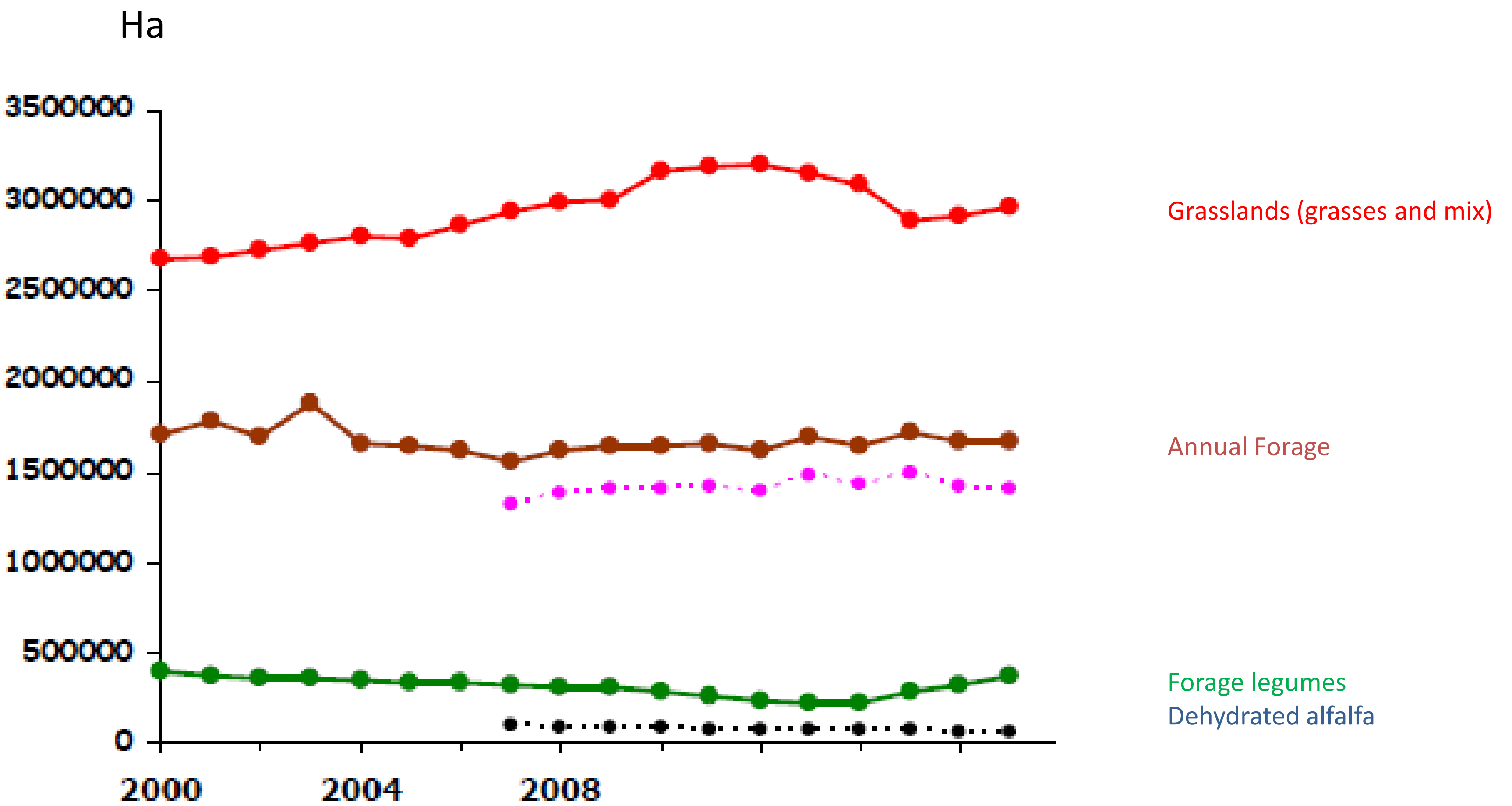
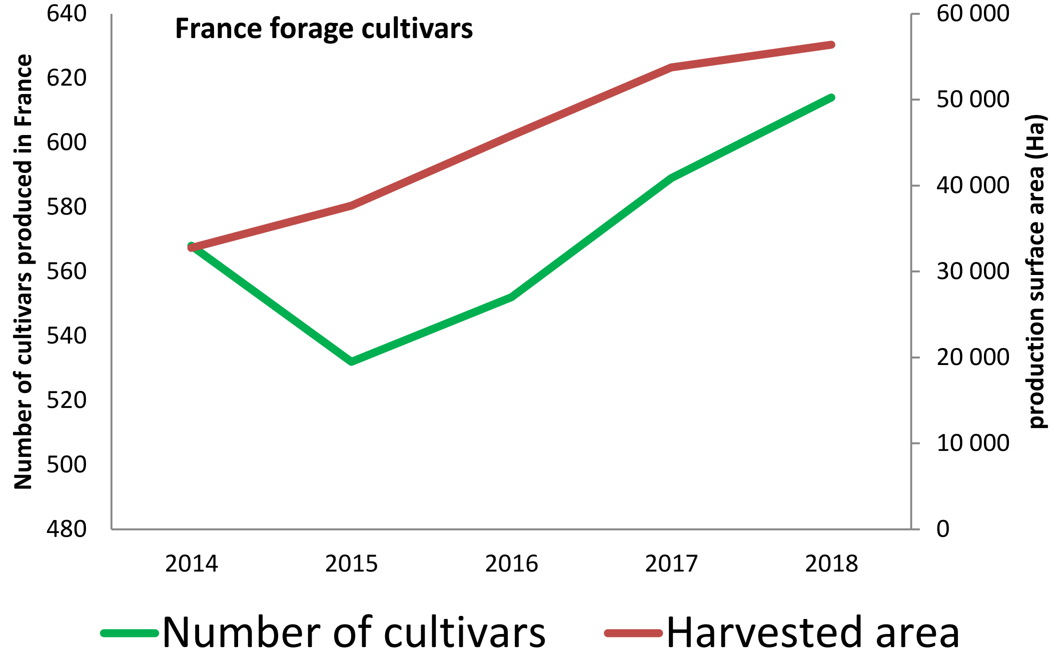
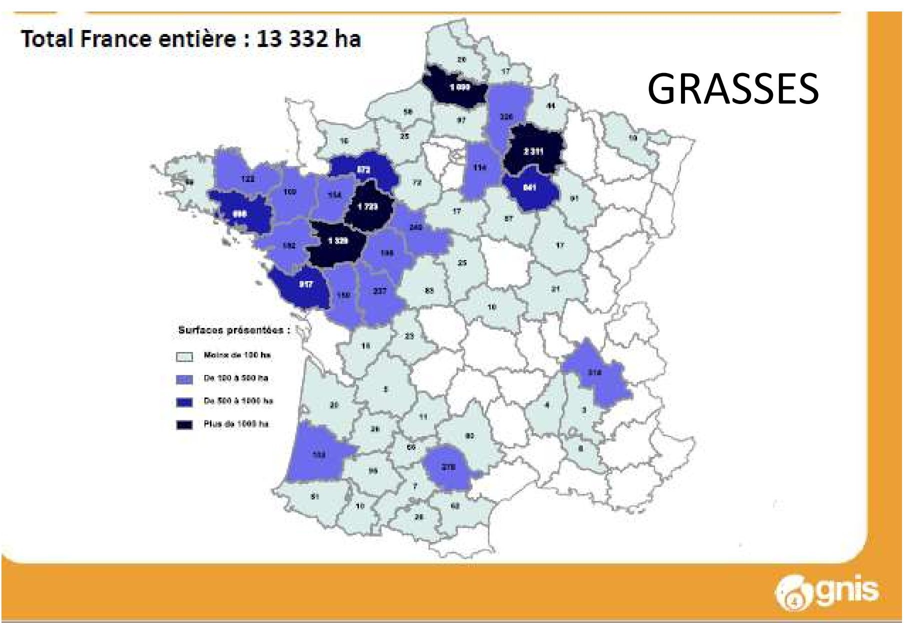
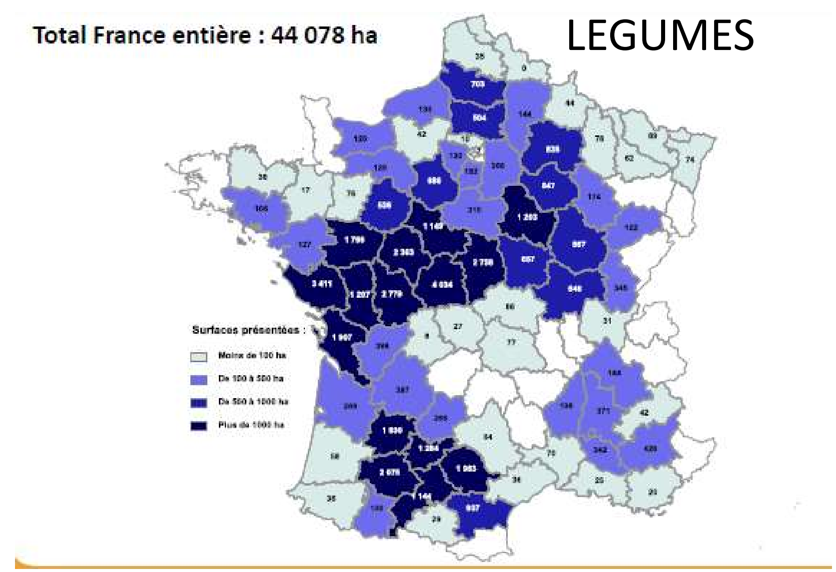
Sown grasslands are a crucial component of agricultural systems in France

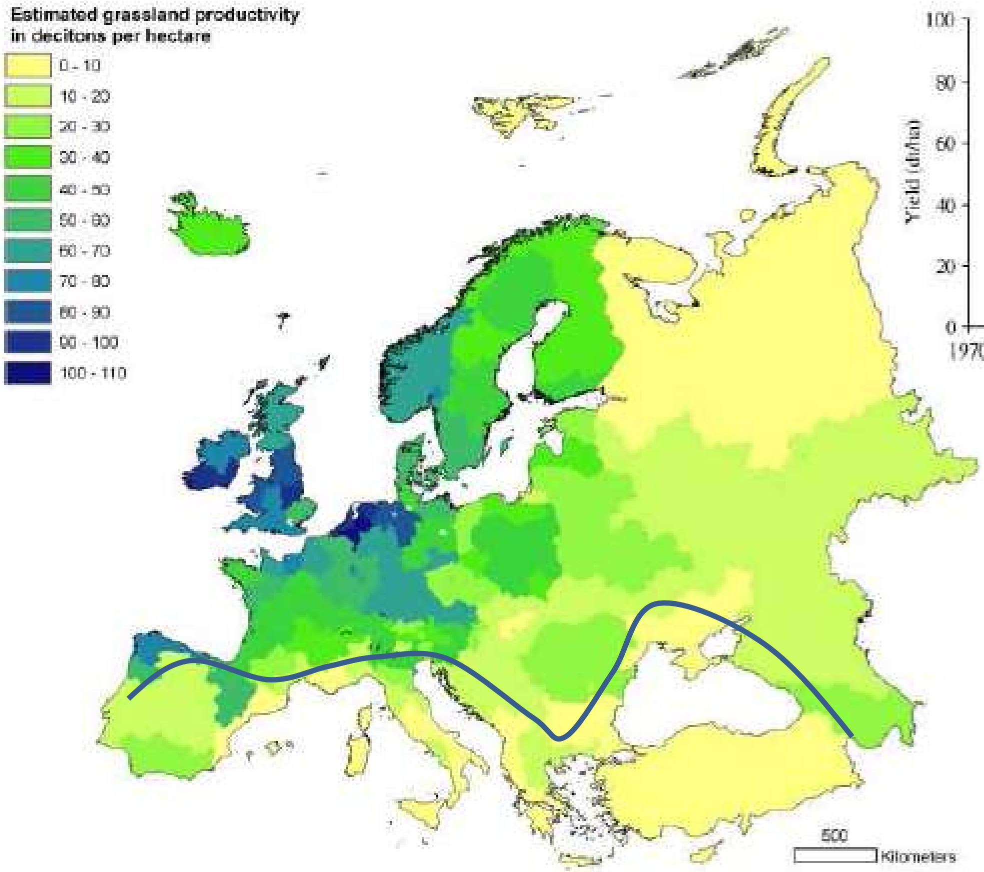


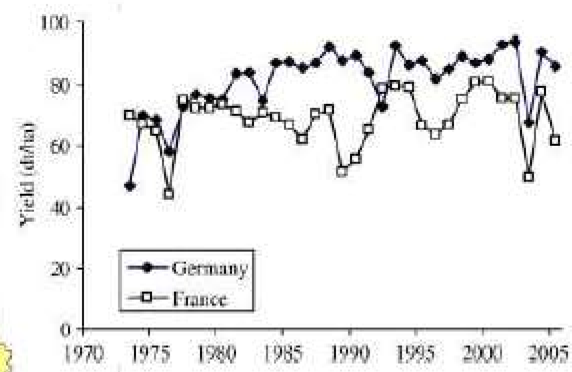
Grass and legume seeds production in FRANCE











Stat nationales 1995-2004. in Smit, Metzger & Ewert, 2008. EJA

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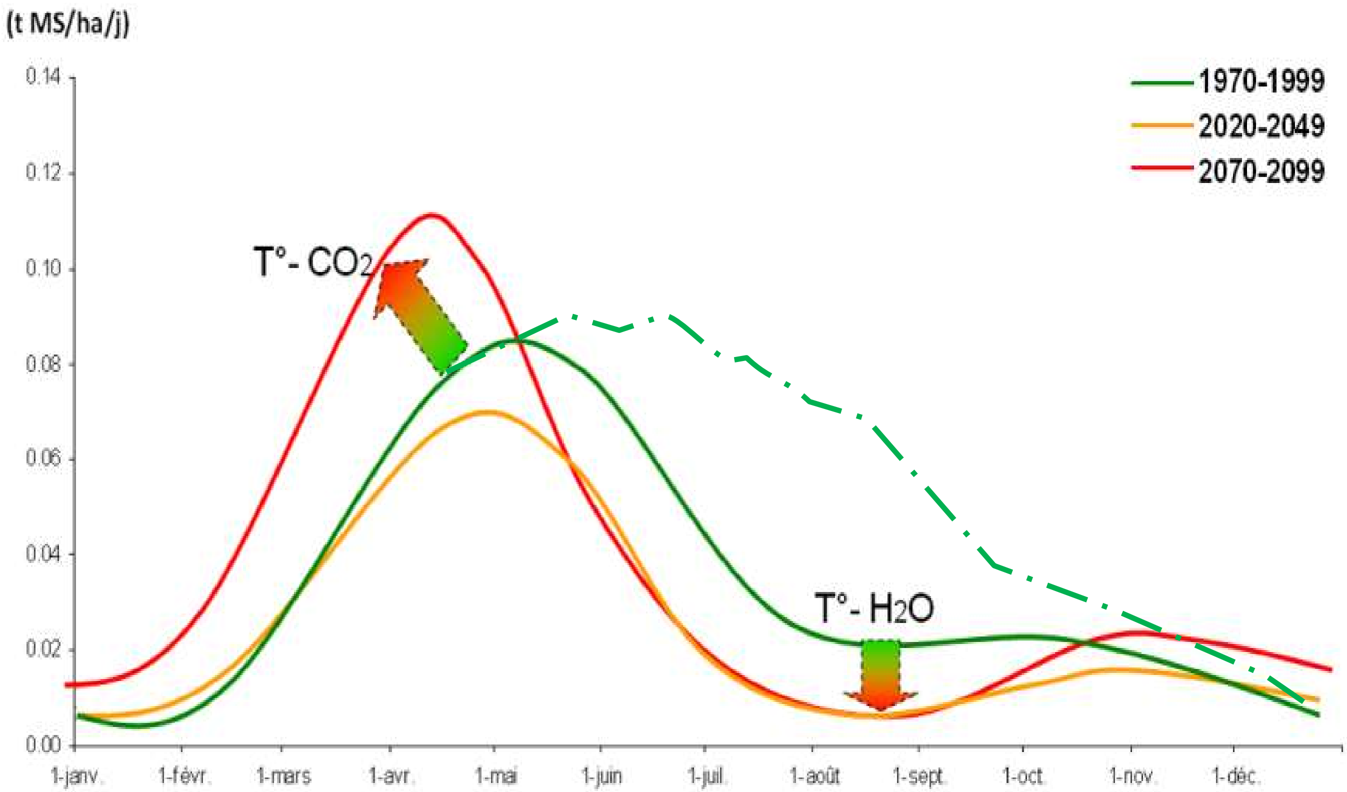
Impact of climate change on grassland productivity

Daily herbage production



CO_2, Temp, rainfalls

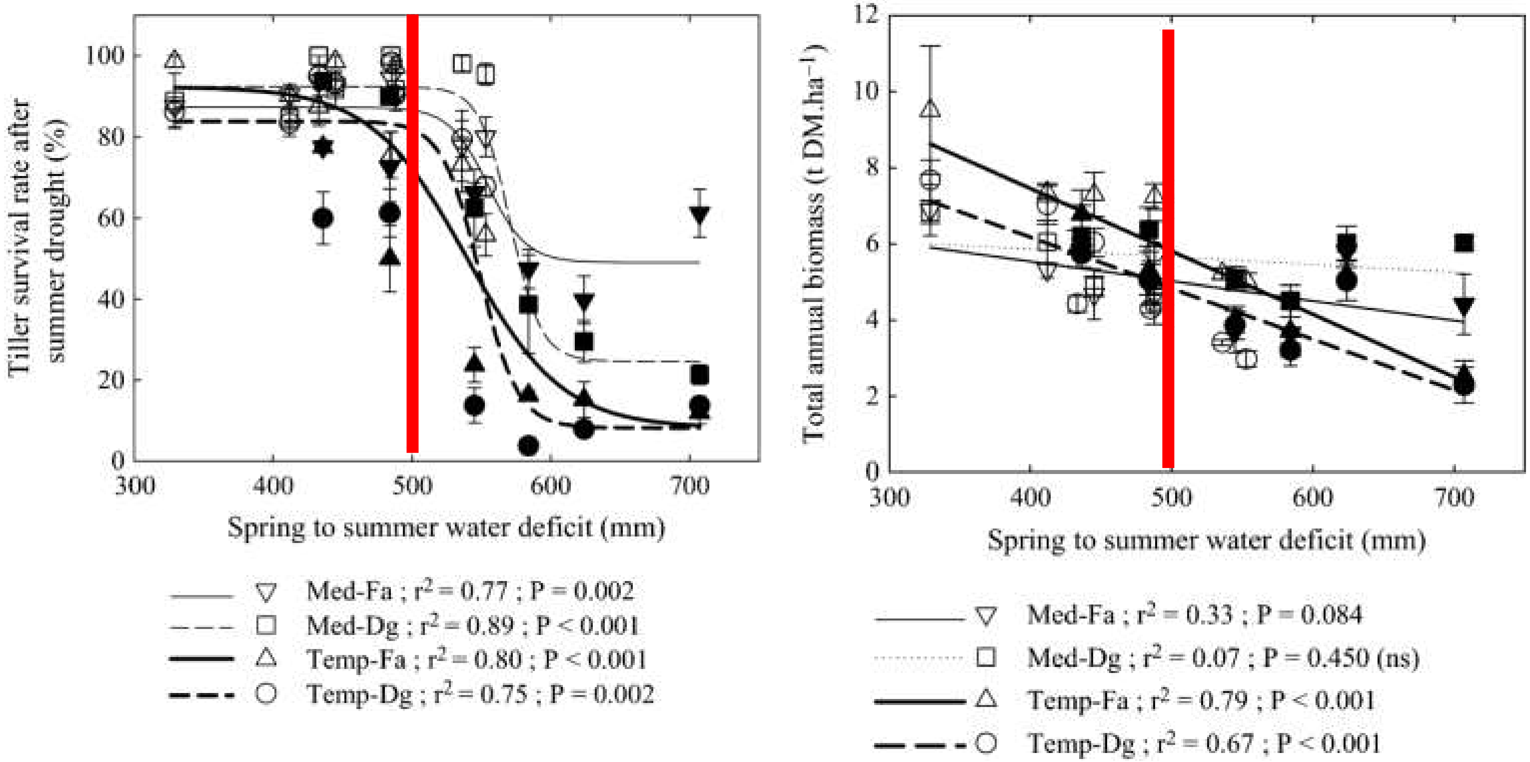
400ppm, +0°, =

450ppm, +1°C, =

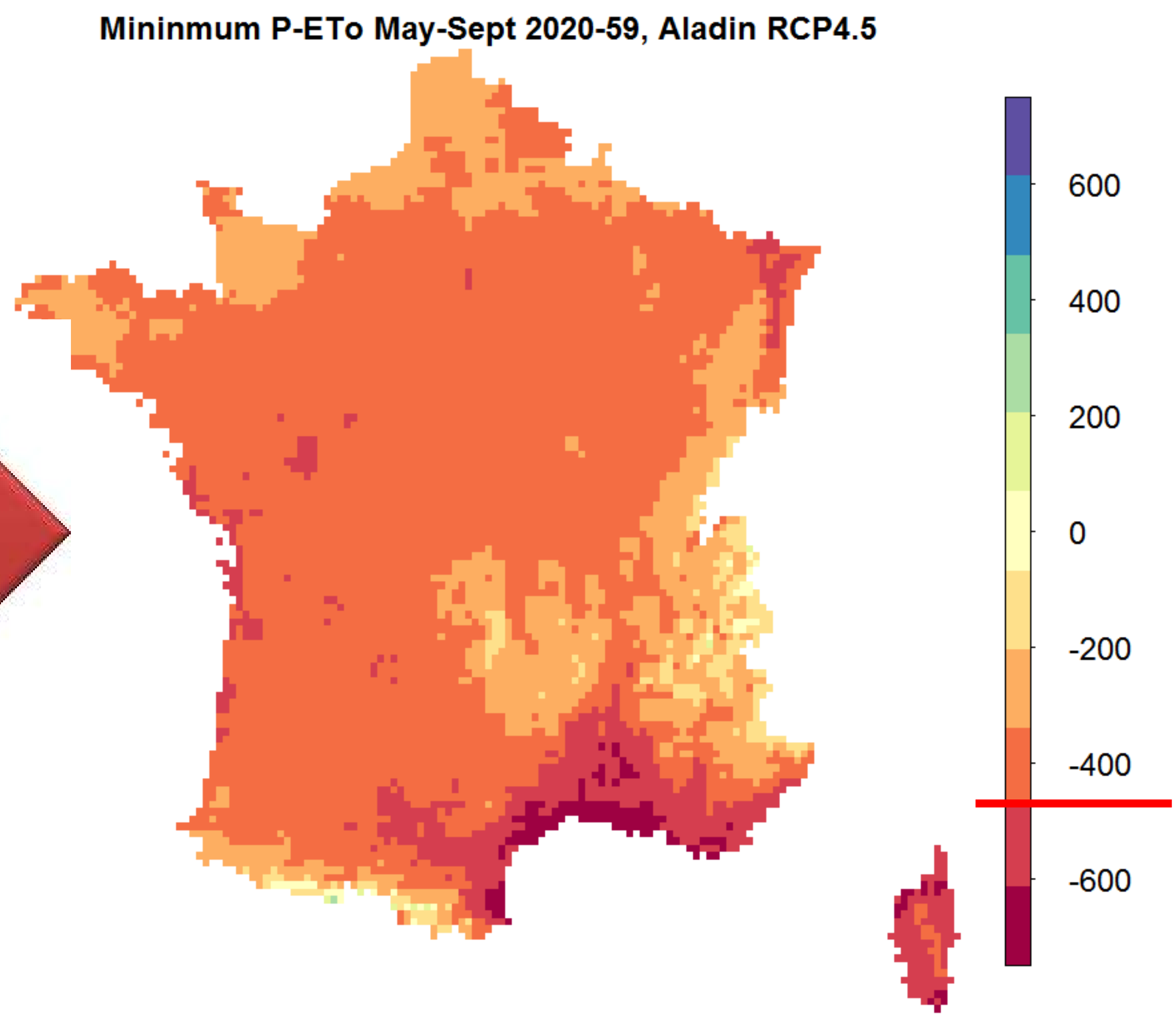
550ppm, +2°C, -30 mm

Simulation of Rye-grass production in Brittany, using the crop model STICS and the climate model Arpege (Meteo France). RCP 4.5. Durand et al 2010.

*Experimental evidence of a summer water deficit **threshold** (ET0-P May-September)*



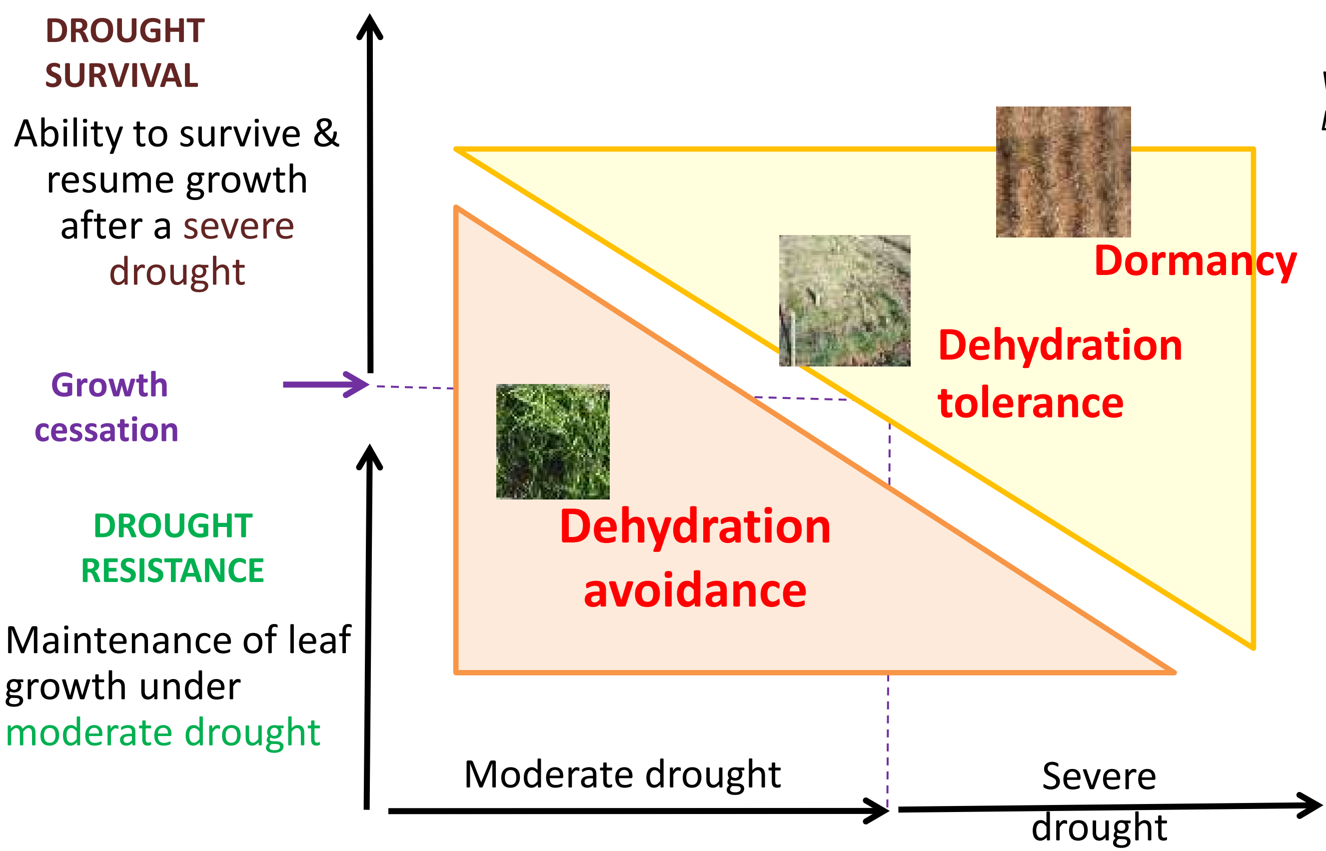
→ Only a few cultivars are adapted to Mediterranean conditions



1 year out of 10 in a near future (RCP 4.5)

P-Eto sur May-September.
Eto – P > 500 mm

Main plant strategies to resist or survive drought



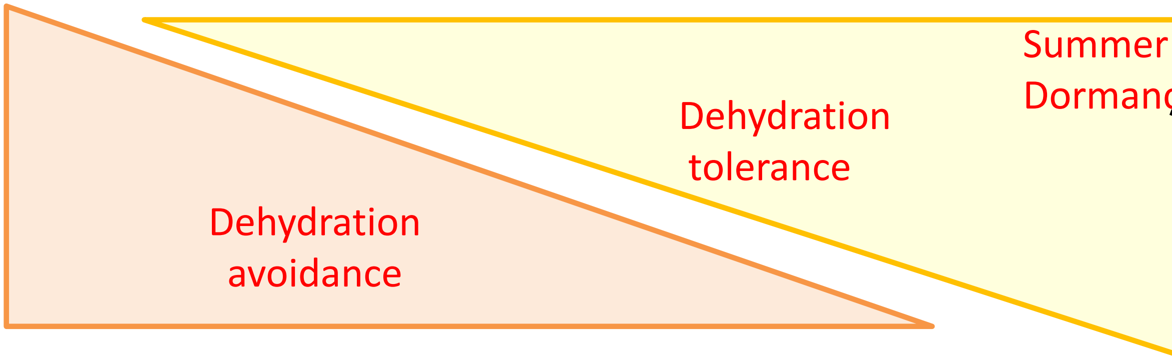
Volaire (2018) Global Change Biology
Florence.volaire@cefe.cnrs.fr

Plants cannot avoid dehydration AND tolerate dehydration

→ Under drought: a strong trade-off between growth and survival

Strategies for breeding drought adapted plants

Volaire & Norton (2016) Annals of Botany



Non – Dormant

Dactylis glomerata

Leaf growth cessation
even under summer irrigation
→ + 30% survival of severe summer drought

Main strategy
to maintain photosynthesis and
biomass production
under moderate drought

Temperate areas

Main strategies
To sacrifice growth during drought
And recover actively after severe drought

Dry and Mediterranean areas (climate change)
Very few available adapted cultivars

To increase dehydration tolerance & summer dormancy is increasingly important under climate change

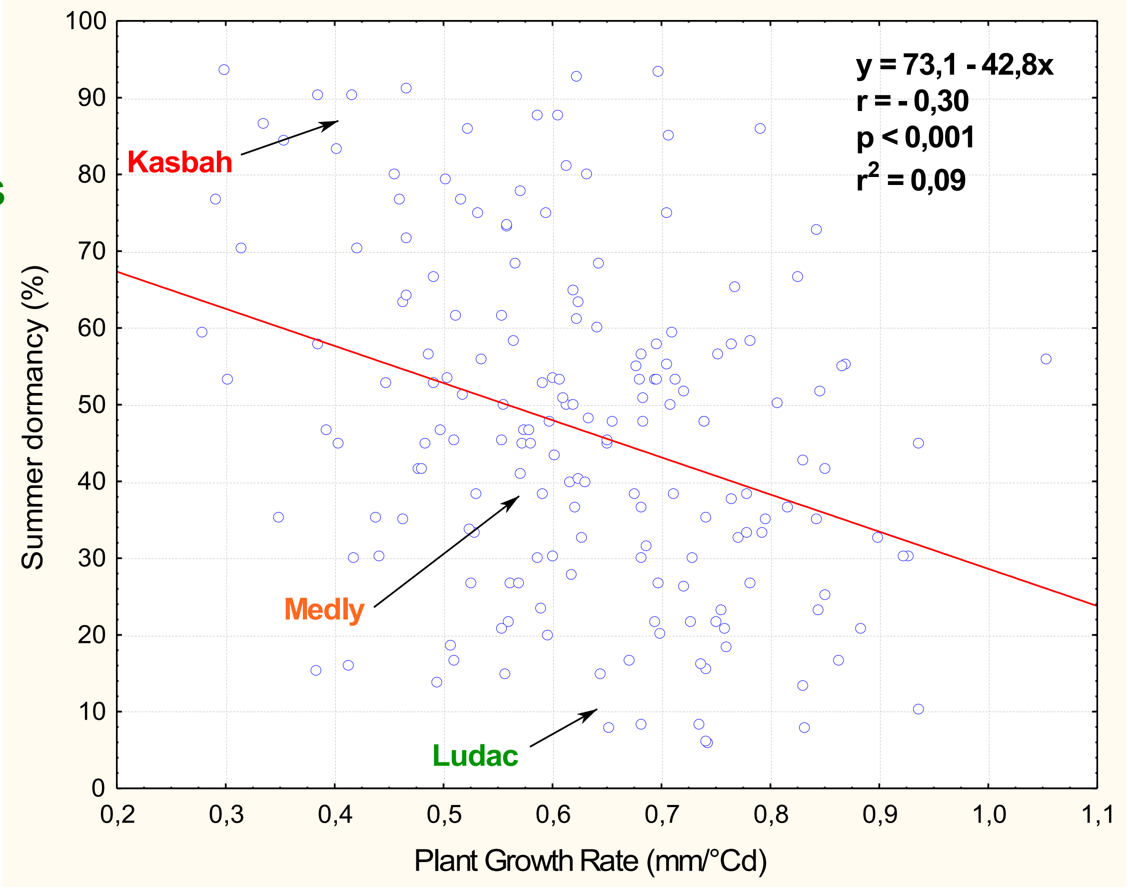
→ Design the right ideotypes according to the target environment

Norton et al. (2016) Agronomy for Sustainable Development

More productive and dormant cultivars, breaking the negative genetic correlation between both traits.

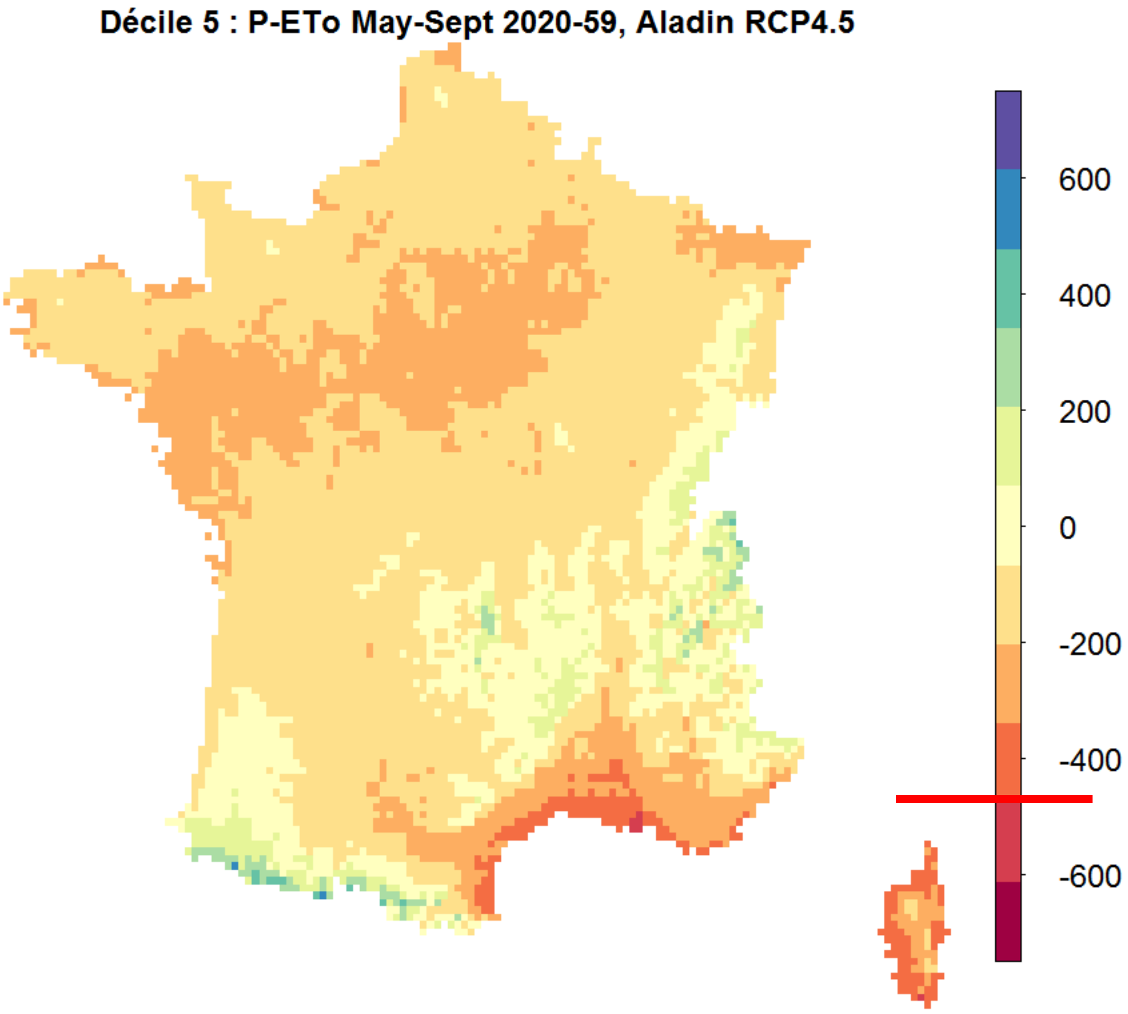
Understand the determinism of summer dormancy

QTL Analysis

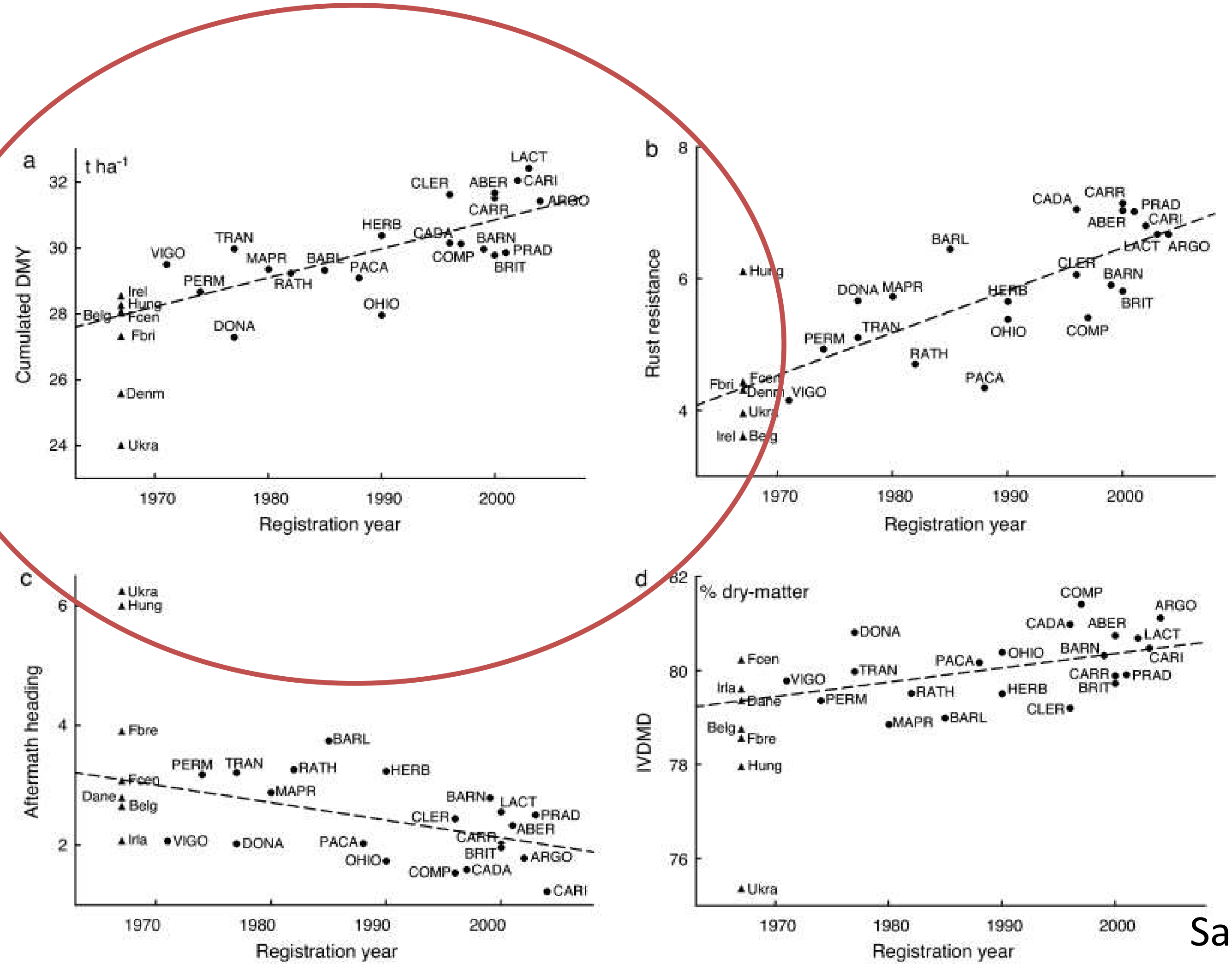


Kallida et al. (2016) Frontiers in Plant Science 7: 82

In the Temperate regions, producing high value forage throughout the year is important

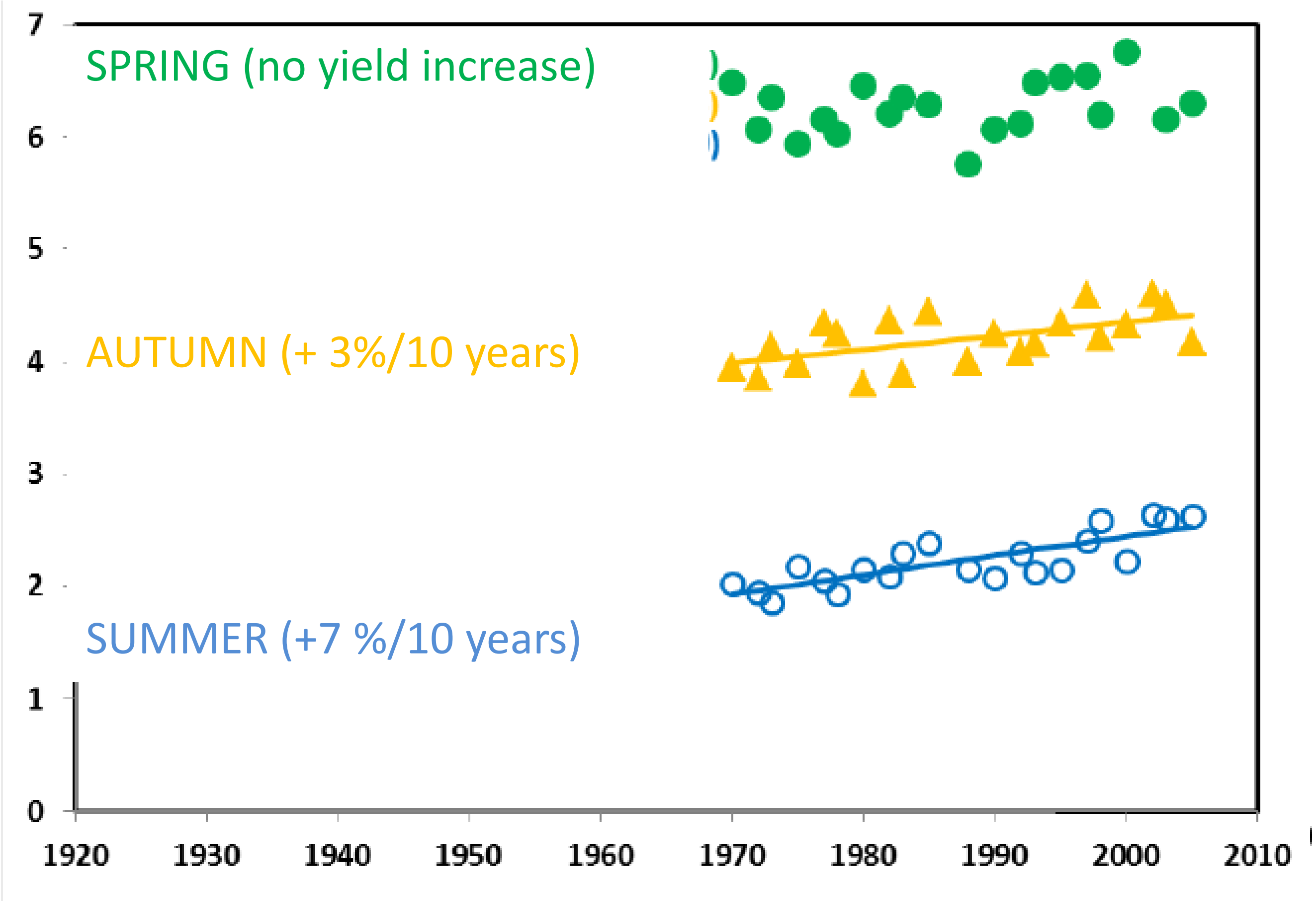


The prennial ryegrass annual yield has improved by + 10 % in 30 years: i.e. more than the negative impact of Climat change



Sampoux et al 2010

Breeders succeeded so far in reducing the negative impact of climate change in summer and autumn.



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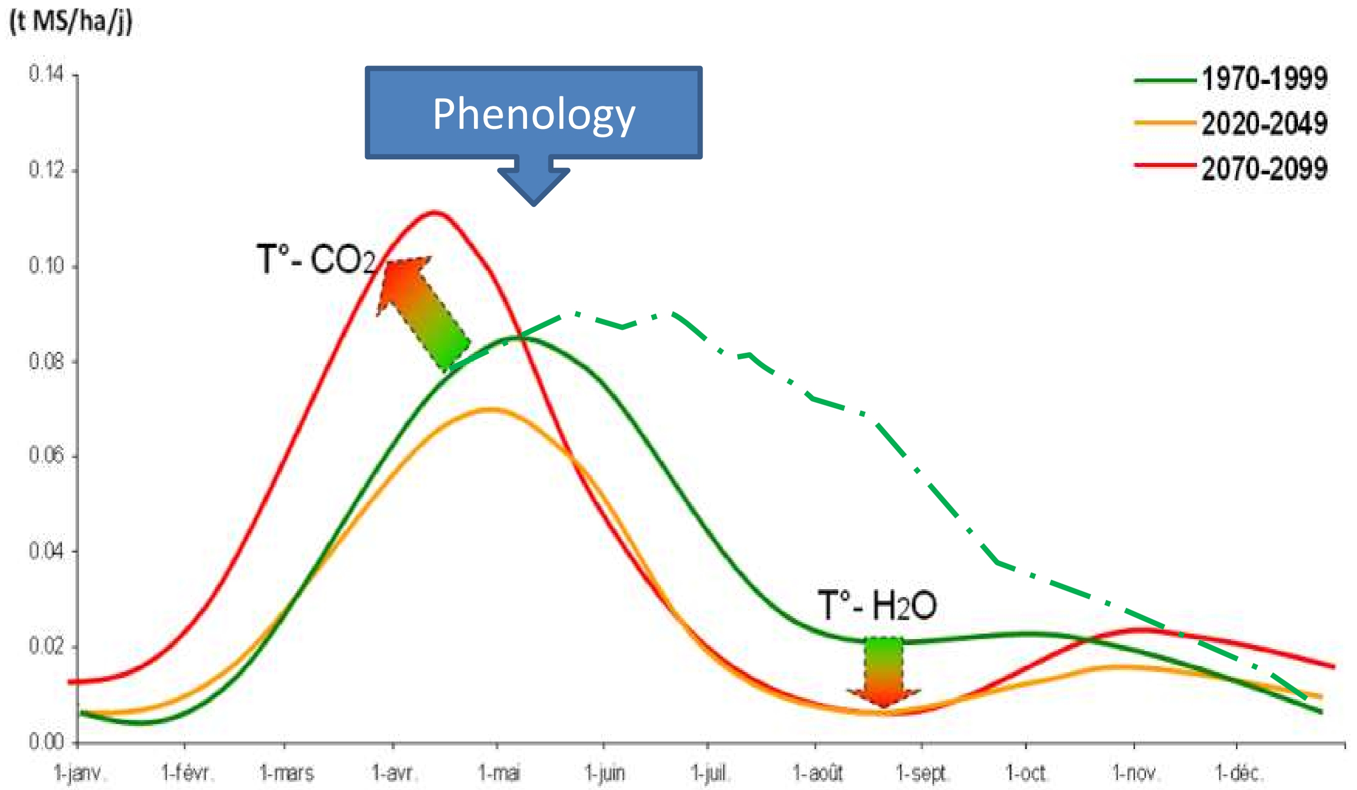
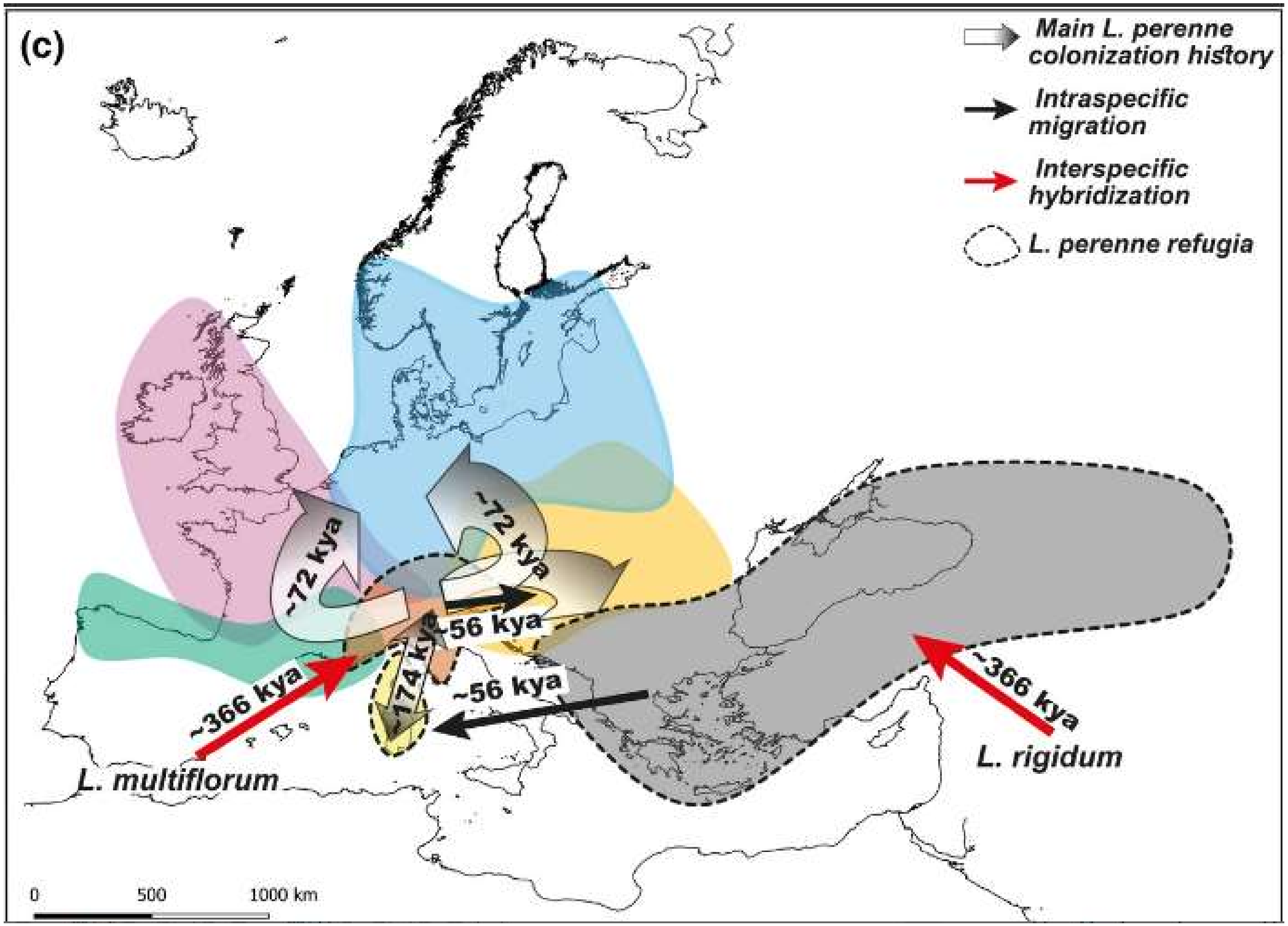
Adapt sown grasslands to Climate Change

Daily herbage production



Simulation of Rye-grass production in Brittany, using the crop model STICS and the climate model Arpege (Meteo France). Durand et al 2010.

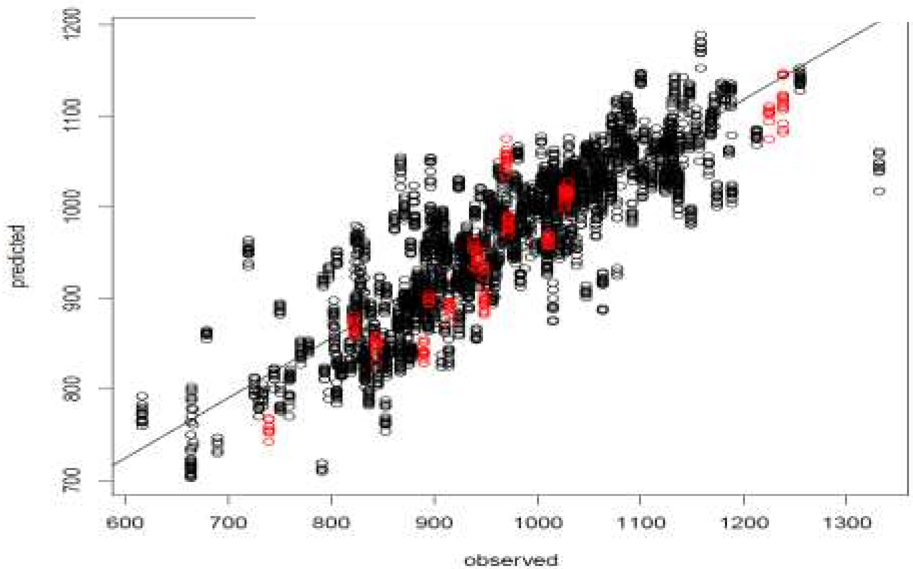
Early European expansion of *perennial ryegrass* lead to a rich underexploited variability a recent study coordinated by INRA, with European Ressource Centers, revealed.



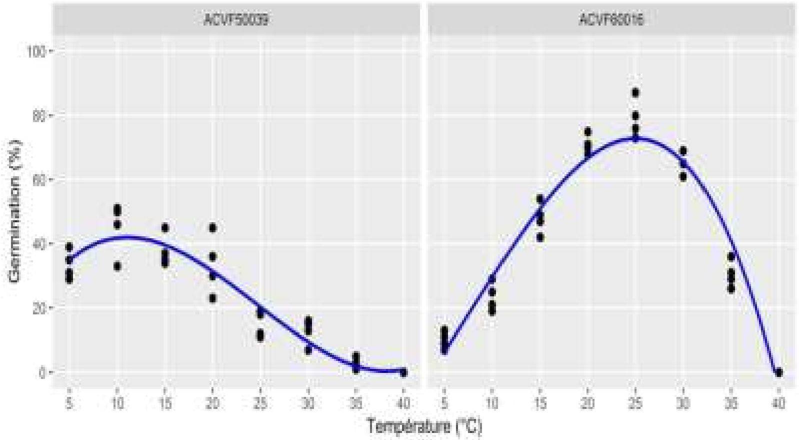
Blanco Pastor et al 2019

Focus on phenology: highly heritable in grasses –eg Perennial ryegrass populations in Europe/ cv.

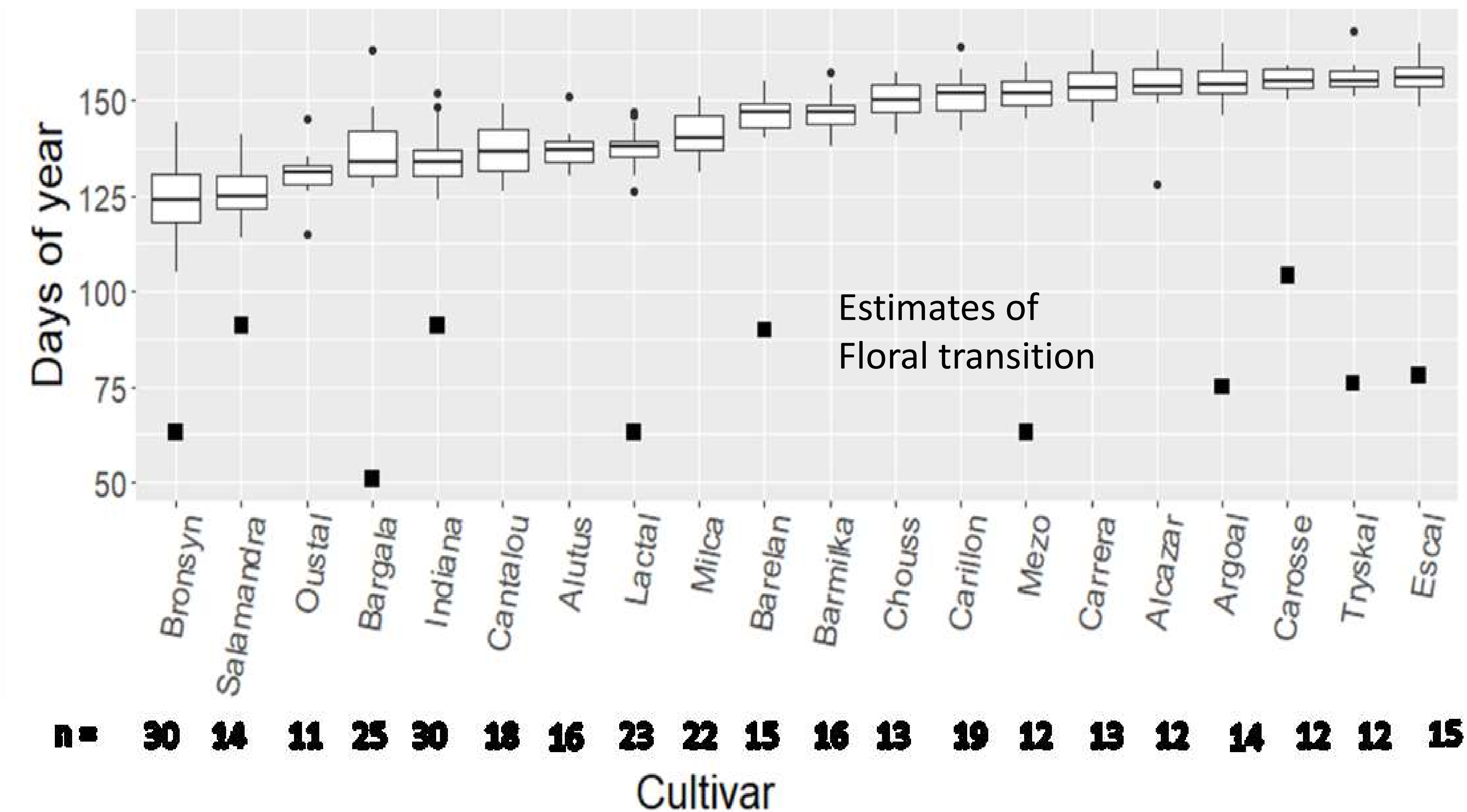
Heading date



Germination rates



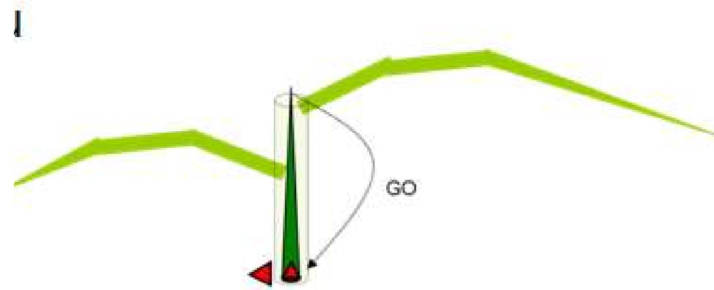
heading date and floral transition in perennial ryegrass



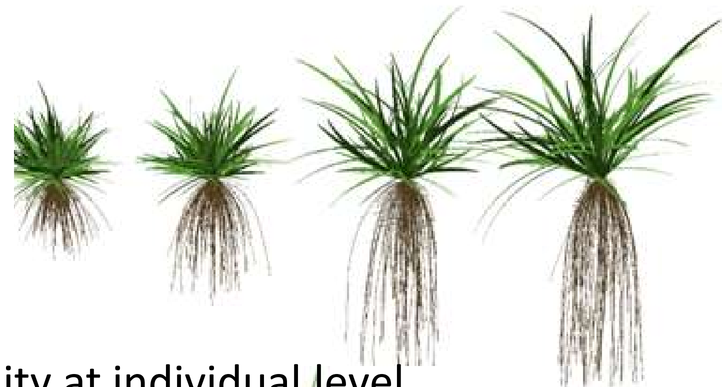
Data GEVES. Eucarpia meeting 2019

L-grass

A plant simulation model for computing ideotypes based on dynamics morphological traits



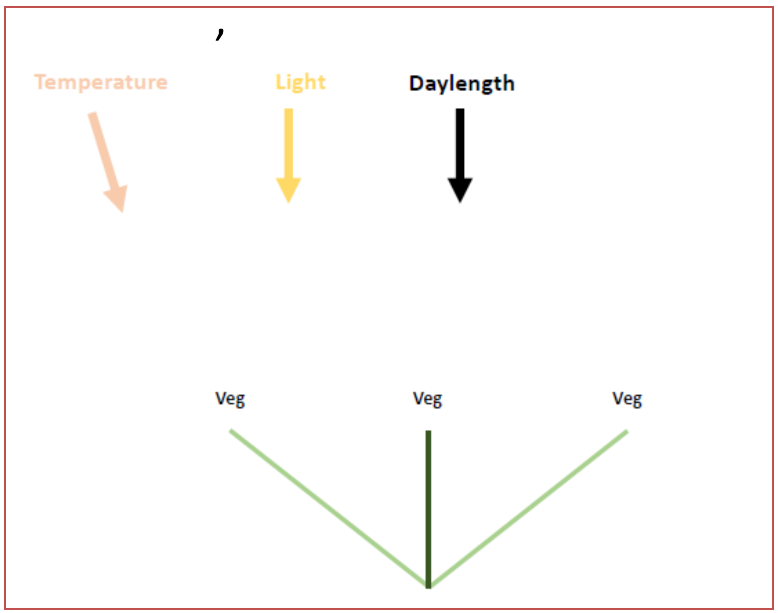
Response to cutting and management (water nitrogen…)

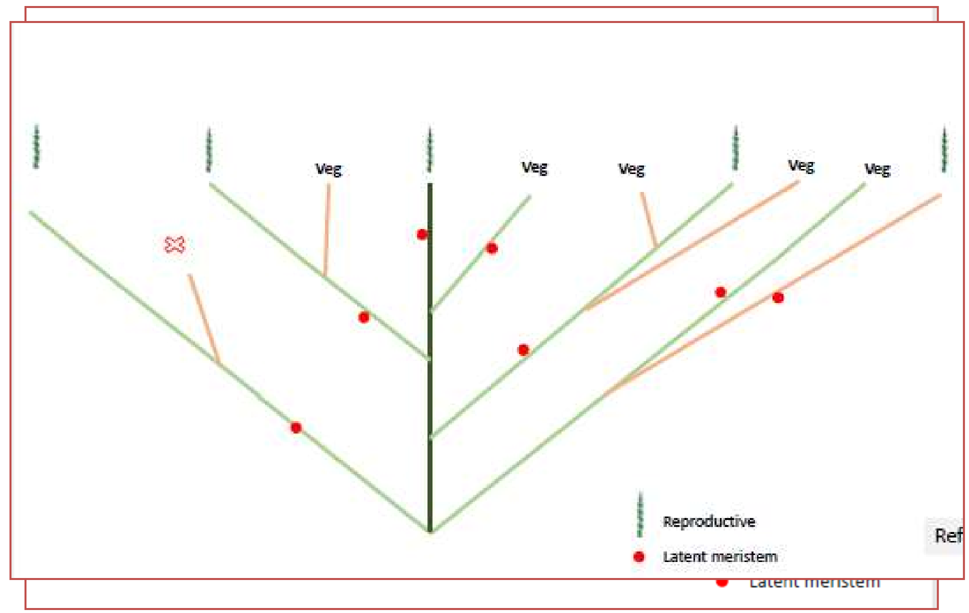


Genetic diversity at individual level

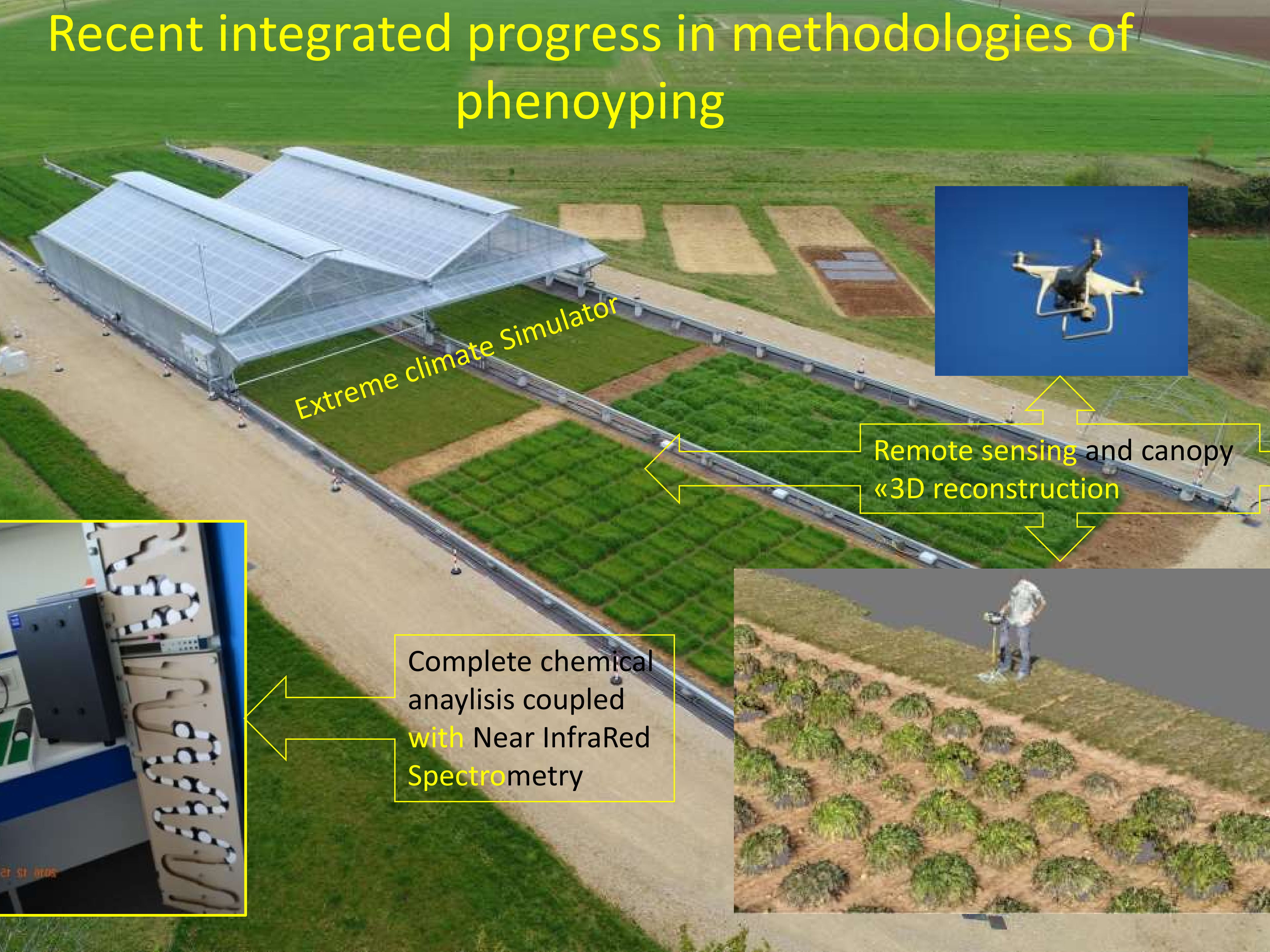
Simulate Phenology of forage grasses in order to understand the genetic variability of the response to climate

→ Adding a module of floral transition and heading to L-Grass



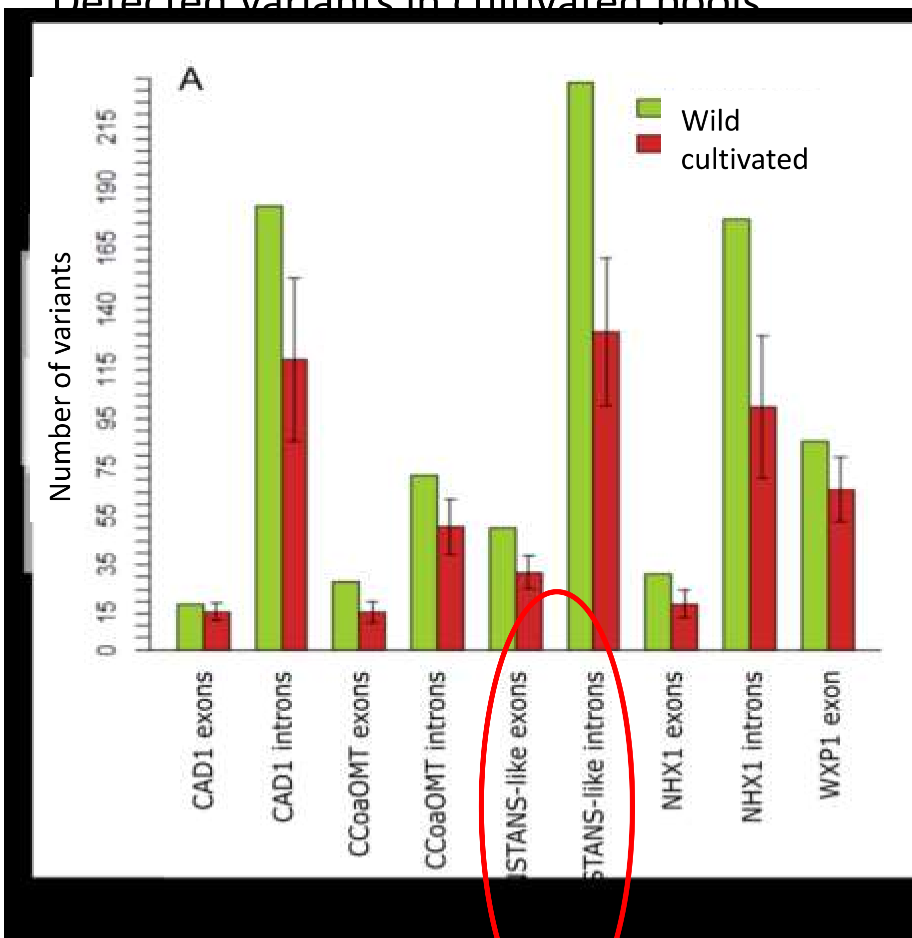


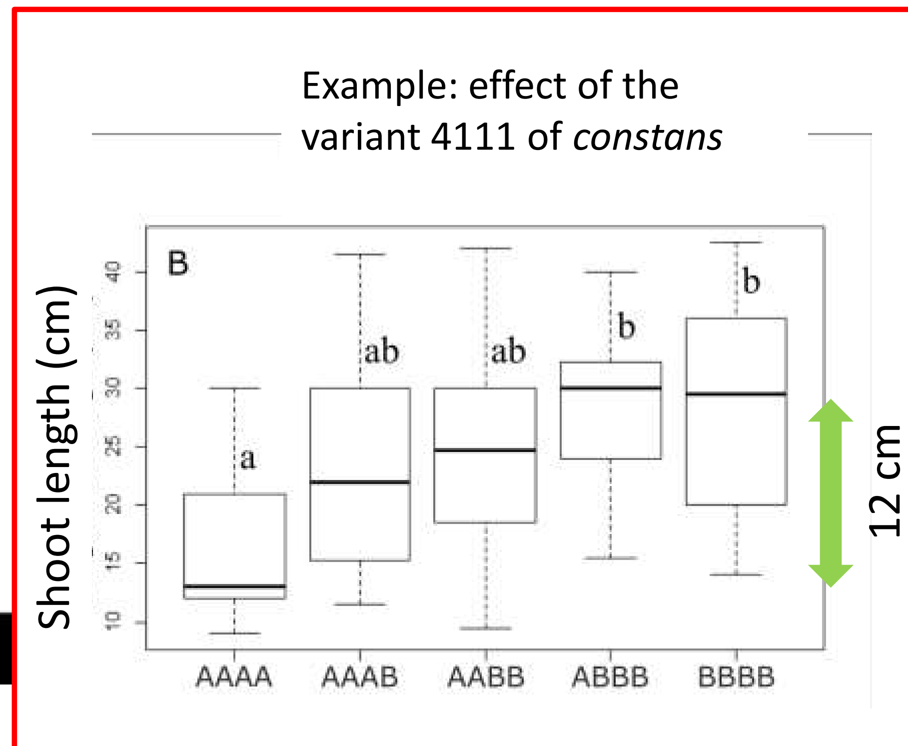
Recent integrated progress in methodologies of phenoyping



Intense genetic resources investigations in lucerne. E.g; Allele mining for breeding Alfalfa

Detected variants in cultivated pools





PhD wih Jouffray Drillaud , B Julier – P Barre
C. Gréard et al. 2018; C. Gréard 2019

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The need for mixed grasslands

- To reduce the dependancy of agriculture to fossil fuels, legumes must take a greater part
- But they grow slowly at first, due to
  - Initial dependancy on nitrate (before symbiosis is functionnal)
  - Initiation of shoot growth zones from bud stage (different from grasses)
- Very sensitiv to weed competition

→ **sowing of mixtures.**

→ But what composition ?

Nbre d'an d'exploit.	Mélange		Disponib	Densité	Sacs kg	Dactyle	Fétuque	Fétuque	Fétuque	Fléole	Pâturin d	RGA préc	
Mélanges pour cultures 1 an	❑	AT-17 BIO®	B	36	20								
	❑	AT-106		36	20								
	❑	AT-Solvert Incarnat		35	20								
Mélanges pour cultures 1 à 2 ans	❑	AT-200 Tetra	B	35	20								
	❑	AT-210 A		30	20								
Mélanges pour cultures 3 à 4 ans	❑	AT-300	B	30	20	20		33,3		10			
	❑	AT-310		32	20	17,2		31,3		7,8		15,5	
	❑	AT-323 inoculé	B	38	20	15,7		31,4		7,9			
	❑	AT-33 inoculé	B	35	20	10		22,8		4,2		10	
	❑	AT-330 M	B	33	20	16,7		36,3		7,6		10,6	
	❑	AT-340	B	33	20			36,4	12,1	12,1		12,1	12,1
	❑	AT-360		33	20					12,2	30,3	24,2	24,2
	❑	AT-362		32	20		46,9				31,2	12,5	
	❑	AT-Harvestore inoculé	B	35	20			20		5,7		7,1	
	❑	AT-Legumix		30	20								
Mélanges pour cultures 4 ans et +	❑	AT-41 F		40	20	12,5	7,5	20	7,5	7,5	25	7,5	
	❑	AT-43 RM		36	20	13,9	16,6				27,8	7,1	18
	❑	AT-430 Extra		36	20	13,9			8,3	8,3	27,4	13,9	13,9
	❑	AT-430 M	B	36	20	13,9			8,3	8,3	27,8	12,5	12,6
	❑	AT-440 BIO®	B	32	20				15,6	9,4	31,3	15,6	15,6
	❑	AT-440 Extra		32	20				15,5	9,4	31,2	15,5	15,5
	❑	AT-440 Reno	B	20	20						30	30	30
	❑	AT-46 Pâture		38	20		26,3	18,4			26,3	10,5	5,3
	❑	AT-460		33	20					12,1	30,3	24,2	24,3

FRANCE PRAIRIE
MÉLANGE LABELLISÉ

INTERÊT DES MÉLANGES

R·A·G·T SEMENCES

RGT STOX PROTÉINE 4

LES MÉLANGES

Demonstrating the importance of some intraspecific diversity

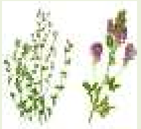
Graminées

Ray-Grass

Dactyle

Fétuque

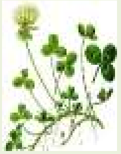
Légumineuses



Luzerne

Trèfle violet

Lotier



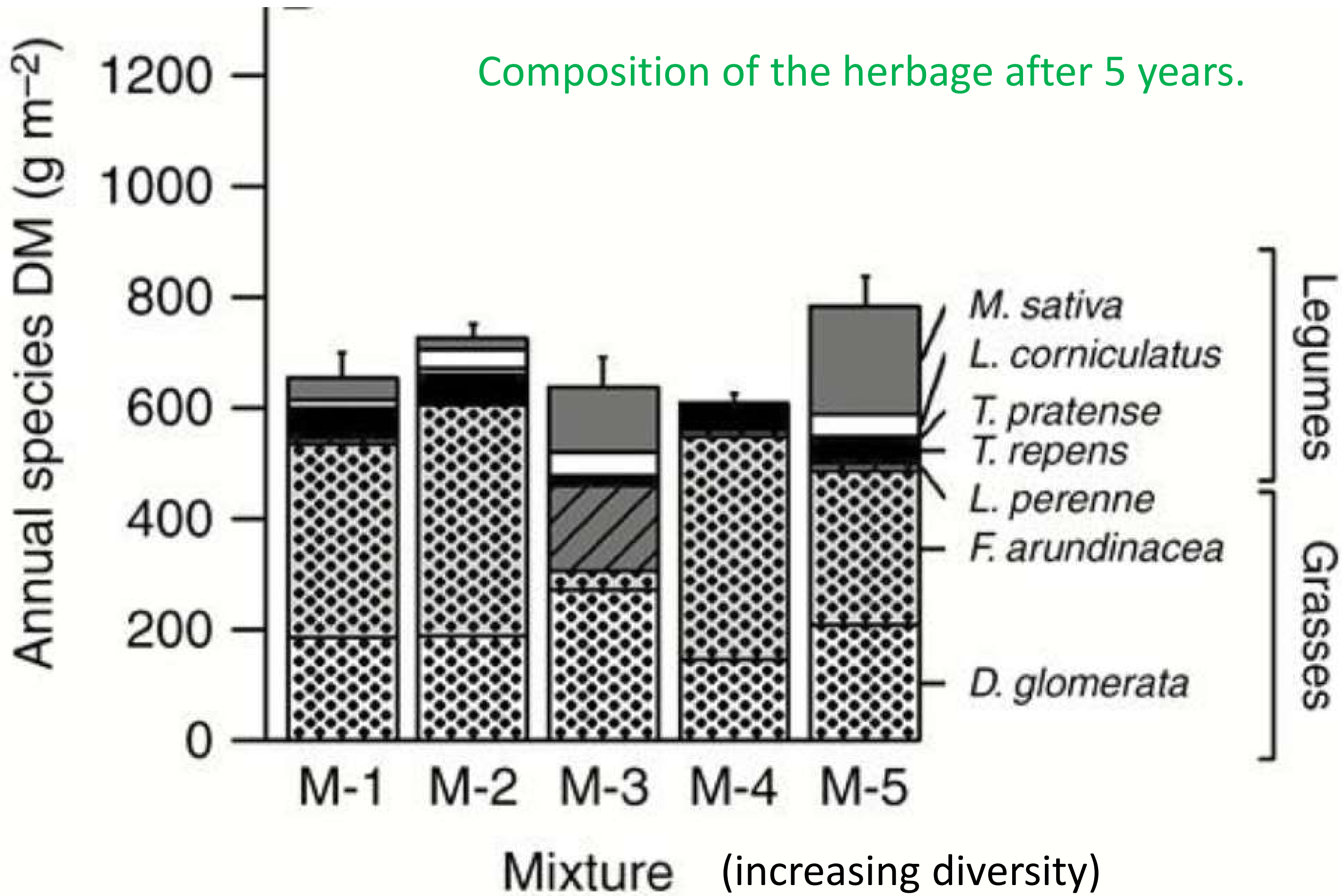
Trèfle blanc

5 mixtures using the **same** species but with different **numbers** and kinds of varieties per species

Jouffray-Drillaud (St Sauvant)

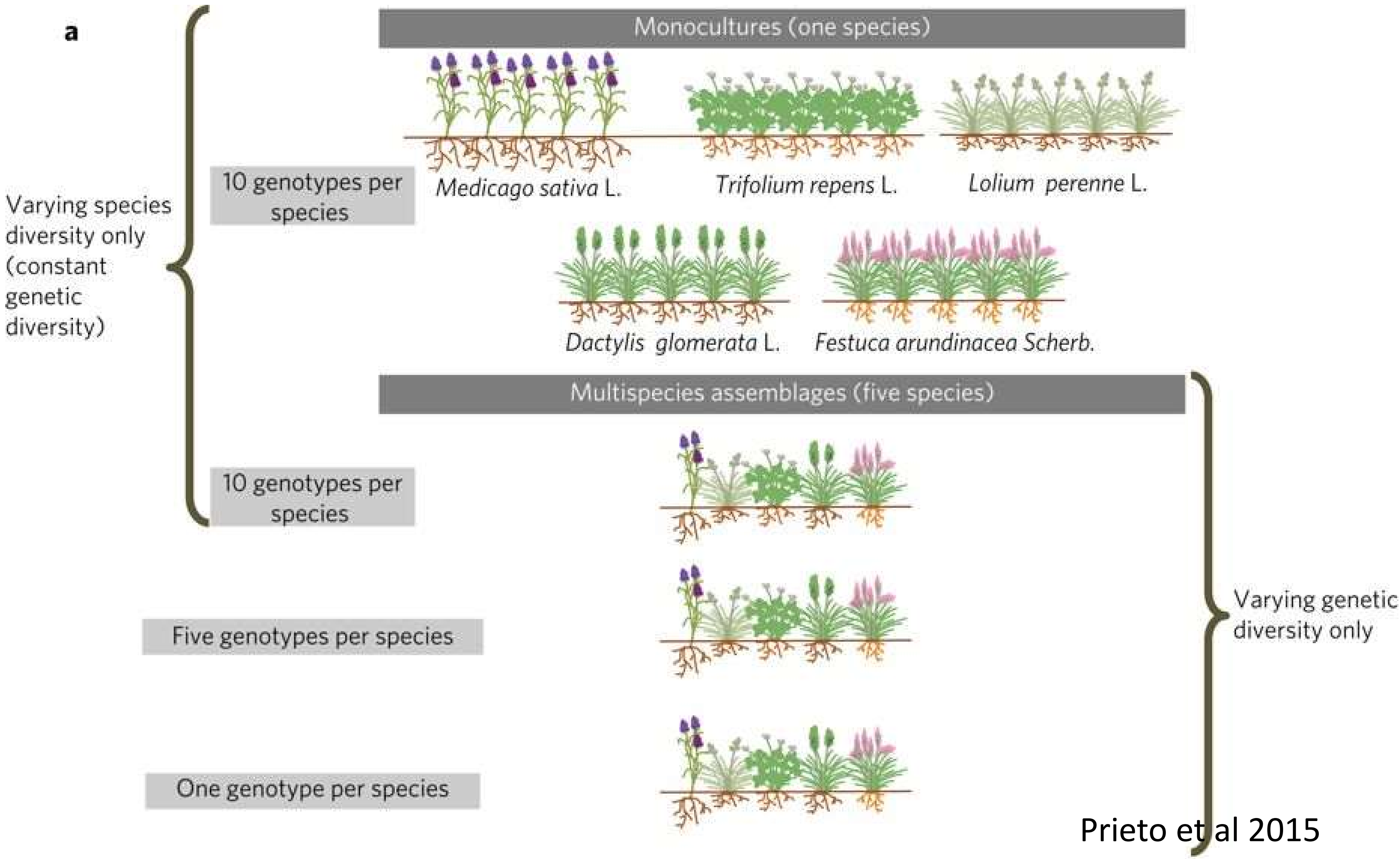
Many cultivars are better than the best ones in pure stands.

→ Stability
→ Legume proportion in herbage



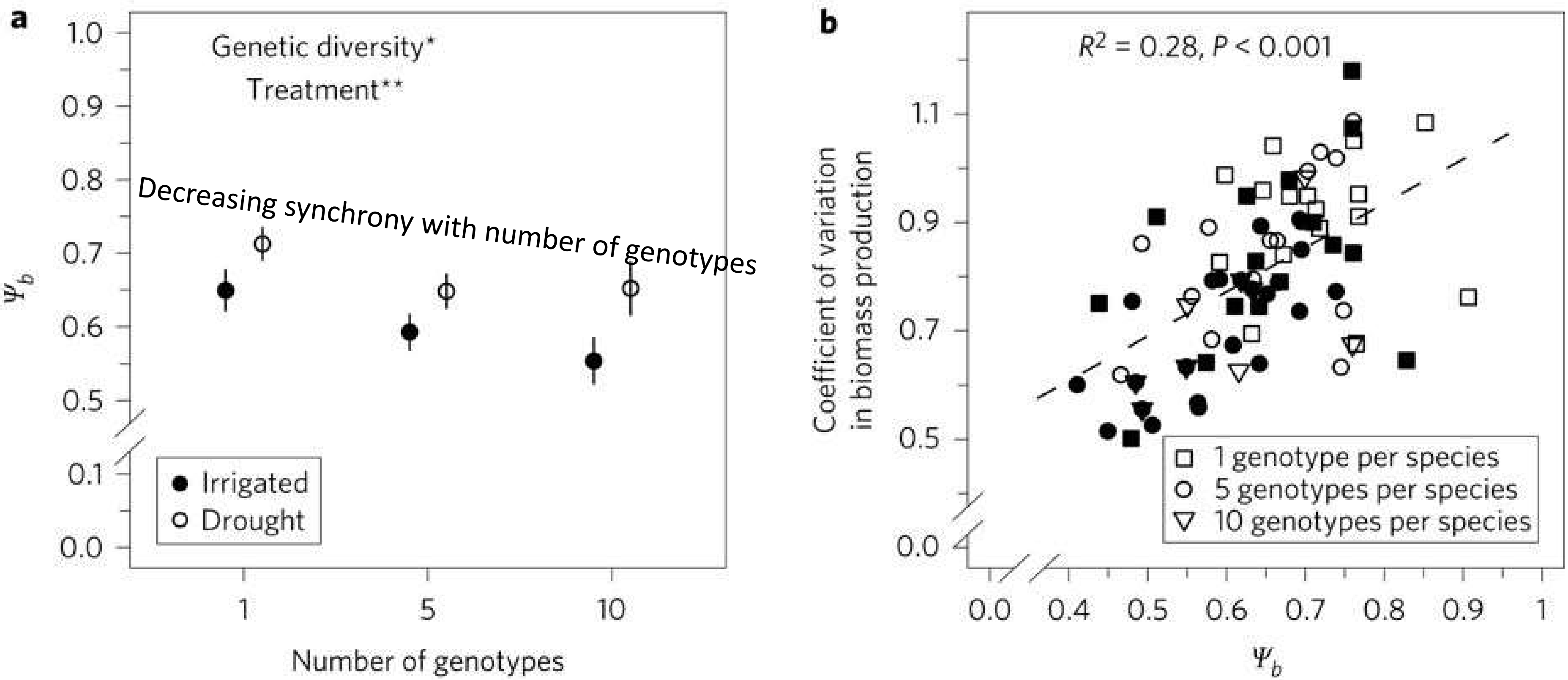
Meilhac et al 2019. Annals of Botany

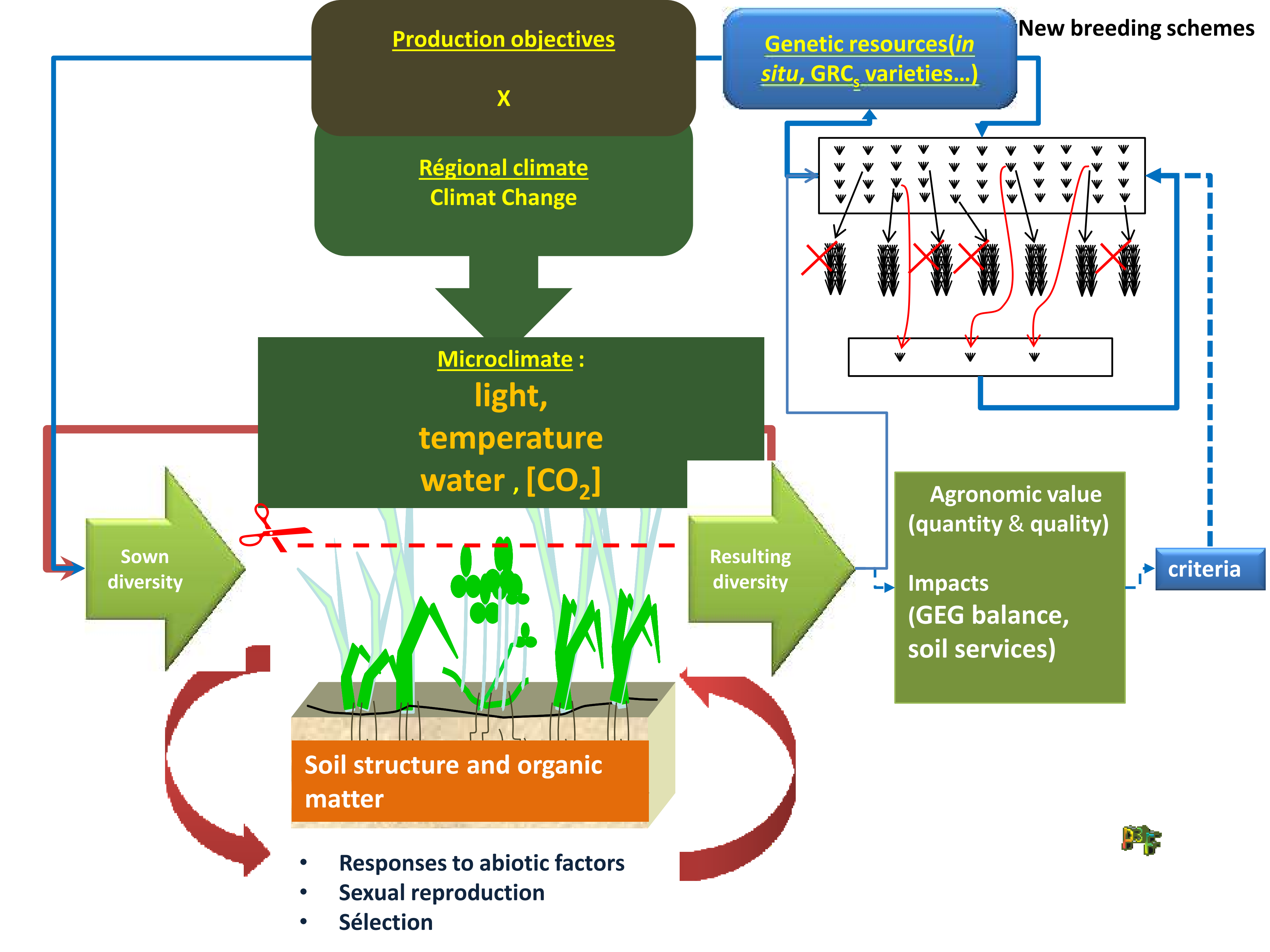
According to another experiment, the reason appears to be the intraspecific variability of phenology.



Prieto et al 2015

Intra specific differences in **phenology** improved species mixtures stability





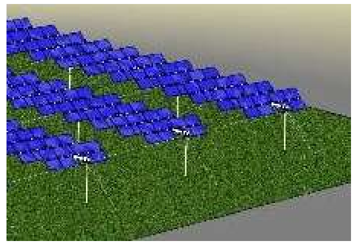
Production objectives
X
Régional climate
Climat Change
Microclimate :
light,
temperature
water , [CO2]
Genetic resources(in situ, GRCs varieties...)
New breeding schemes
Sown diversity
Resulting diversity
Agronomic value (quantity & quality)
Impacts (GEG balance, soil services)
criteria
Soil structure and organic matter
• Responses to abiotic factors
• Sexual reproduction
• Sélection

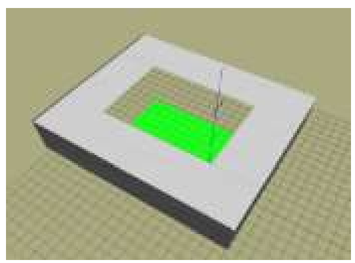
Extension of our knowledge to other area:

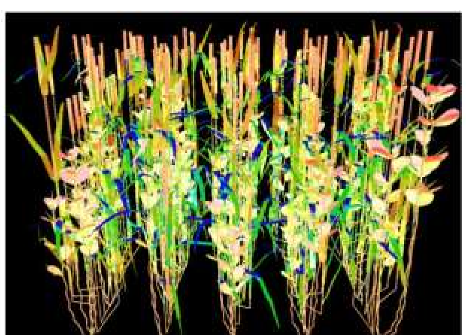
Turf and forage biomass management under stadium covers, solar panels , cereals…

Neutral shading

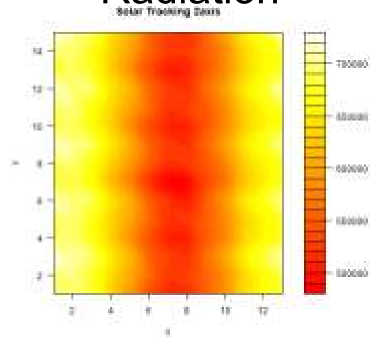
Modelisation 3D

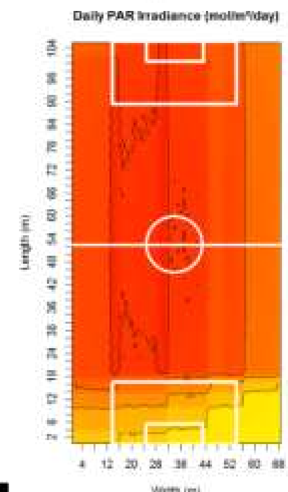




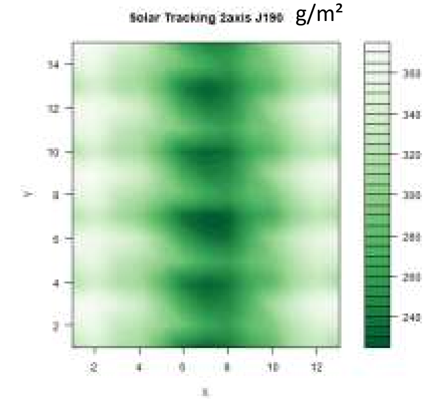


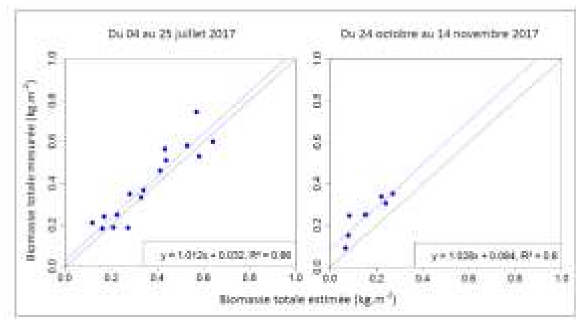
Modelisation Radiation





Crop modelling





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Conclusion

- The role of sown grassland in **ecological intensification** is crucial

- Despite of- and due to the intrinsic diversity, forage cultivars exhibit
  - Most efficient **feed** for cattle
  - Strong **resilience** to climate change,
  - Consistent margins **of genetic progress**

- Collection, study and conservation of **genetic resources** was and will remain crucial

- **INRA** is engaged with multiple **partnerships** at Local, National and European levels in both private and public sectors.


Thank you for your attention