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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
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► To cite this version:

Jean-Louis Durand, Lina Qadir Ahmed, Thierry Bariac, Romain Barillot, Philippe Barre, et al.. Latest public research on forage and turf and update on CLIMAGIE. ISF World Seed Congress 2019, Jun 2019, Nice, France. 37 diapos. hal-02789481

HAL Id: hal-02789481

<https://hal.inrae.fr/hal-02789481v1>

Submitted on 5 Jun 2020

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Latest public research on forage and turf and update on CLIMAGIE

Jean-Louis Durand, Lina Ahmed, Thierry Bariac, Romain Barillot, Philippe Barre, Jose Luis Blanco Pastor, Didier Combes, Abraham Escobar, Lucas Faverjon, Ela Frak, Marc Ghesquière, Wagdi Ghaleb, Camille Gréard, Bernadette Julier, Thomas Keep, Isabelle Litrico, Gaëtan Louarn, Julien Meilhac, Vincent Migault, Catherine Picon-Cochard, Marie-Pascale Prudhomme, Simon Rouet, Jean-Paul Sampoux, Serge Zaka, Florence Volaire.

INRA Research units: UR P³F, UREP, EVA, CEFE

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



Nice 5 June 2019

INRA

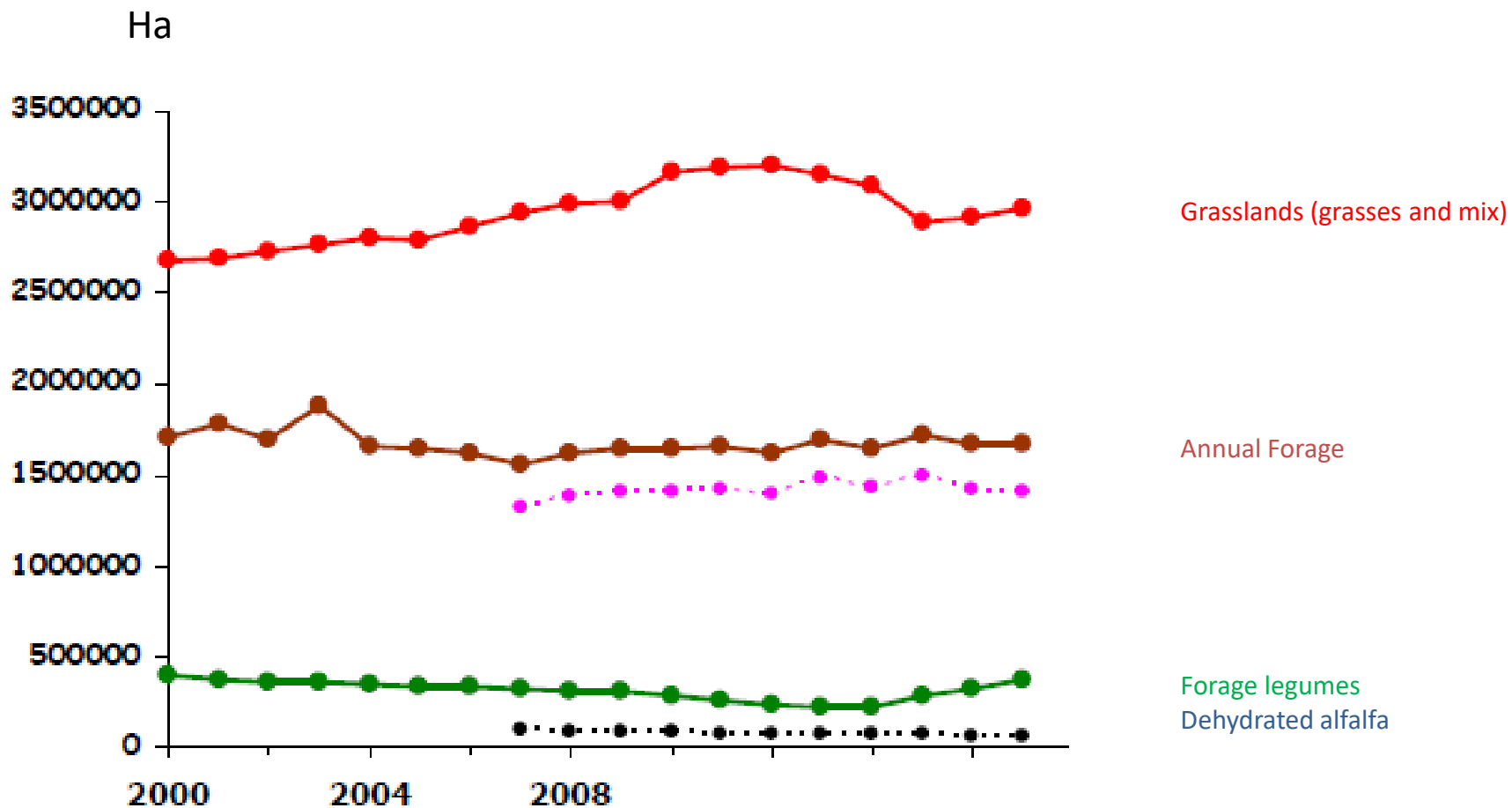
for sown grasslands improvement

- 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>

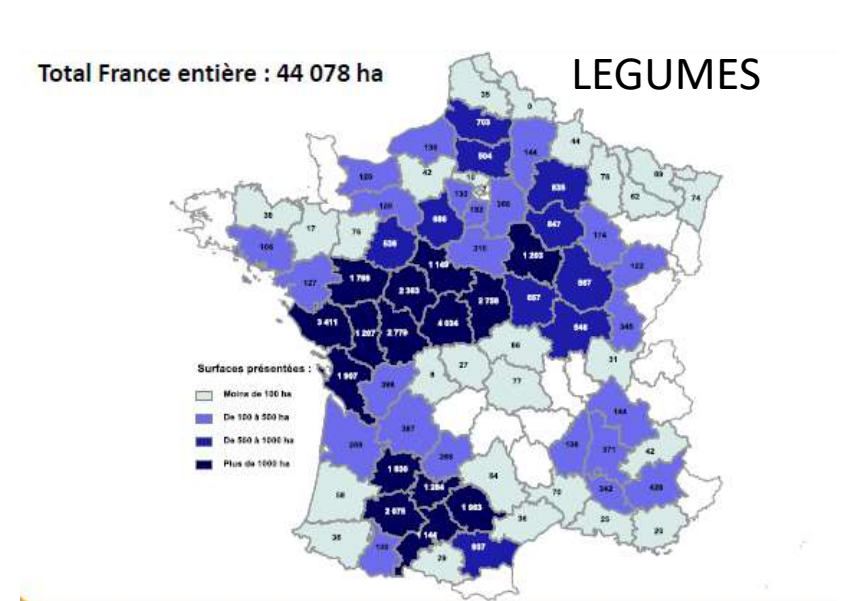
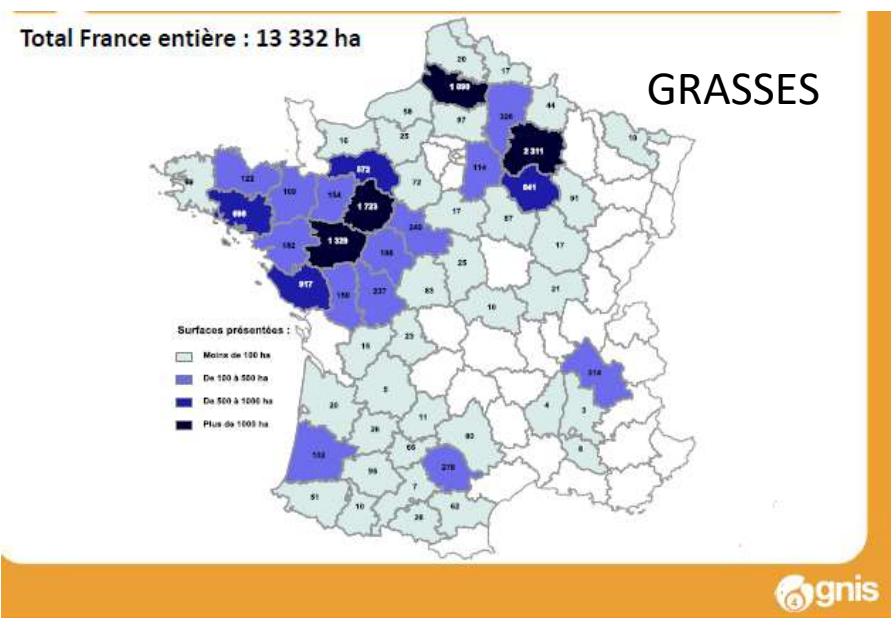
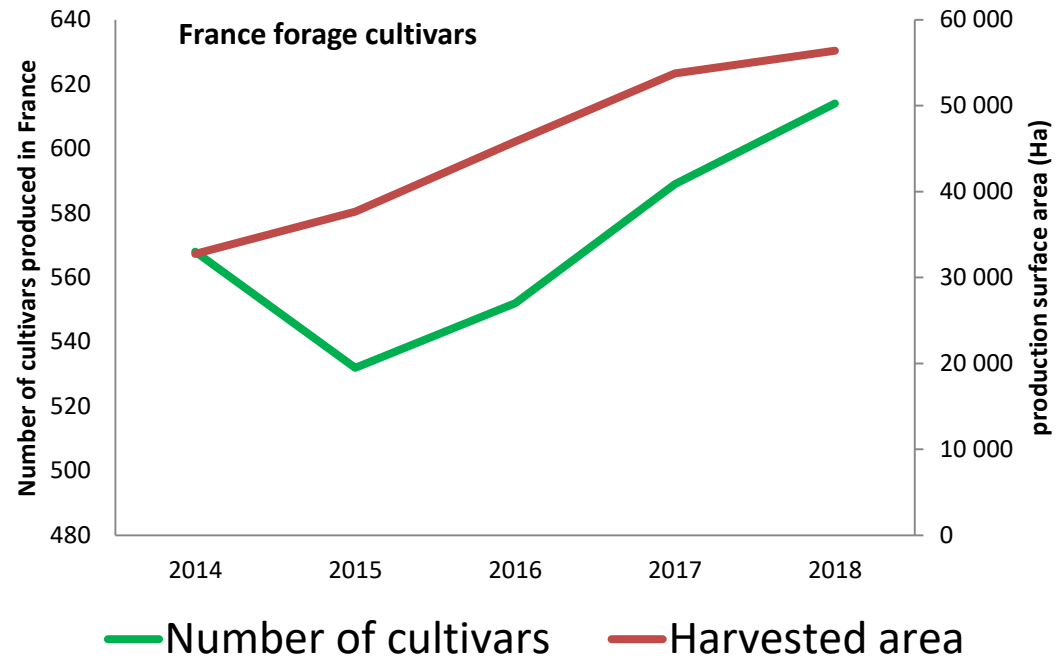
- I. The importance of sown grasslands in France
- II. Adapt grasslands to climate change
- III. The challenge of breeding for multi-species grasslands
- IV. Conclusions

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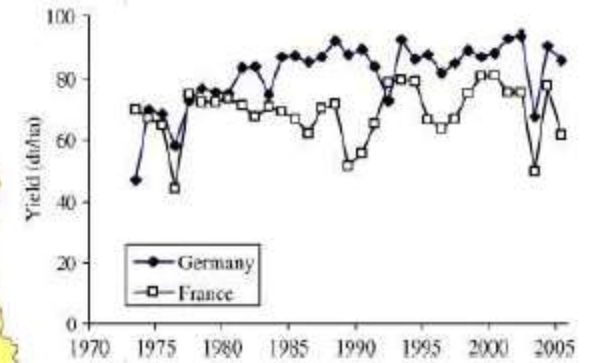
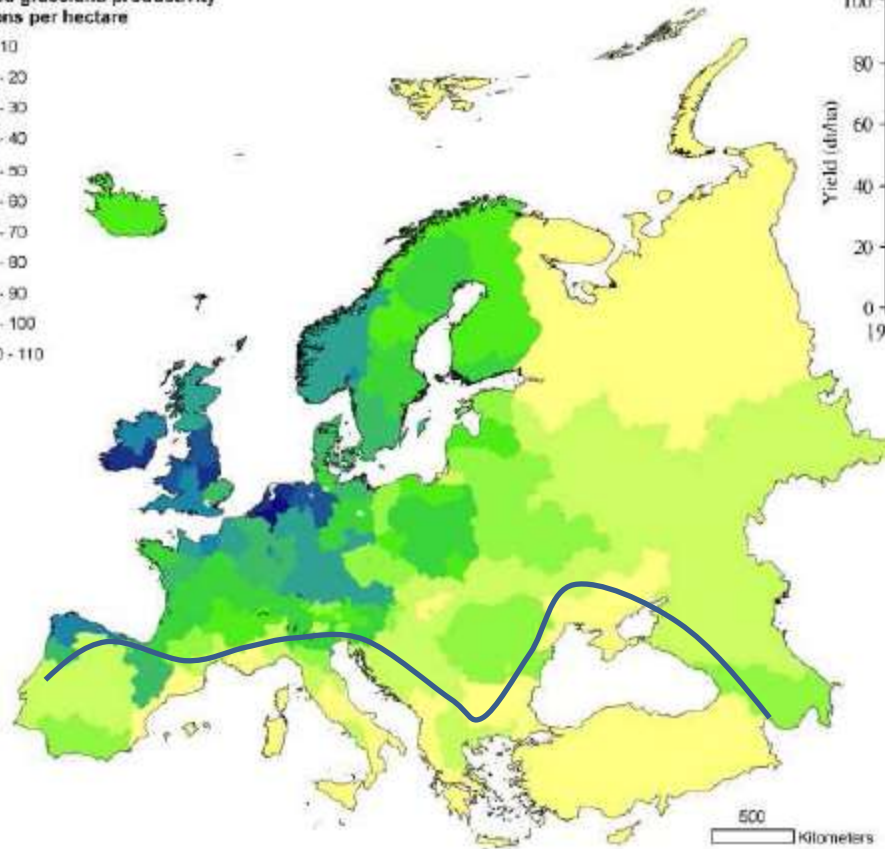
Sown grasslands are a crucial component of agricultural systems in France



Grass and legume seeds production in FRANCE



Estimated grassland productivity
in decitons per hectare



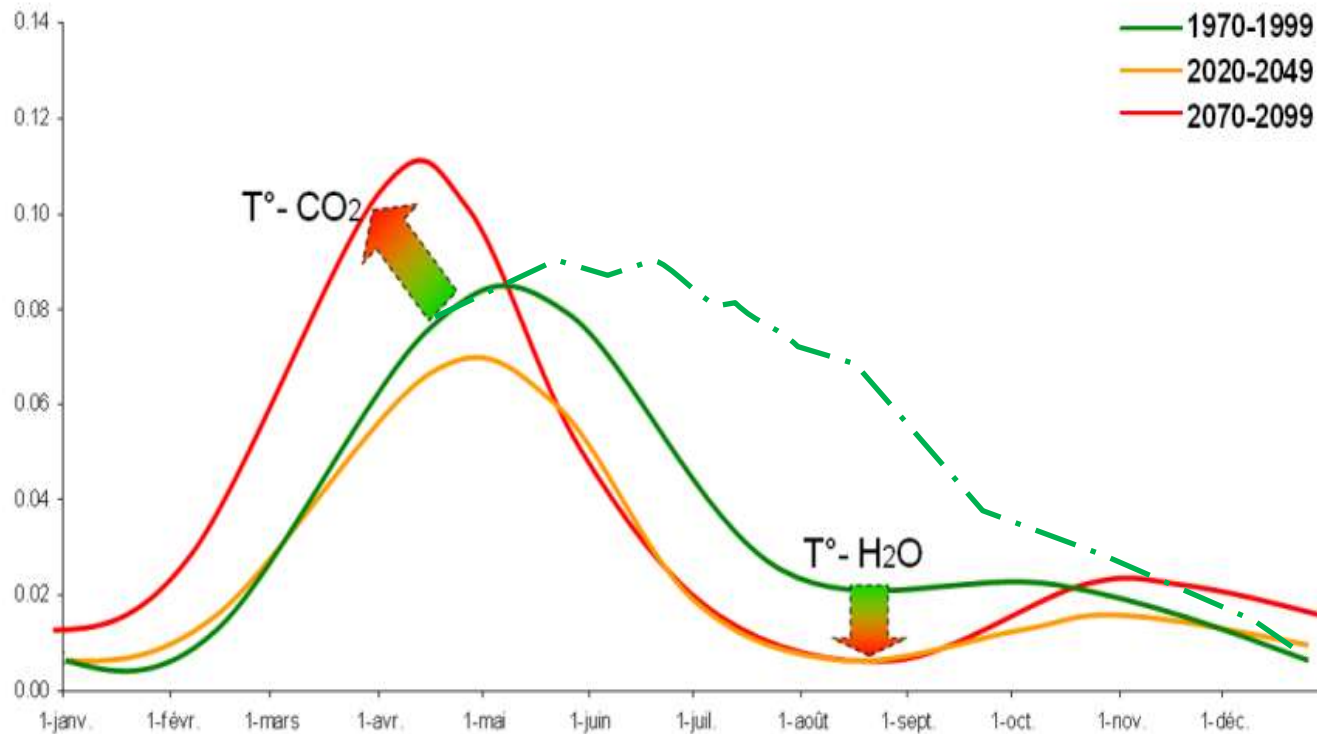
Stat nationales 1995-2004. in Smit,
Metzger & Ewert, 2008. EJA

- I. The importance of sown grasslands in France
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Impact of climate change on grassland productivity

Daily herbage production

(t MS/ha/j)



CO₂, Temp, rainfalls

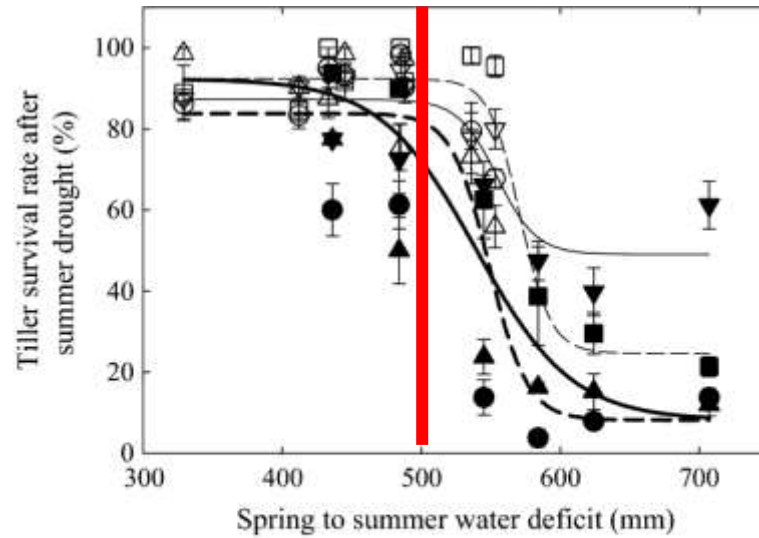
400ppm, +0°, =

450ppm, +1°C, =

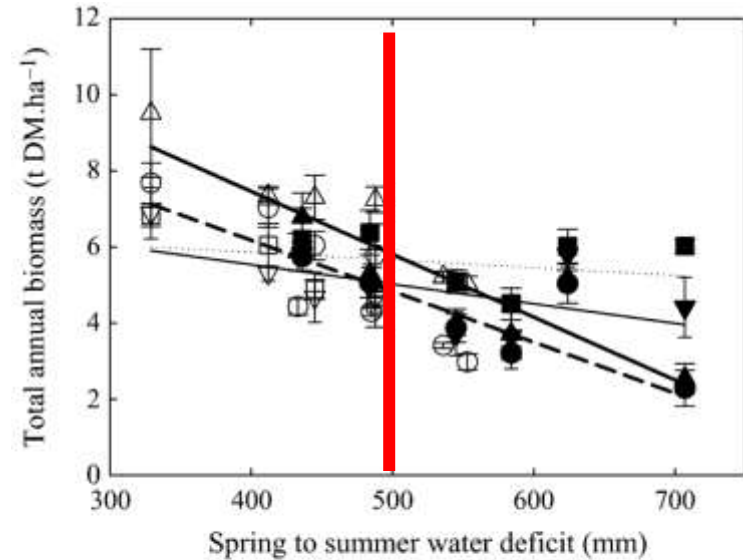
550ppm, +2°C, -30 mm

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)



- ▽ Med-Fa ; $r^2 = 0.77$; $P = 0.002$
- - - □ Med-Dg ; $r^2 = 0.89$; $P < 0.001$
- △ Temp-Fa ; $r^2 = 0.80$; $P < 0.001$
- - - ○ Temp-Dg ; $r^2 = 0.75$; $P = 0.002$

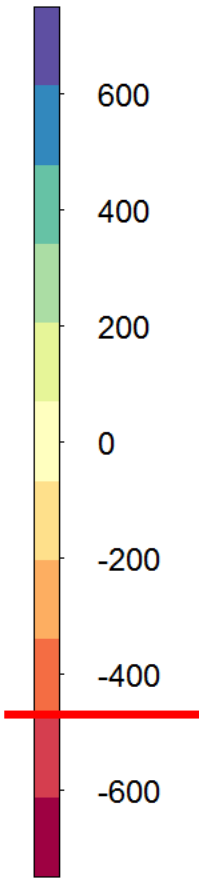
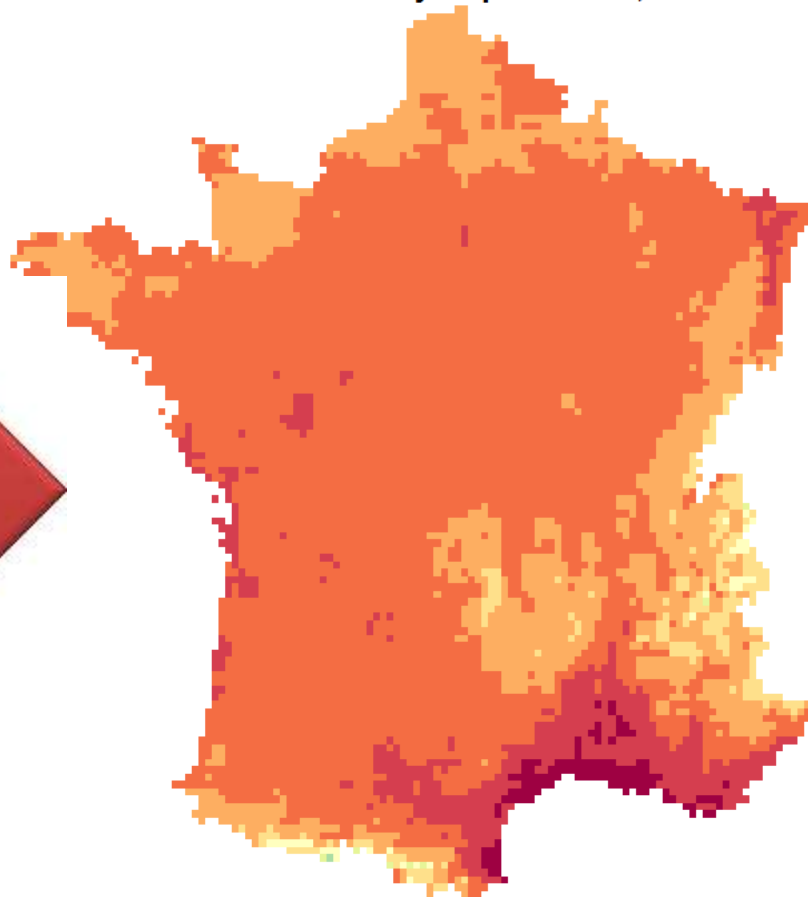


- ▽ Med-Fa ; $r^2 = 0.33$; $P = 0.084$
- □ Med-Dg ; $r^2 = 0.07$; $P = 0.450$ (ns)
- △ Temp-Fa ; $r^2 = 0.79$; $P < 0.001$
- - - ○ Temp-Dg ; $r^2 = 0.67$; $P < 0.001$

→ Only a few cultivars are adapted to Mediterranean conditions

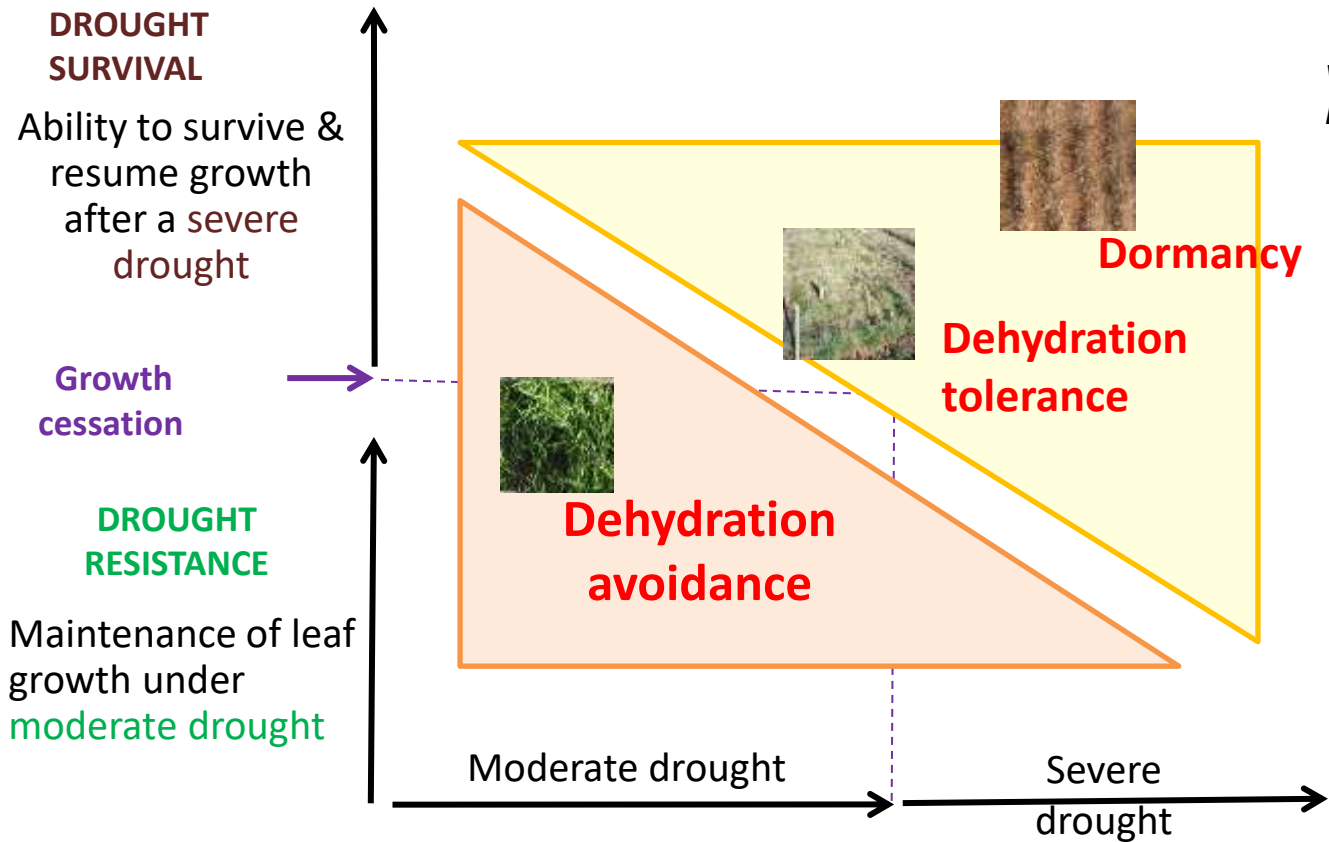
Minimum P-ETo May-Sept 2020-59, Aladin RCP4.5

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



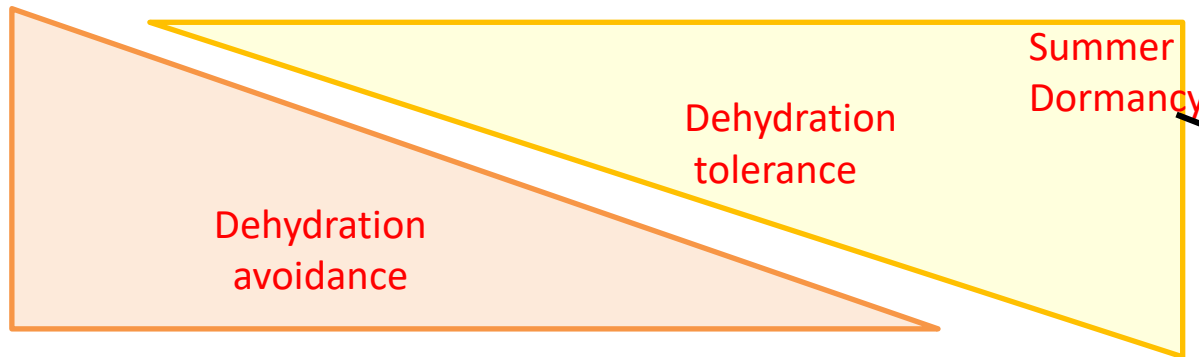
Voltaire (2018) Global Change Biology
Florence.voltaire@cefe.cnrs.fr

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

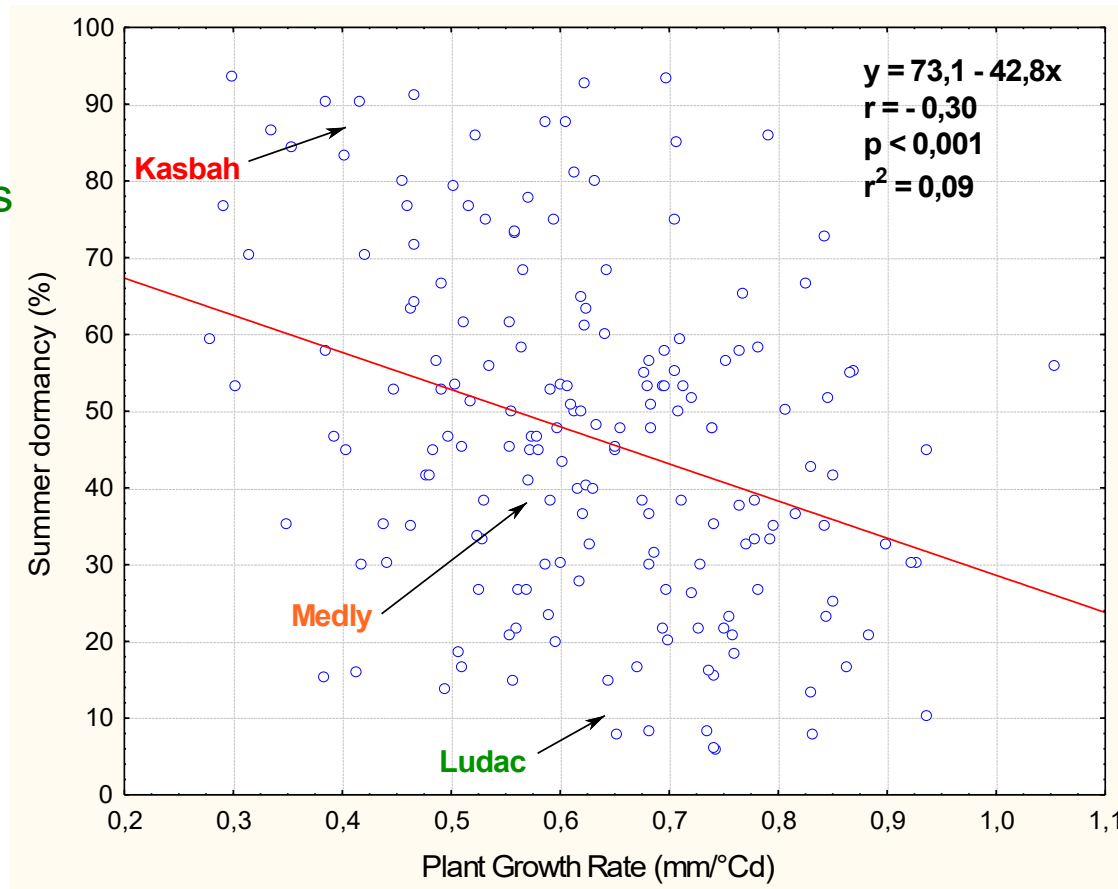
To increase dehydration tolerance & summer dormancy is increasingly important under climate change

→ Design the right ideotypes according to the target environment

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

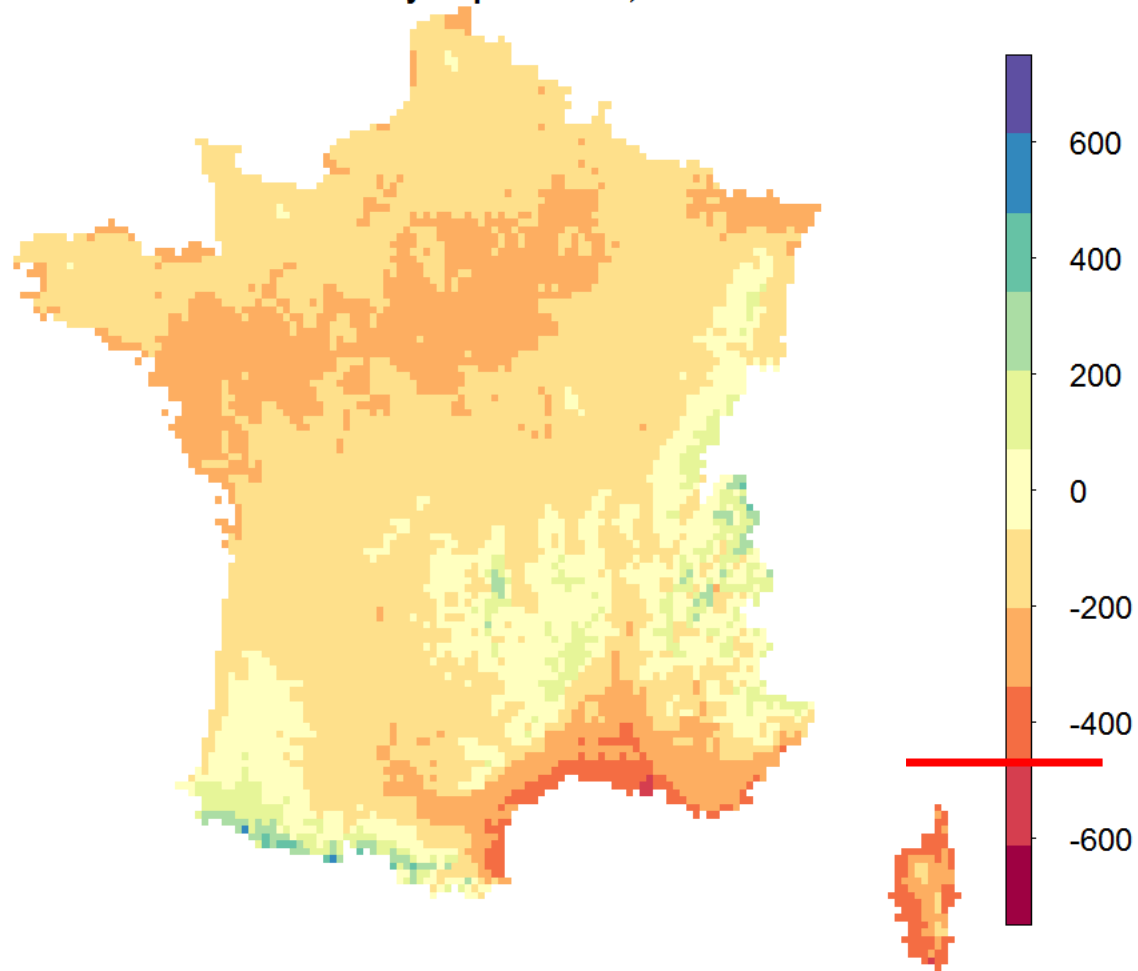
Understand the determinism of summer dormancy

QTL Analysis

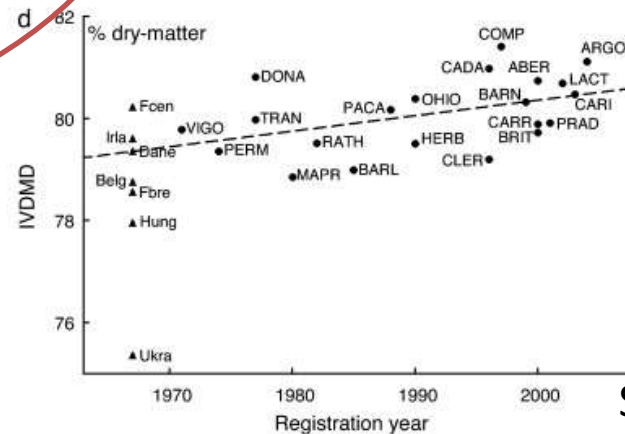
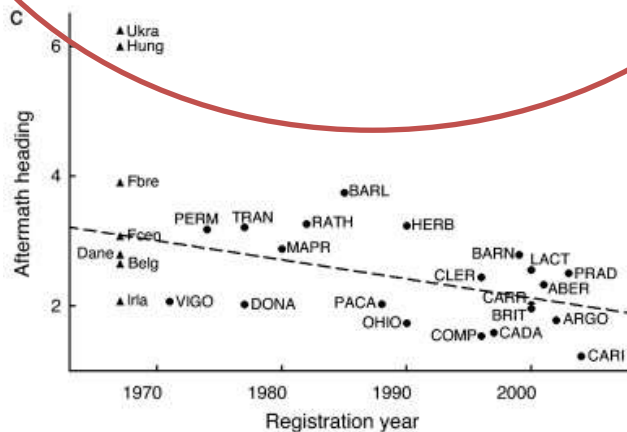
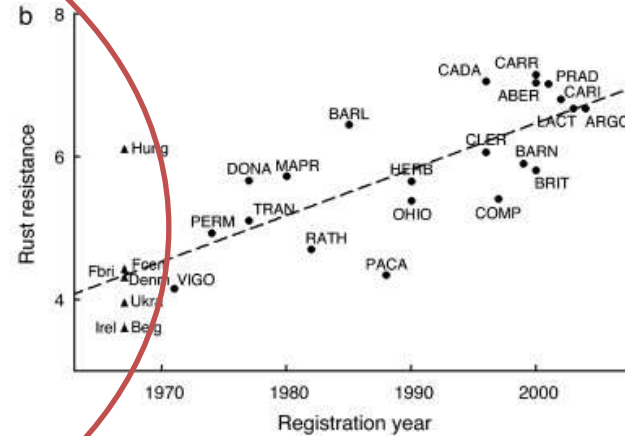
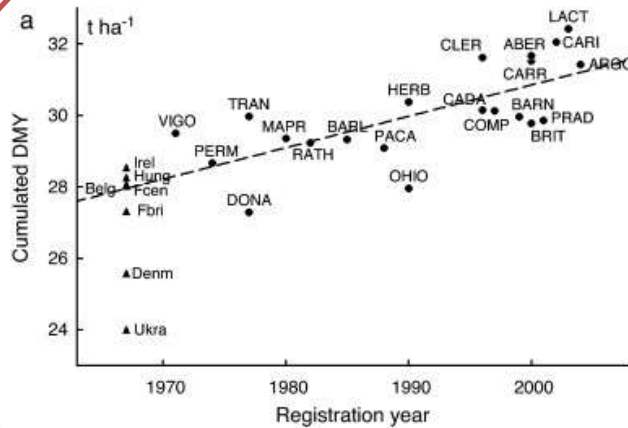


In the Temperate regions, producing high value forage throughout the year is important

Décile 5 : P-ETo May-Sept 2020-59, Aladin RCP4.5

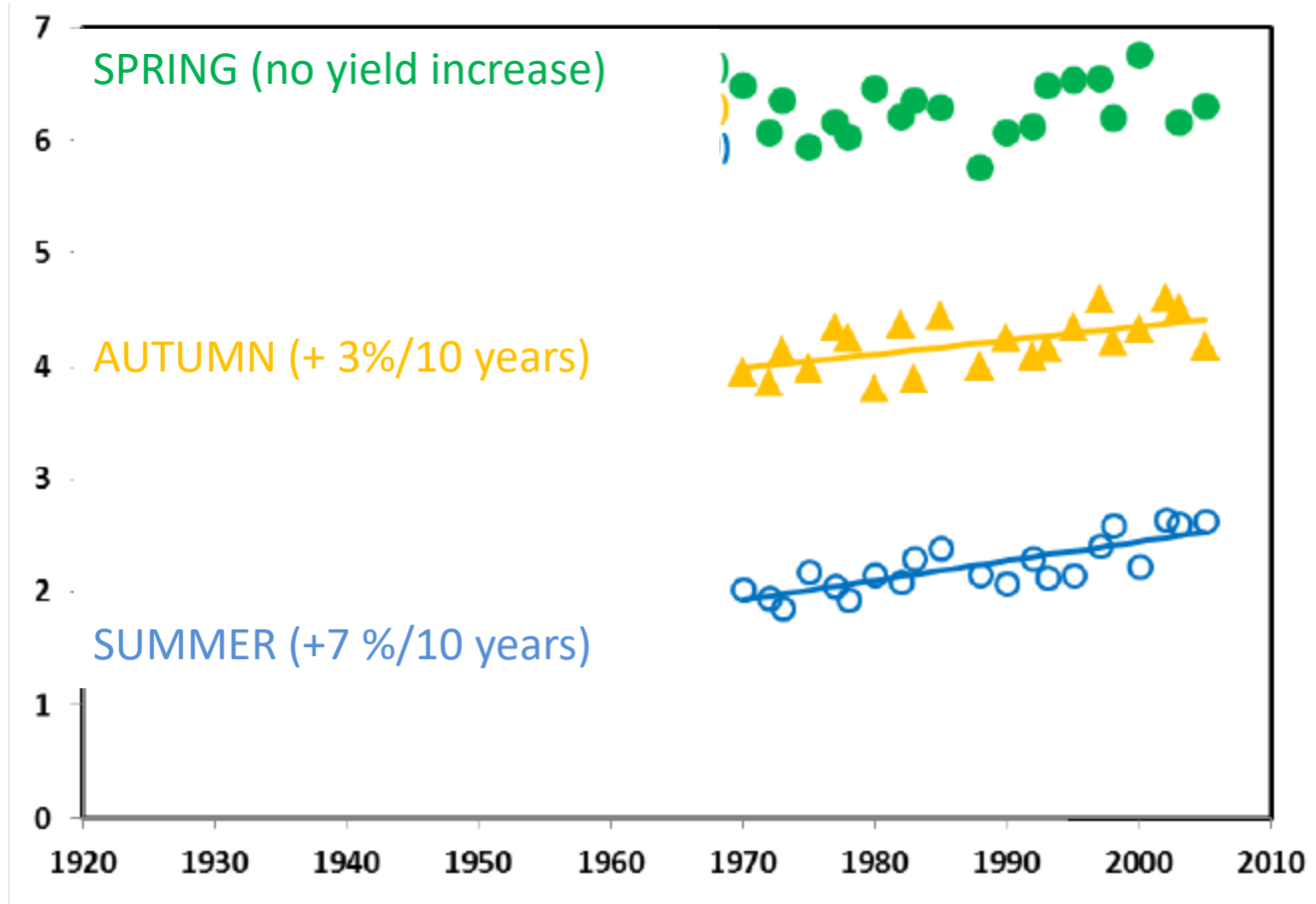


The preennial ryegrass annual yield has improved by + 10 % in 30 years: i.e. more than the negative impact of Climat change



Sampoux et al 2010

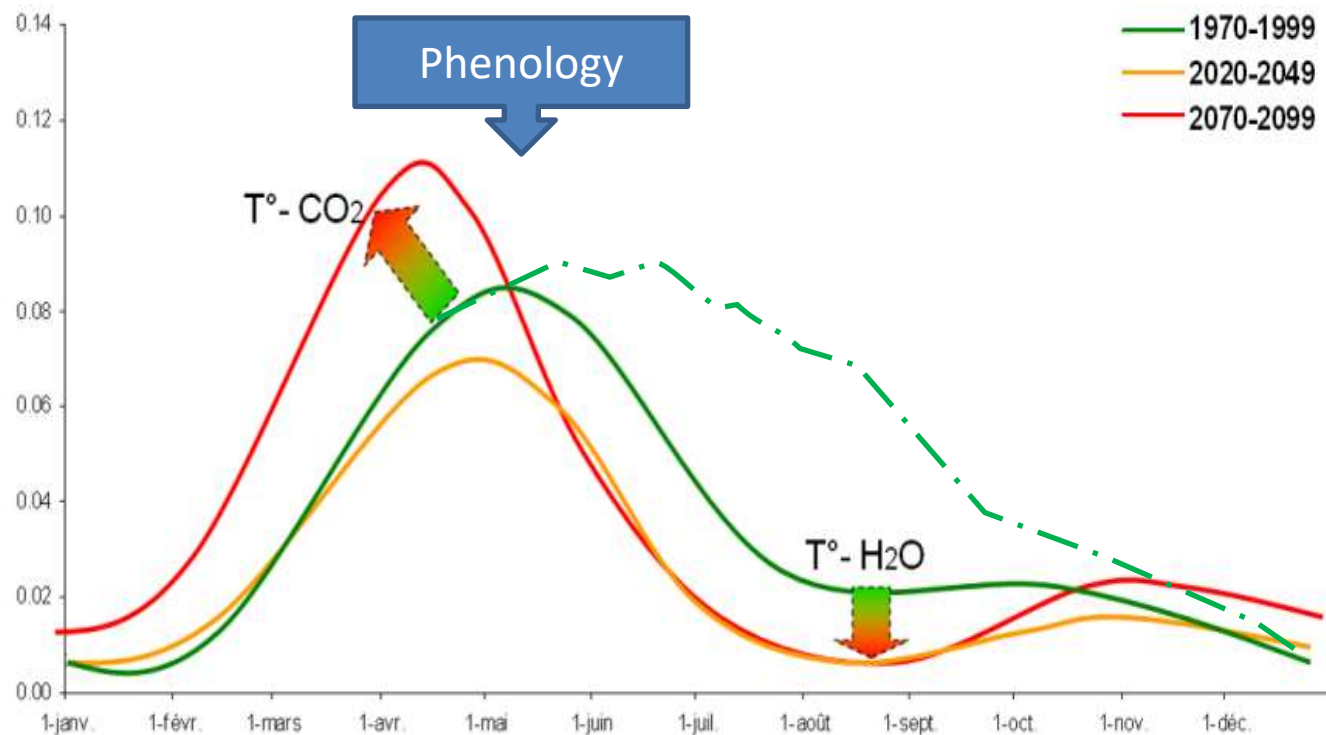
Breeders succeeded so far in reducing the negative impact of climate change in summer and autumn.



Adapt sown grasslands to Climate Change

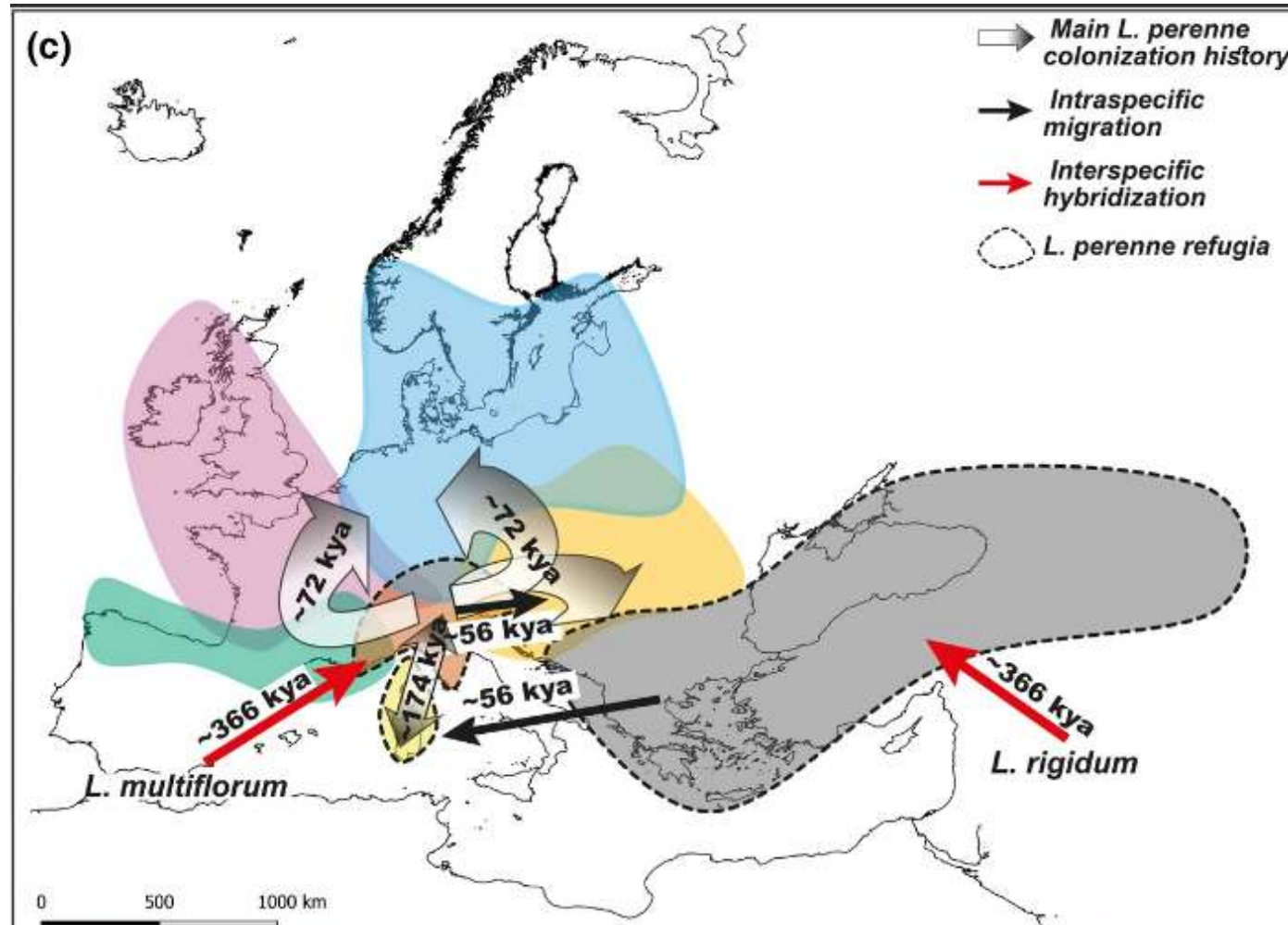
Daily herbage
production

(t MS/ha/j)



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

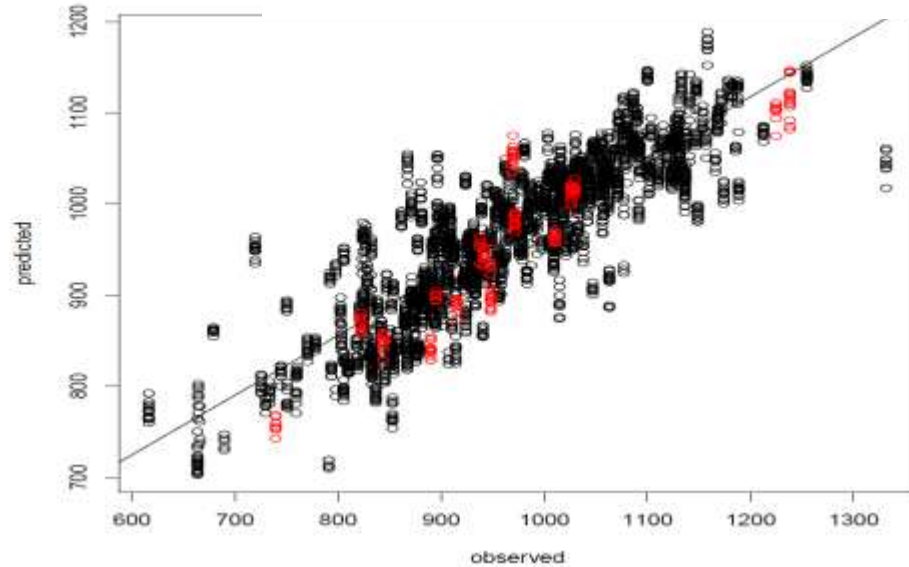
Early European expansion of *perennial ryegrass* lead to a rich underexploited variability a recent study coordinated by INRA, with European Ressource Centers, revealed.



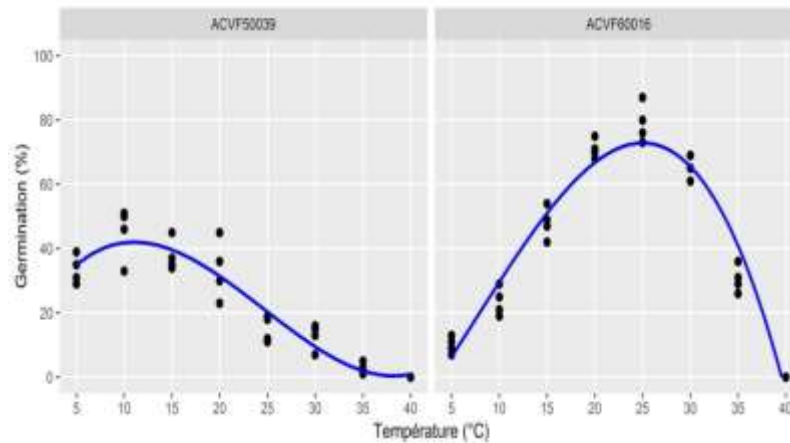
Blanco Pastor et al 2019

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

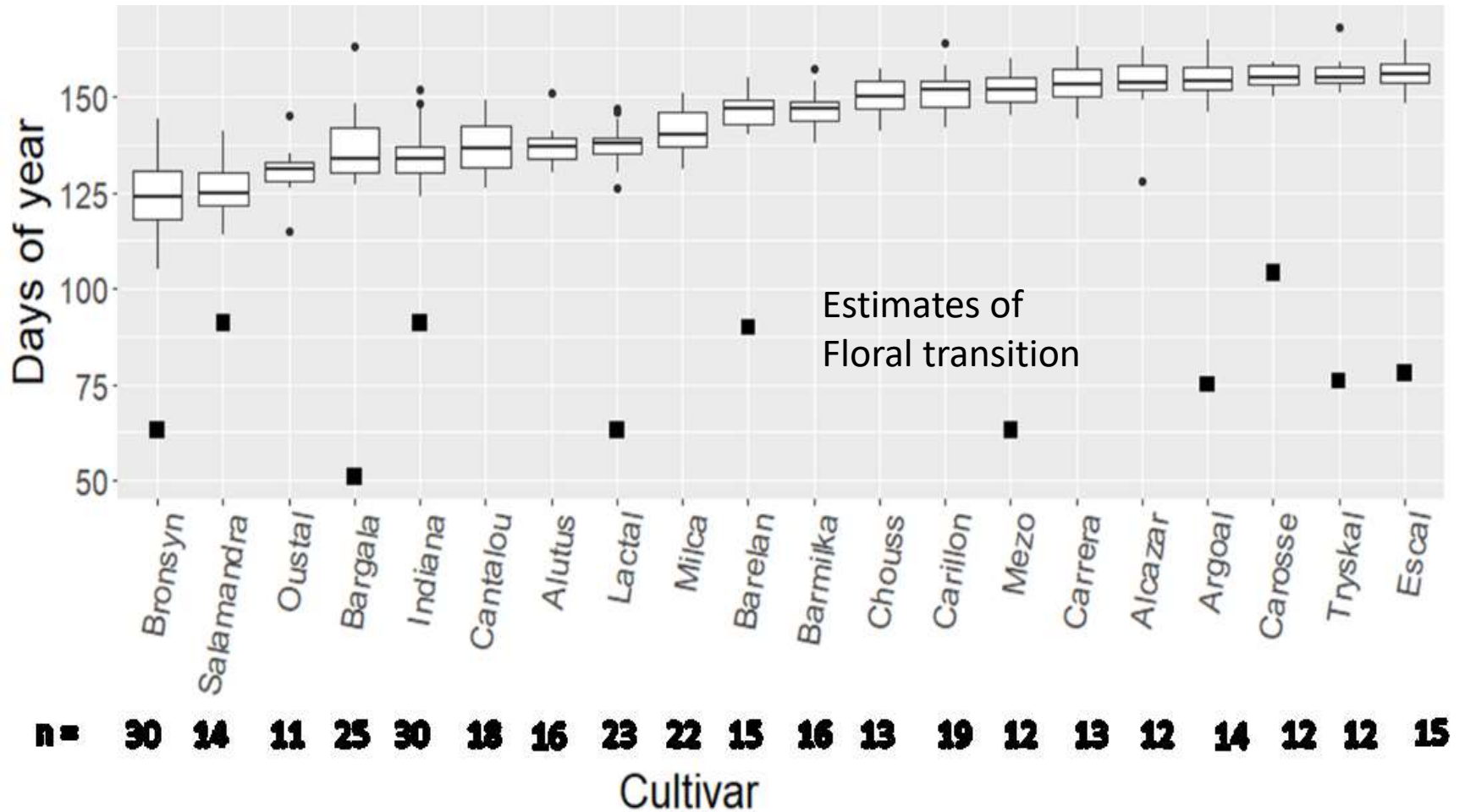
Heading date



Germination rates



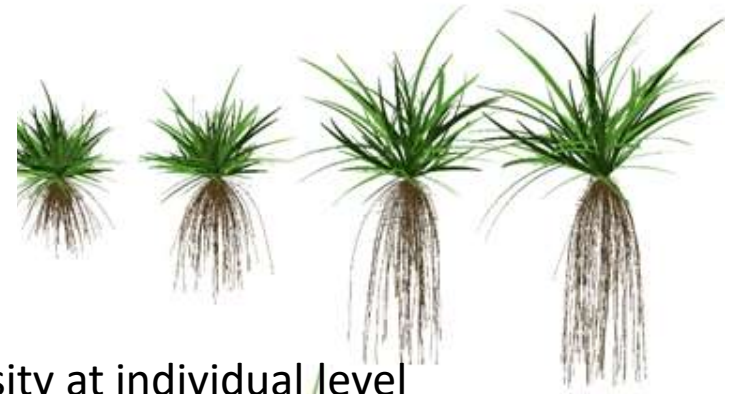
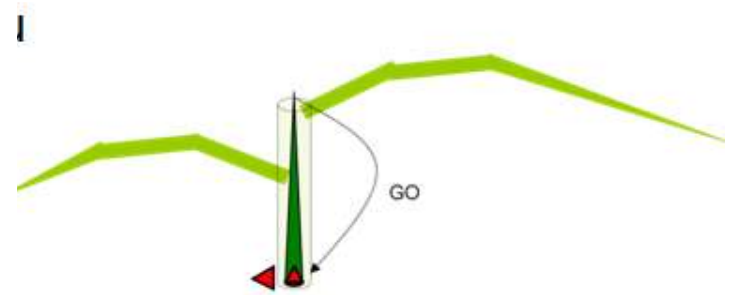
heading date and floral transition in perennial ryegrass



L-grass

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

Response to cutting and management (water nitrogen...)

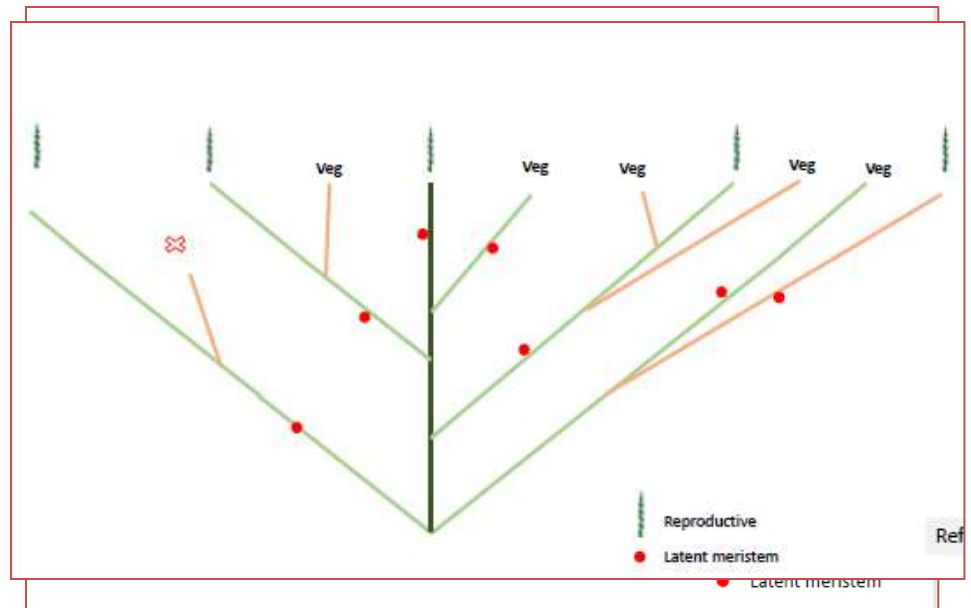
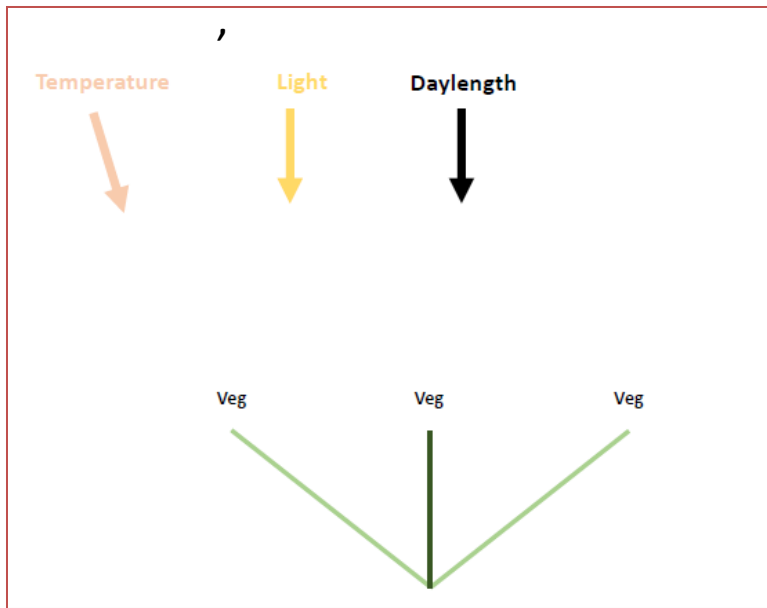


Genetic diversity at individual level

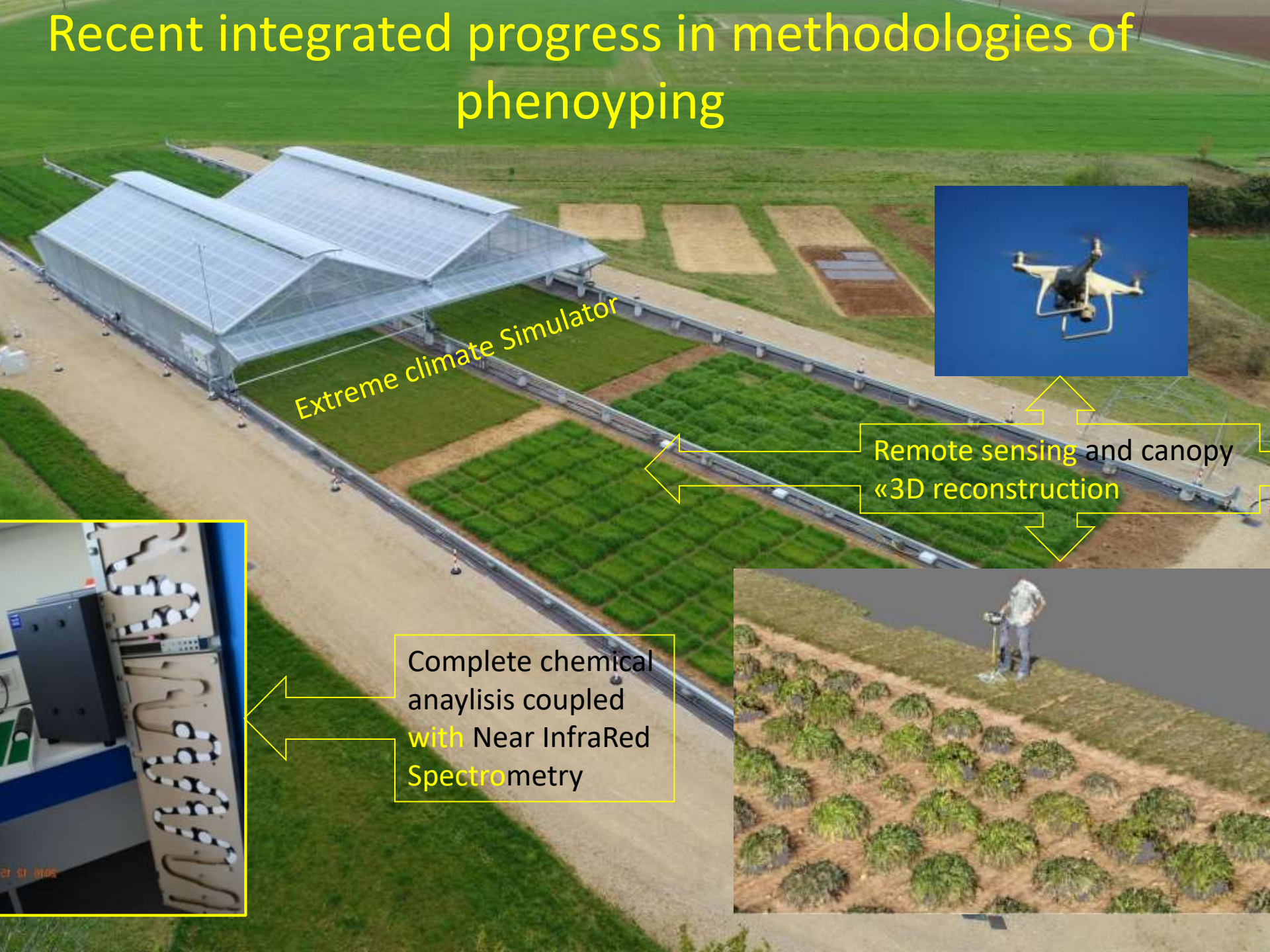


Simulate Phenology of forage grasses in order to understand the genetic variability of the response to climate

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



Recent integrated progress in methodologies of phenotyping



Extreme climate Simulator



Remote sensing and canopy
«3D reconstruction

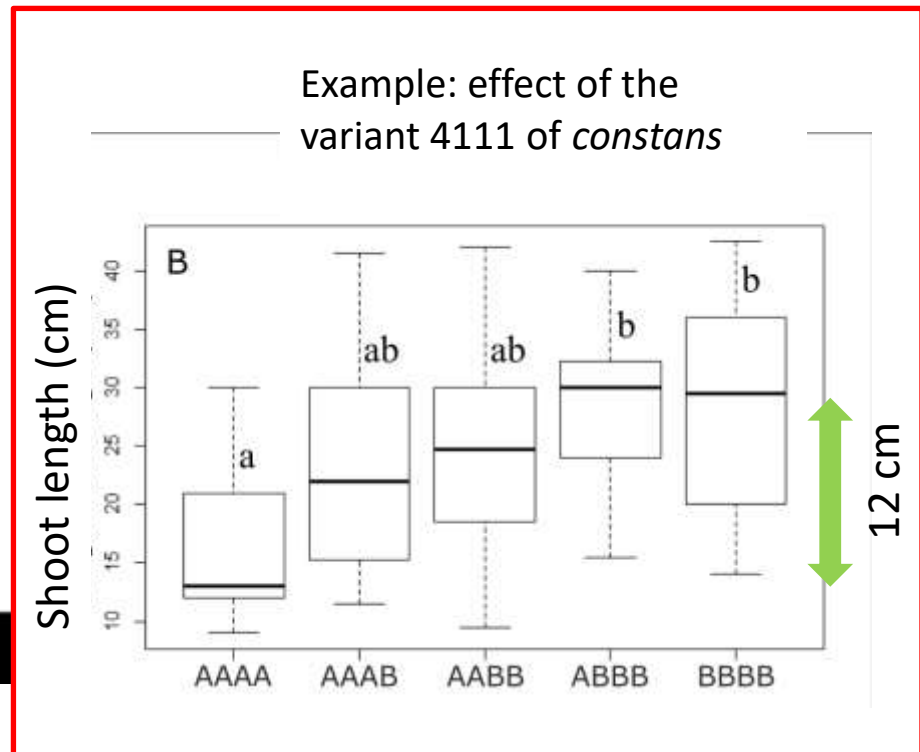
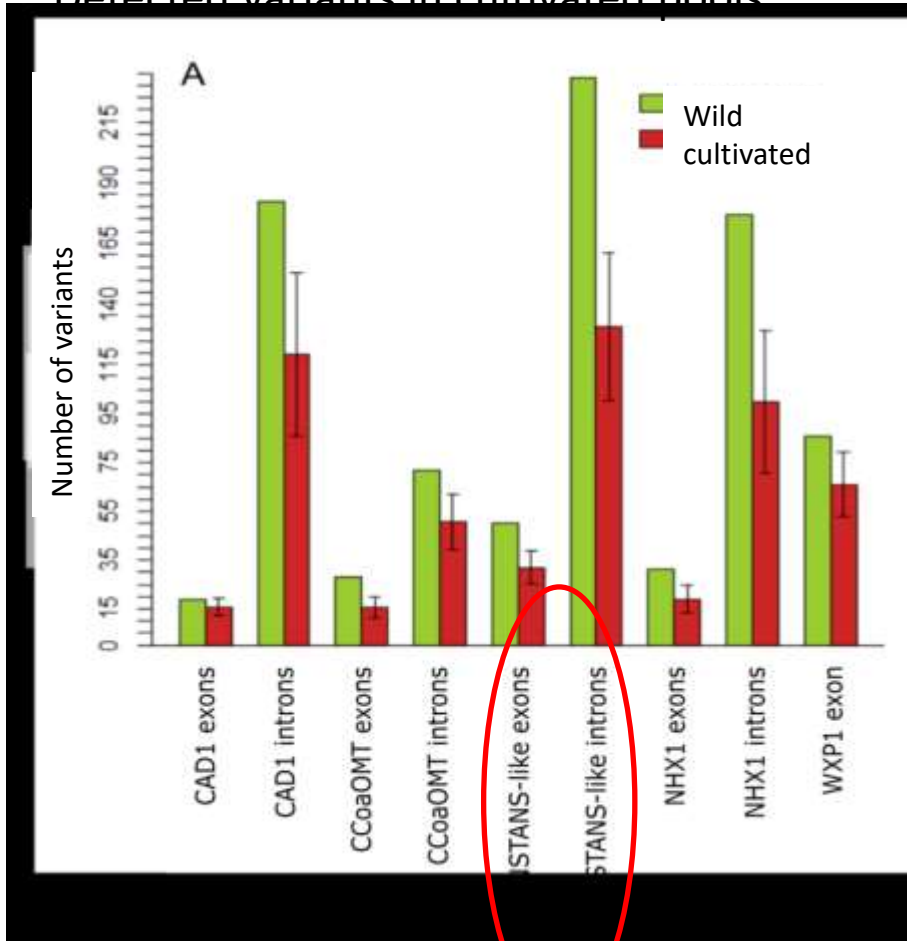


Complete chemical analysis coupled
with Near InfraRed Spectrometry



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

Detected variants in cultivated pools



- I. The importance of sown grasslands in France
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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 fonctionnal)
 - Initiation of shoot growth zones from bud stage (different from grasses)
- Very sensitiv to weed competition

→ **sowing of mixtures.**

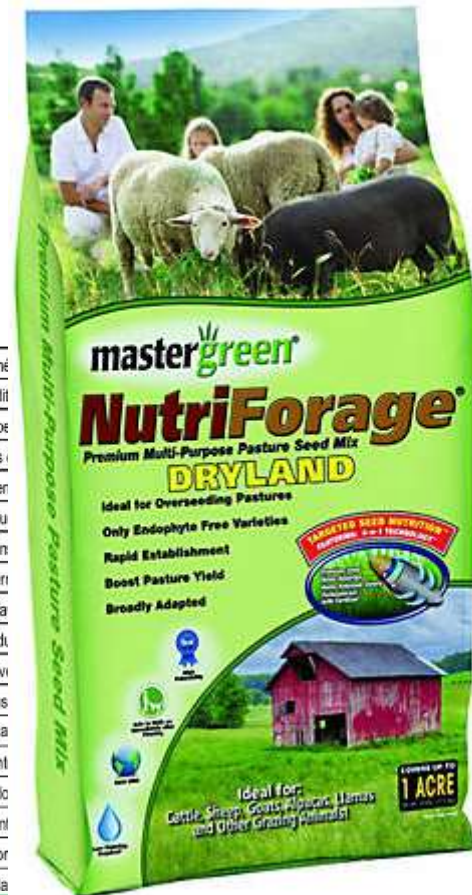


→ But what composition ?

Nbre d'ar d'exploit:	Mélange	Disponib	Densité s	Sacs kg	Mélange					RGA préc	
					Dactyle	Fétuque	Fétuque	Fleole	Pâturin d		
Mélanges pour cultures 1 an	<input type="checkbox"/> AT-17 BIO*	B	36	20							
	<input type="checkbox"/> AT-106		36	20							
	<input type="checkbox"/> AT-Solvert Incarnat		35	20							
Mélanges pour cultures 1 à 2 ans	<input type="checkbox"/> AT-200 Tetra	B	35	20							
	<input type="checkbox"/> AT-210 A		30	20							
Mélanges pour cultures 3 à 4 ans	<input type="checkbox"/> AT-300	B	30	20	20	33,3	10				
	<input type="checkbox"/> AT-310		32	20	17,2	31,3	7,8	15,5			
	<input type="checkbox"/> AT-323 inoculé	B	38	20	15,7	31,4	7,9				
	<input type="checkbox"/> AT-33 inoculé	B	35	20	10	22,8	4,2	10			
	<input type="checkbox"/> AT-330 M	B	33	20	16,7	36,3	7,6	10,6			
	<input type="checkbox"/> AT-340	B	33	20		36,4	12,1	12,1			
	<input type="checkbox"/> AT-360		33	20			12,2	30,3	24,2	24,2	
	<input type="checkbox"/> AT-362		32	20	46,9			31,2	12,5		
	<input type="checkbox"/> AT-Harvestore inoculé	B	35	20		20	5,7	7,1		64,3	
	<input type="checkbox"/> AT-Legumix		30	20						90	
Mélanges pour cultures 4 ans et +	<input type="checkbox"/> AT-41 F		40	20	12,5	7,5	20	7,5	7,5	25	7,5
	<input type="checkbox"/> AT-43 RM		36	20	13,9	16,6		27,8	7,1	18	
	<input type="checkbox"/> AT-430 Extra		36	20	13,9		8,3	8,3	27,4	13,9	13,9
	<input type="checkbox"/> AT-430 M	B	36	20	13,9		8,3	8,3	27,8	12,6	12,6
	<input type="checkbox"/> AT-440 BIO*	B	32	20			15,6	9,4	31,3	15,6	15,6
	<input type="checkbox"/> AT-440 Extra		32	20			15,5	9,4	31,2	15,5	15,5
	<input type="checkbox"/> AT-440 Reno	B	20	20					30	30	30
	<input type="checkbox"/> AT-46 Pâture		38	20	26,3	18,4			26,3	10,5	5,3
	<input type="checkbox"/> AT-460		33	20			12,1	13,0	3,2	24,3	



annuel, très appétent, gélf, si culture dérobée né
 annuel, très appétent, gélf, excellente digestibilit
 hivernant pour ensilage de printemps, une coupe
 extra productif, excellentes valeurs alimentaires
 12-18 mois hivernant, excellentes valeurs alime
 ensilage avec RGH pour zone séchante, TV longu
 plus précoce que le 330 M grâce au RGH pour en
 luzernier extra productif, la fétuque des prés per
 avec luzerne, peut convenir aux zones peu fa
 fauche, le must des mélanges en moyenne de



Mélange moyenne durée très polyvalent pour zone fav
 Mélange pâture à base de trèfle violet pour pâture, sans
 Mélange pâture à base de trèfle violet pour pâture, situa
 Mélange luzernier pour ensilage, gros volume, excellent
 Mélange de légumineuses pour fauche ou interculture lc
 Mélange longue durée d'altitude (ou le ray grass ne tient
 Mélange longue durée pour conditions difficiles, très bor
 Mélange longue durée très polyvalent. le must des méla



RGT STOX PROTÉINE 4

INTÉRÊT DES MÉLANGES



stabilité.
ilité, très souple d'utilisation.
couples.
e et Agrostide)

Demonstrating the importance of some intraspecific diversity

Graminées



Ray-Grass



Dactyle



Fétuque

Légumineuses



Luzerne



Trèfle violet



Lotier



Trèfle blanc

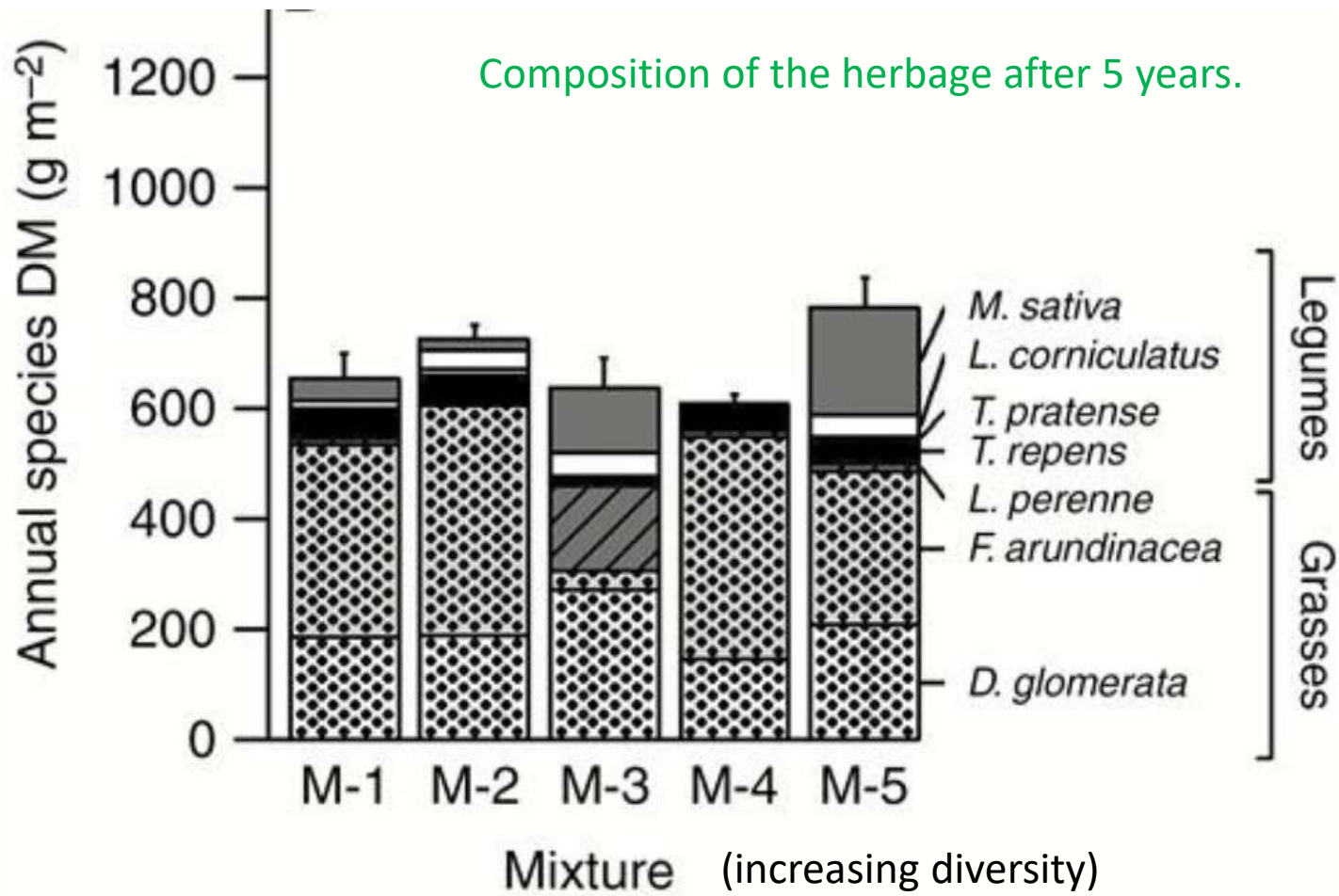
5 mixtures using the **same** species but with different **numbers** and kinds of varieties per species



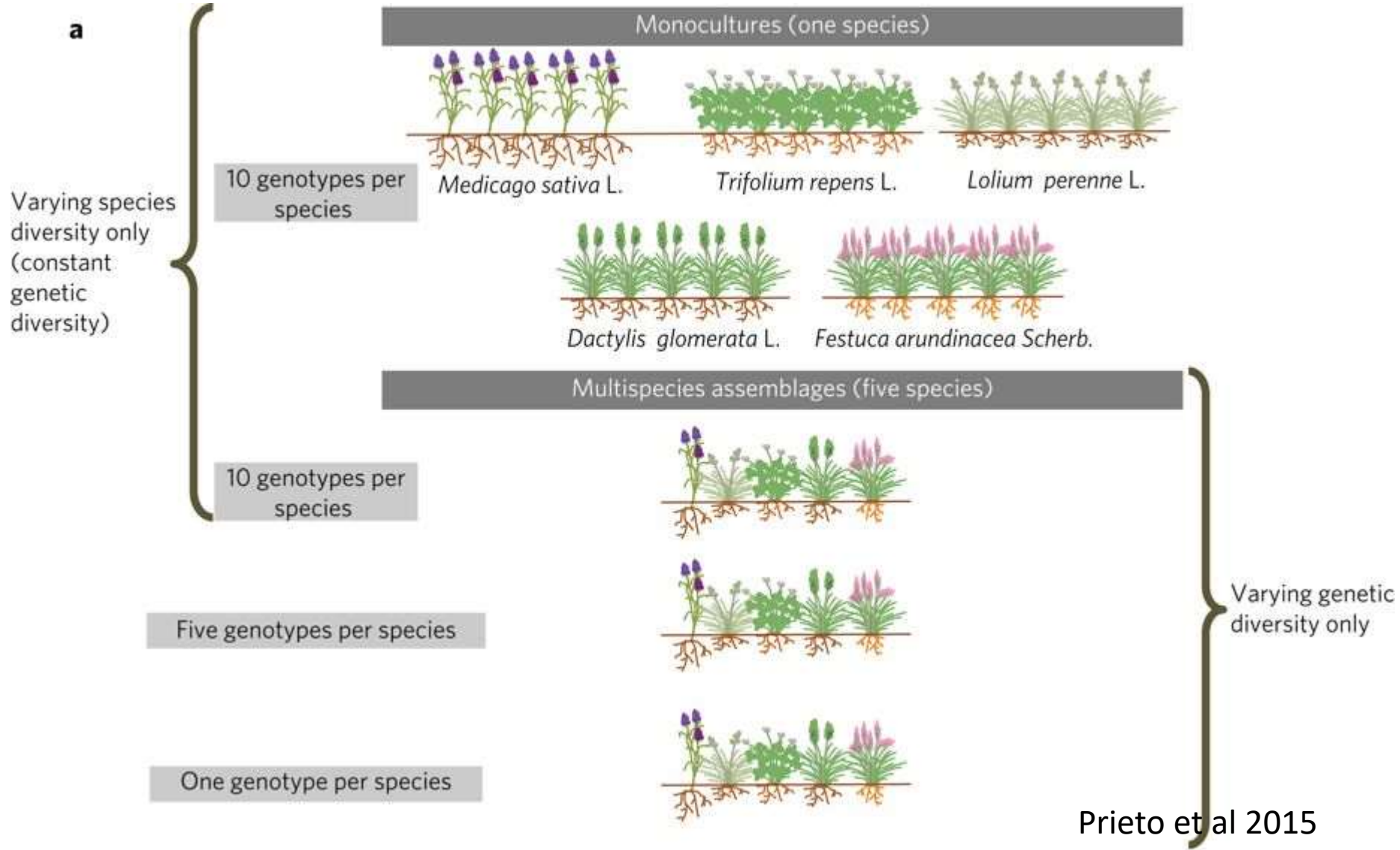
Jouffray-Drillaud (St Sauvant)

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

- Stability
- Legume proportion in herbage

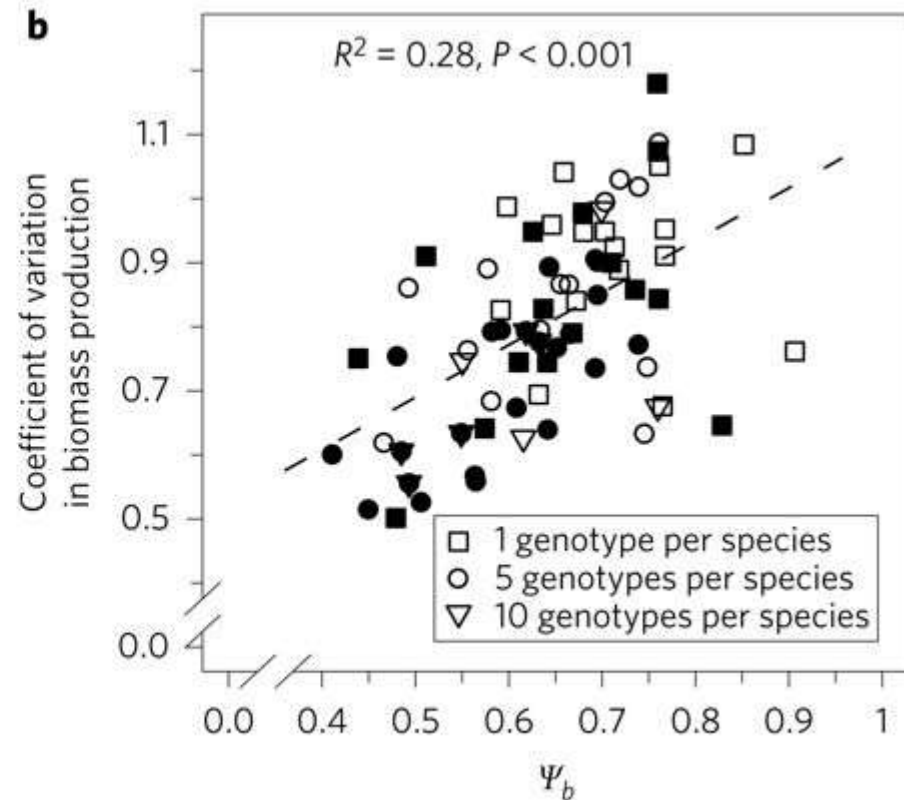
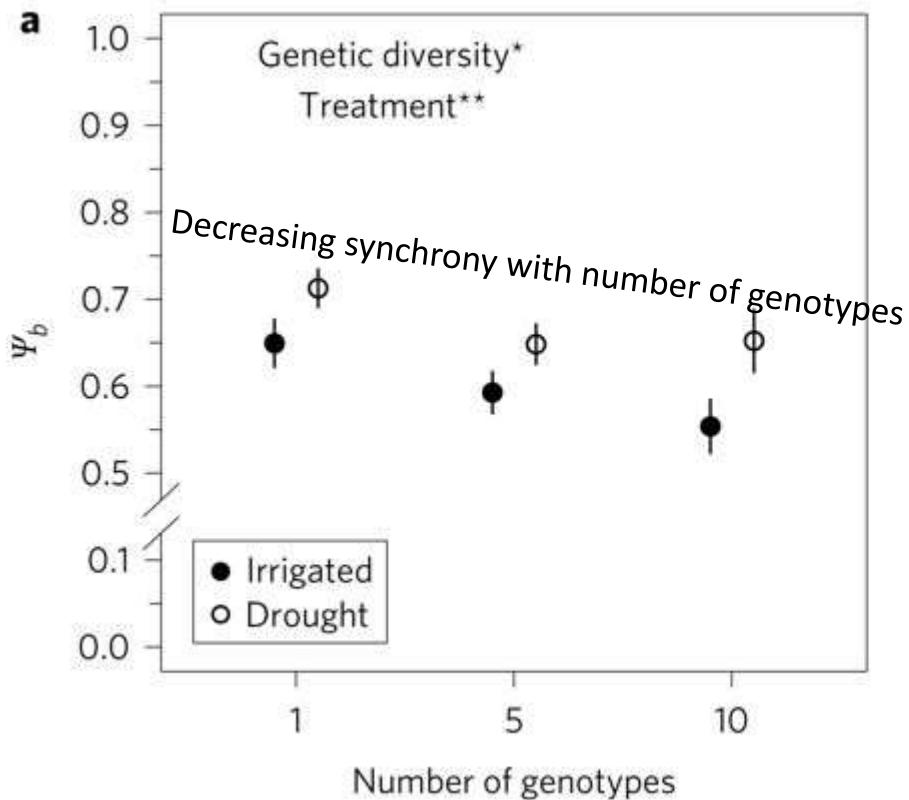


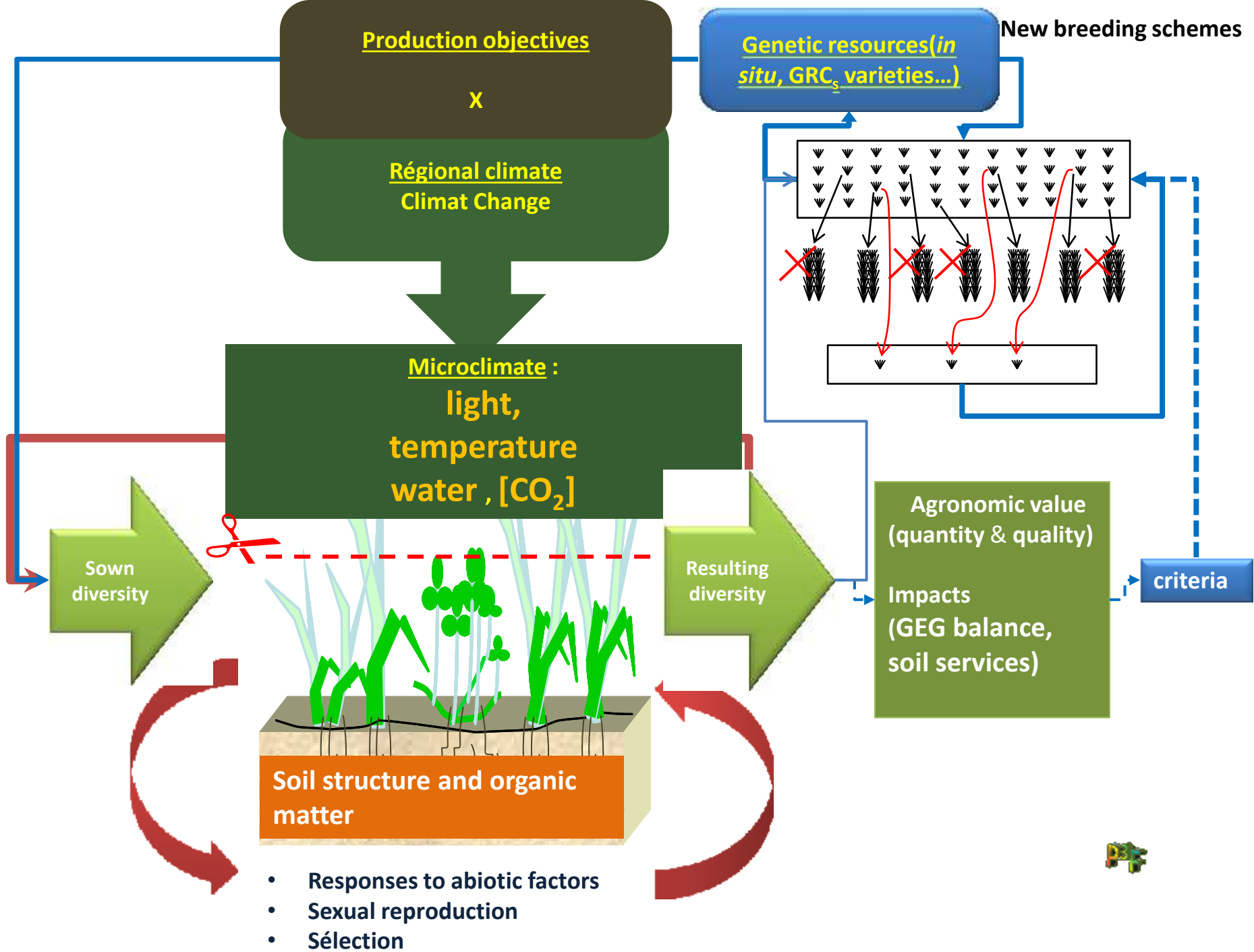
According to another experiment, the reason appears to be the intraspecific variability of phenology.





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





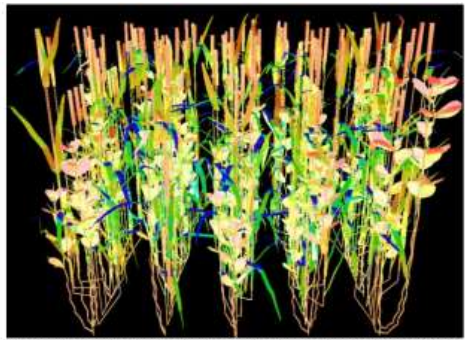
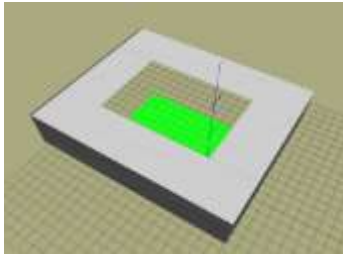
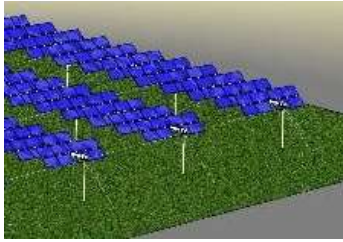
Extension of our knowledge to other area:

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

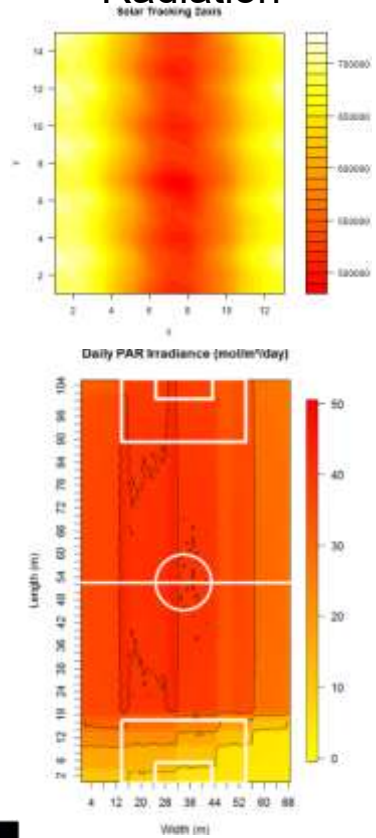
Neutral shading



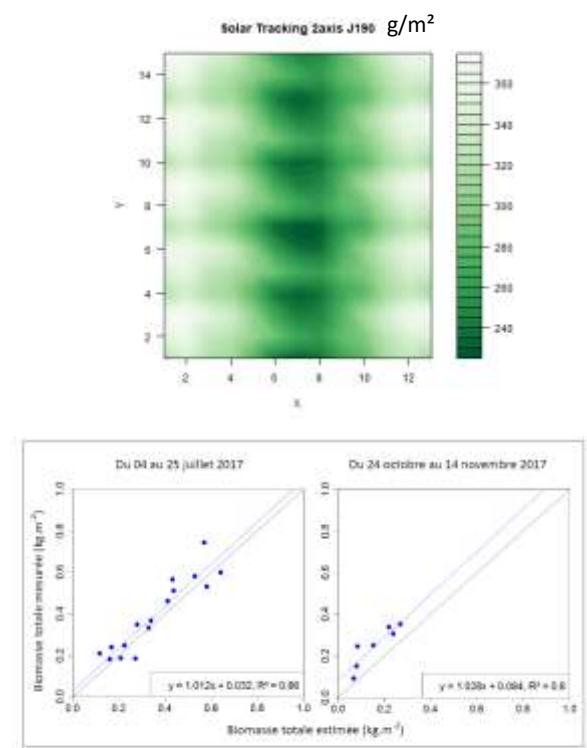
Modelisation 3D



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