

Norms of reaction for maritime pine

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B4EST international conference – Managing Forest Genetic Resources for an uncertain future

Norms of reaction for maritime pine

Session A : Accelerating breeding to cope with new challenges and uncertain future – 20th June 2022

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Maritime pine (*Pinus Pinaster*) breeding in France

« Landes de Gascogne » forest

- 0,8 million hectares (24% of French wood harvest)
- Main uses in carpentry, joinery, stationery



- Plantations with **improved seedlings**
- Mainly based on the Landes provenance

Recurrent selection scheme

- Started in the ~1960 ightarrow 3rd genetation today



- Targeted traits :
 - Growth (height, circumference, straightness)
 - Adaptation to the environment
 - Wood quality
- Genetic values estimated with pedigree

- Dynamic phenotypes : NoR Classical selection focuses on final growth traits Integrative phenotypes with no consideration of the environment NoR : pattern of phenotypic expression of a single genotype across a range of environments GENOTYP GENOTYPE B OTHER EXTREME ENVIRONMENT EXTREME • Consideration of dynamic and explicative traits
- Evaluation and prediction of genetic values taking account of the environnement (even in unobserved environments)





Experimental design and measurments

Experimental design for maritime pine (6300 trees)



Experimental design

- 2 locations : Cestas (humid) & Escource (dry)
- Installation in **1996** : **26** years old trees
- 150 half-sib families with 35 individuals/family \rightarrow 6300 trees per site
- **Complete** block design (1 individual of each family per block)

Phenotypic measurments :

- Classical growth measures at different ages (height, circumference, straightness)
- Core sampling of **325** trees per site :



Environmental measurments :

• Conventional annual climate measurements (temperature, rainfall...)

Experimental design and measurments























Random regression model (RRM)



 We model individual trajectories according to the level of aridity of the environment (Martonne index)

• Mean trajectories, additive genetic effect and permanent environmental effects are modeled by 2-order Legendre polynomials







Norms of reaction : heritabilty and genetic correlations

 $y_{ij} = Mean trajectory(t_i) + Additive genetic effect_i(t_j) + Permanent environmental effect_i(t_j) + \varepsilon_{ij}$

0.3 -0.2 -Heritability (h²) 0.1-0.0-400 300 200 Level of aridity (Martonne index)

Genetic correlations between environments (levels of aridity) estimated with RRM2



Heritability of ring surface estimated with a random regression model of order 2 (RRM2)

 $y_{ij} = Mean trajectory(t_j) + Additive genetic effect_i(t_j) + Permanent environmental effect_i(t_j) + \varepsilon_{ij}$

 $y_{ij} = Mean trajectory(t_j) + Additive genetic effect_i(t_j) + Permanent environmental effect_i(t_j) + \varepsilon_{ij}$

1000 -**Genetic BLUP** 0 --1000 -250 300 350 400 Level of aridity (Martonne index)

Evolution of individual genetic values across environments

 $y_{ij} = Mean trajectory(t_j) + Additive genetic effect_i(t_j) + Permanent environmental effect_i(t_j) + \varepsilon_{ij}$



 $y_{ij} = Mean trajectory(t_j) + Additive genetic effect_i(t_j) + Permanent environmental effect_i(t_j) + \varepsilon_{ij}$



Conclusion and prospects

• <u>With :</u>

- Phenotypic measurments : densitometric profiles
- Simple climatic characterization : Martonne's aridity index
- Genetic data : pedigree or molecular markers information
- \rightarrow Norms of reaction : individual genetic values across a range of environments

• Main prospects :

- Improve environmental characterization :
 - Consideration of previous years, better differentiation of experimental sites...
 - Use of a growth simulation model (GO+ : based on environmental characteristics of each site (stand density, groundwater height)) to incorporate more explanatory parameters into the annual index (soil water reserve, evapotranspiration demand)
- Extend to other inter-ring phenotypic traits (ex: average ring density)
- Construct NoR for intra-ring growth



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Thank you for your attention

