INTRODUCTION TO

ANIMAL BREEDING

Lecture Nr 5

The potential effects of crossbreeding

The main kinds of crossbreeding plans

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Definitions

The potential effects of crossbreeding

Plans to improve or create a population

Plans to produce a terminal generation

Summary

Genre - Species -Hybridisation

Equus

Stallion x Mare

Horse

Equus caballus

x

Mule

Hybrid

[sterile]

Ass x Jenny

Donkey

Equus asinus

Photos:
E. Verrier
SOPEXA
Genovin Services

Splitting the species: Breeds - Crossbreeding

Group of animals sharing some hereditary traits → Breed, Line, Strain


X

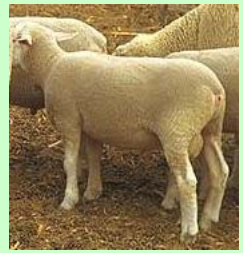
X

X



"Pure" breed lambs (Solognot)


[Fertile]
Crossbred lamb


"Pure" breed lambs (Berrichon du Cher)

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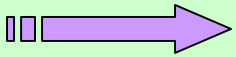
(1) To Provide new genes and/or to benefit from additive differences between populations



To go faster than under within-population selection

Conditions: The "external" population has to

- really be better for the considered trait
- not have a large defect for another trait

(2) Complementarity between traits

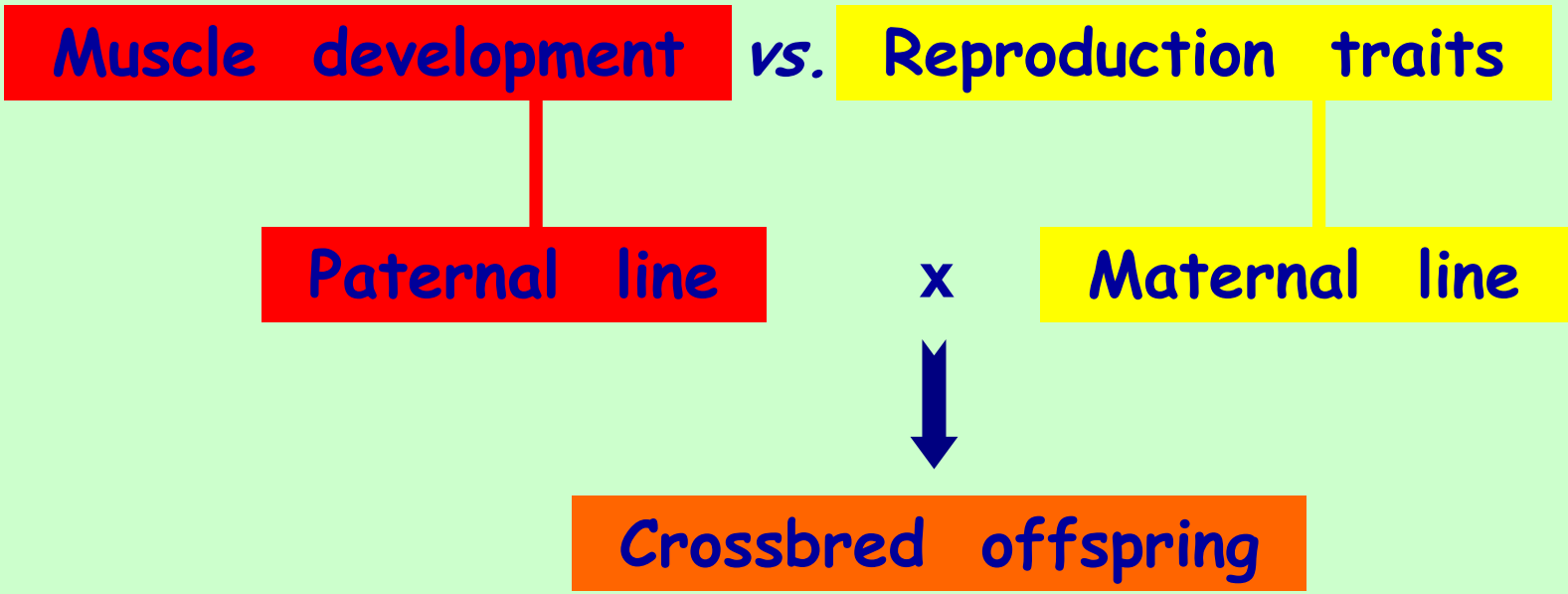
Example: World's most specialised pig breeds

Muscle development	Litter size
Piétrain (Belgium)	**Erhualian** (China)

Is it possible to bring together both traits into a single breed?

Complementarity: principle

Genetic antagonism between traits



Complementarity: economical illustration

Profit per pig sold: P = MF – CS/NP

MF = Price paid to the farmer per pig sold
– Σ costs during fattenig (from suckling to sale)

CS = Annual total cost for a reproducing sow

NP = No piglets suckled per sow and per year

CS/NP = Average cost for a pigler suckled

Complementarity: economical illustration

Profit per pig sold: $P = MF - CS/PN$

Values in Euros (€)	Breed A	Breed B
CS	700	700
MF	70	77
NP	25	20
Profit / pig sold	42 70 - (700/25)	42 77 - (700/20)

For a crossbred piglet (AB or BA), $MF = 73.5 = (70+77)/2$

Male A x Femelle B → $P = 73.5 - (700/20) = 38.5$ … !

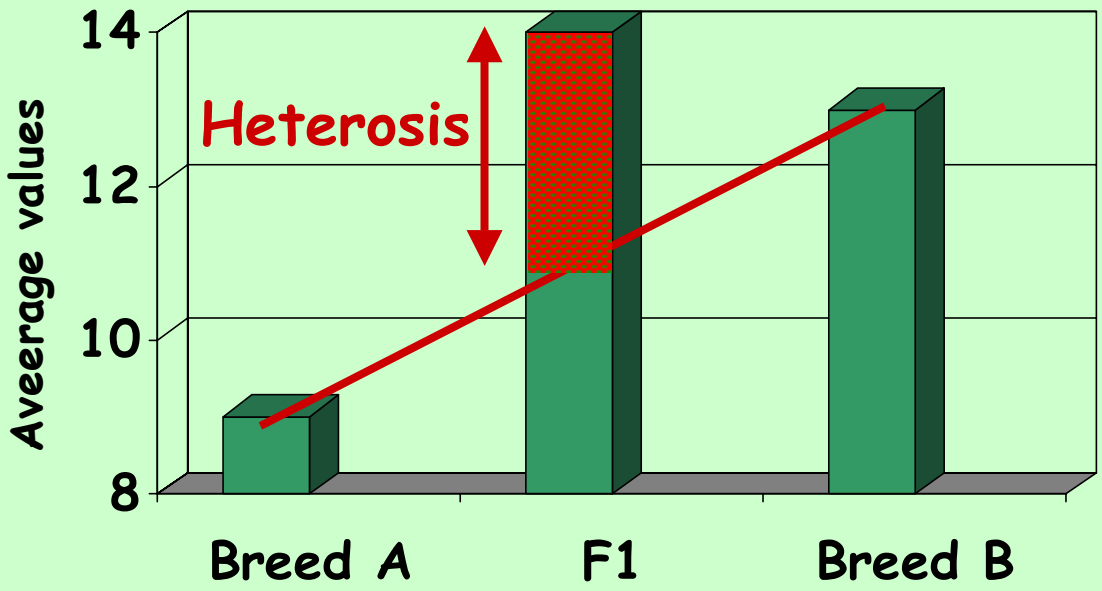
Mâle B x Femelle A → $P = 73.5 - (700/25) = 45.5$

Extra-gain = +3.50 € per pig sold

(3) Heterosis

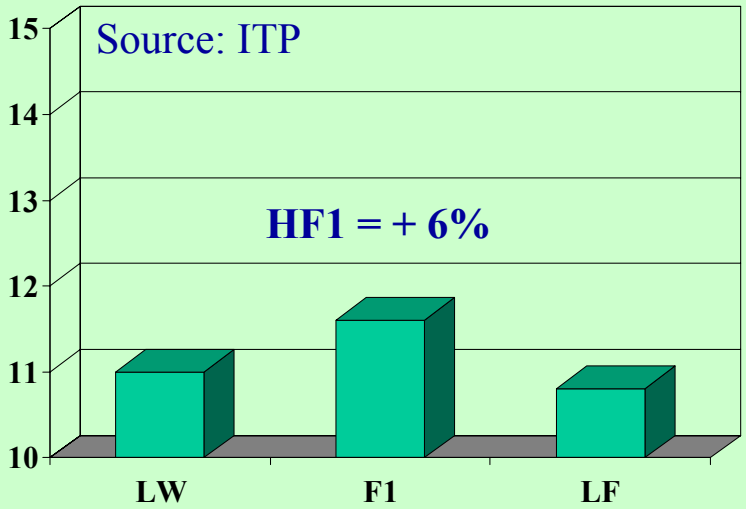
Définition (for a given trait)

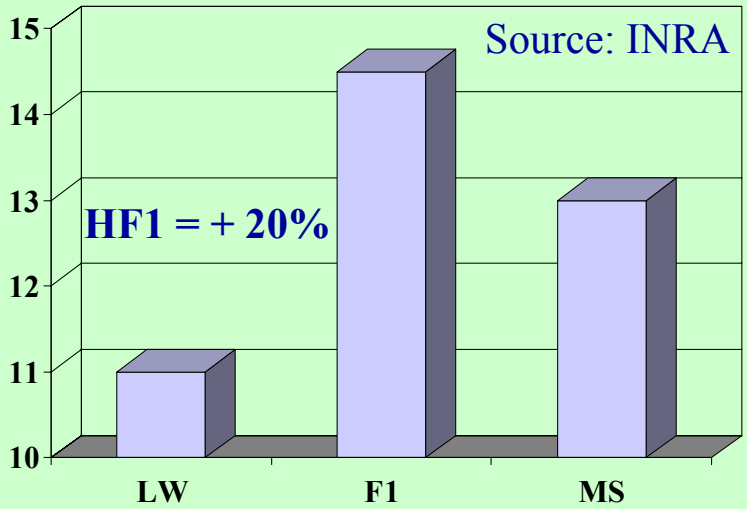
Difference between the average value of crossbred animals and the mean of the average values of both parental breeds



Heterosis according to the breeds crossed

Example: Litter size in pigs





LF = Landrace Français LW = Large White

European breeds

MS = Meishan

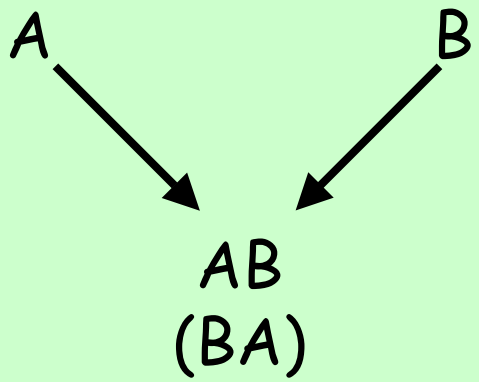
Chinese breed

Hypothesis:
more genetic differences between Chinese and European breeds
than between different European breeds

Direct and maternal heterosis

Direct heterosis

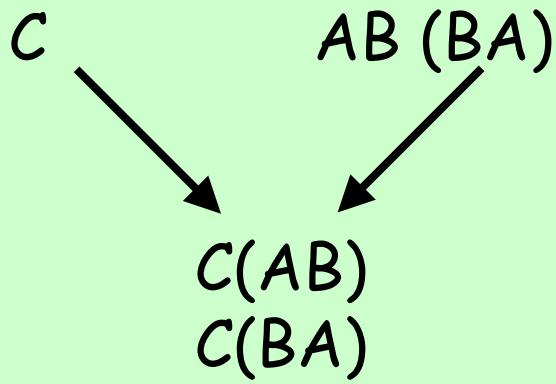
when the animal is crossbred



Difference between
the mean of F1 (AB+BA)/2
and the mean of
pure breeds (A+B)/2

Maternal heterosis

when the animal has a crossbred dam



Difference between
the mean of animals with a F1 dam
[C(AB)+C(BA)]/2
and the mean of animals
with pure breed dams (CA+CB)/2

Heterosis according to the trait

Pigs

Trait	Hétérosis (%)	
	Direct	Maternal
Birth weight	3	2
Suckling weight	5	8
Growth rate after suckling	6	0
Feed consumption / Growth rate	- 4	0
Muscle content within carcass	0	0
Meat acidity after slaughtering	0	0
Litter size at birth	2	6
Litter size at suckling	6	9
Litter weight at suckling	12	10

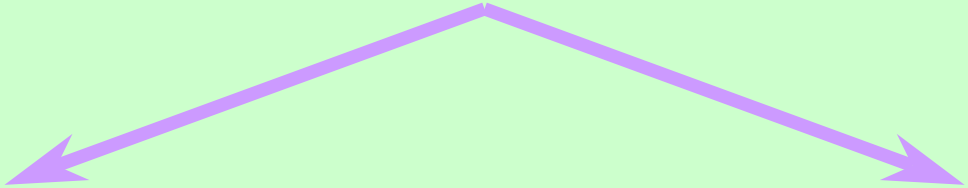
Heterosis according to the trait

Chicken

Trait	Hétérosis (%)	
	Direct	Maternel
Egg production	15	0
8 weeks weight	12	
Feed consumption /egg production	-12	0
Average egg weight	2	0
Egg composition	0	

Two kinds of crossbreeding plans

According to the goal



To modify an existing population
or
to create a new population

To give brith to
a generation of crossbred animals
all intended to be slaughtered,
always using
the parental breeds

Definitions

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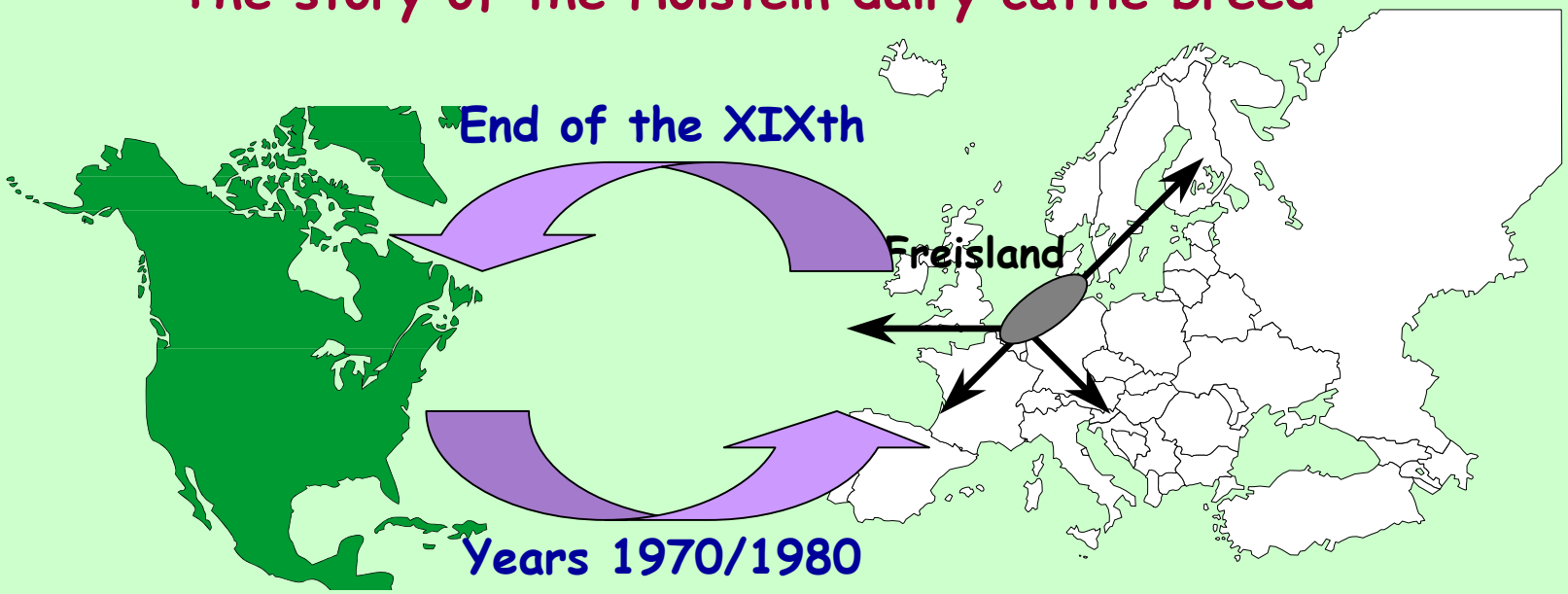
Plans to improve or create a population

Plans to produce a terminal generation

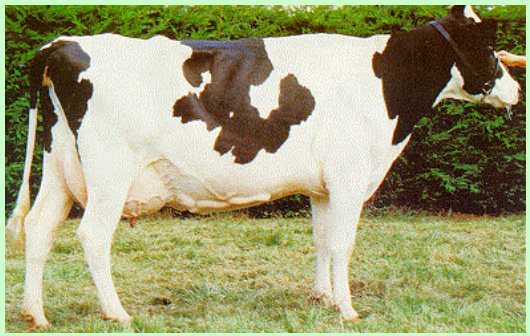
Summary

Crossbreeding to change a breed by another one

- The story of the Holstein dairy cattle breed -



end of the 60s'



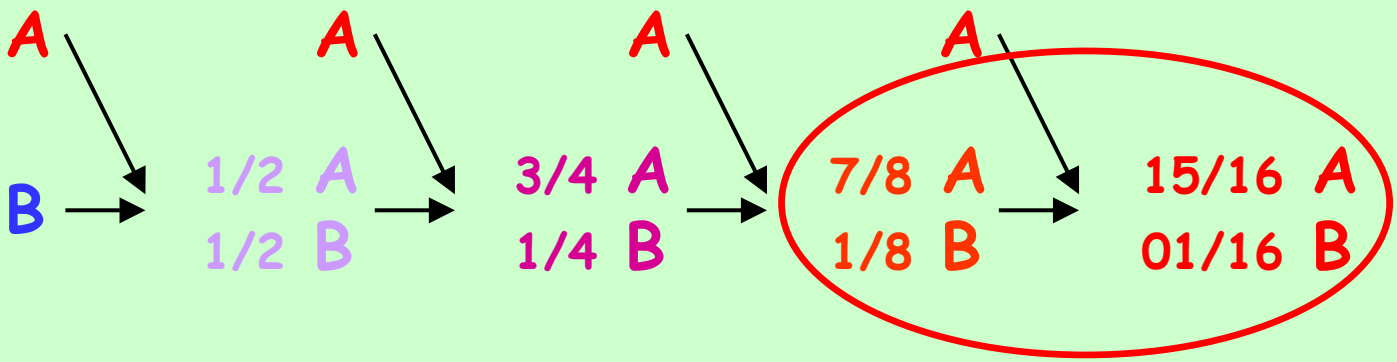
Holstein

via
semen
and
frozen embryos

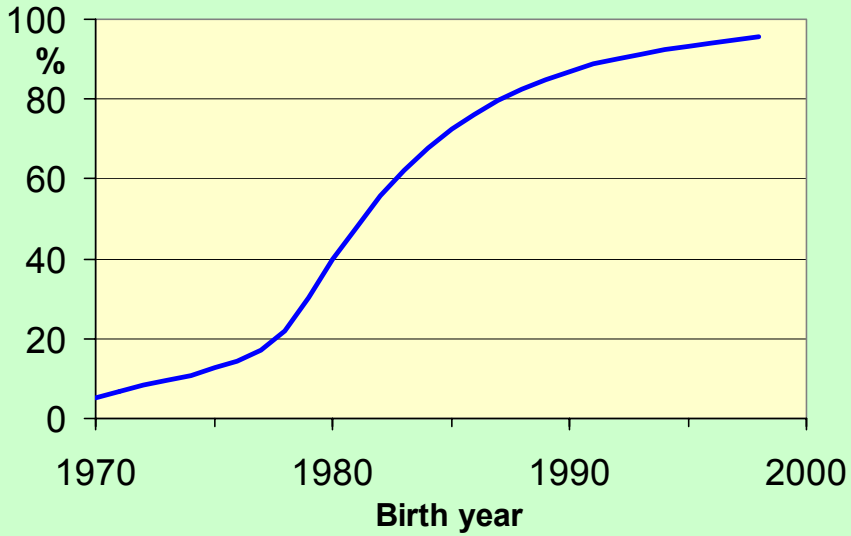
Freisian

Photos: SOPEXA, J. Bougler

Time required for the replacement



Example:
Evolution of the percentage of Holstein genes (from Northern-American ancestors) in the French black-and-white cows assessed by pedigree analysis



Source : Moureaux et al. (2001)

Creation of a mixed line

- The pig production in Haiti -

Status and recent history of pig in Haiti

Pig = animal raised within the familial "garden"
= alive capital

1978 – African pig plague epidemy

1981-1983 – Slaughtering of the whole national pig stock
(programme suggested and financially supported by the USA)

1983-… – Import of animals from American breeds
→ high mortality, bad results under familial conditions, …

1985-… – Development of a new breed by Haitian and French NGOs
with the scientic and technical support of INRA

A new and robust mixed pig line for Haiti

Créole

FWI – Guadeloupe

Photo: D. Renaudeau - INRA

Adaptation to hot and humid conditions
Assumed genetic proximity with the former Haitian Créole

Meishan

China

Photo: C. Legault - INRA

Litter size

Gascon

France

Photo: M. Luquet - ITP

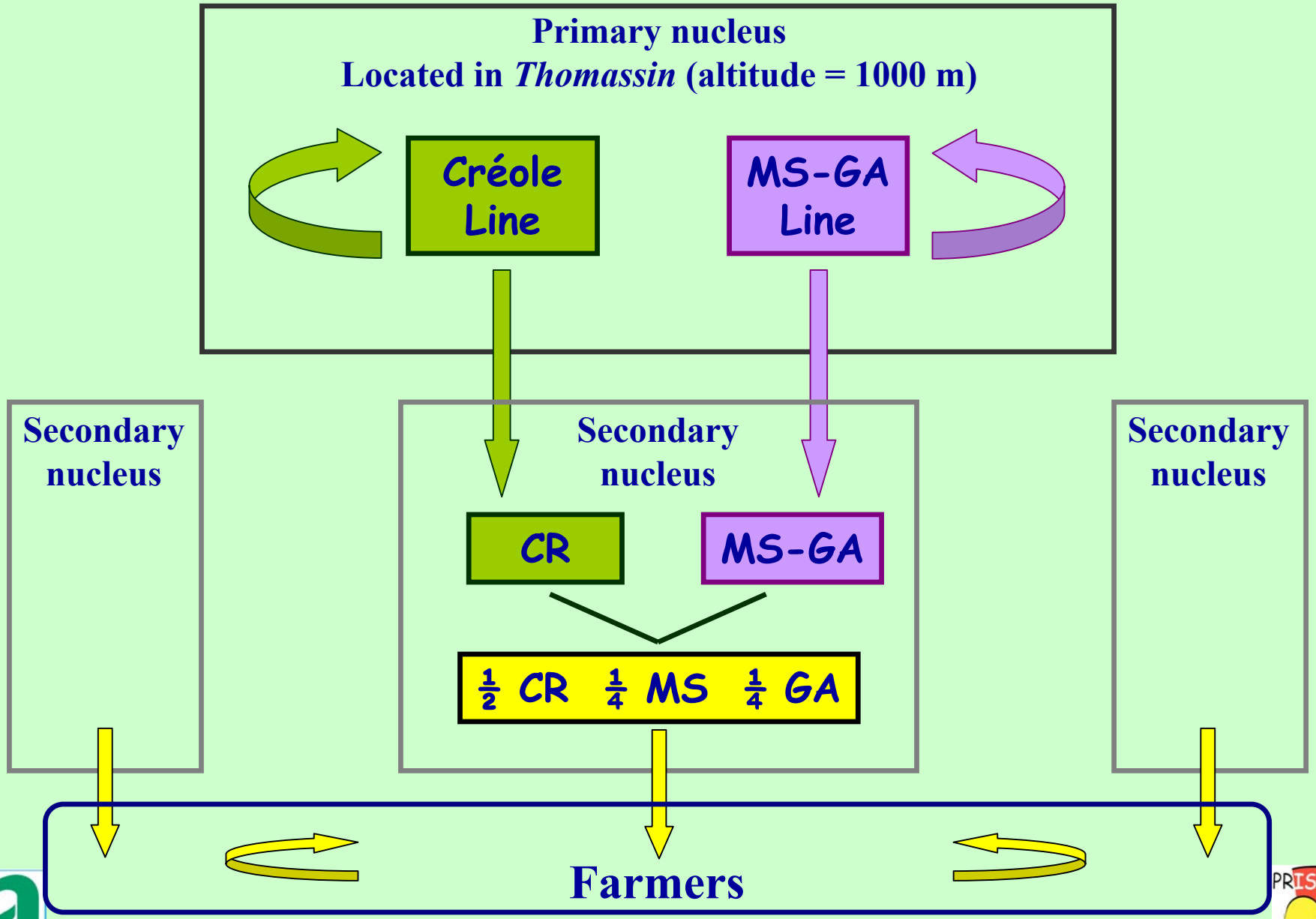
Black color
Robustness

F1

Produced in France and exported to Haiti in 1986 (specific pathogens free piglets)

Mixed line: ½ CR , ¼ MS, ¼ GA

How to spread the new line to the farmers



Results of the programme

1987 – First spreading of young animals from the mixed line

The total number of animals spread in farmers is difficult to assess

About 3000 to 4000 young animals (25 kg) [½ CR, ¼ MS, ¼ GA] per year

Positive economic evaluation of the programme (Cochet, 1998)

The continuity of the programme was very sensitive
to the political unstability of the country

→ Sucession of stops and resurgences

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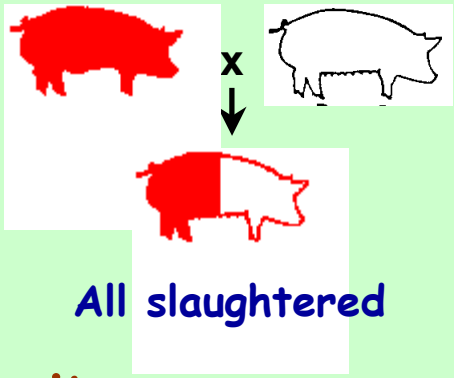
The one-generation crossbreeding

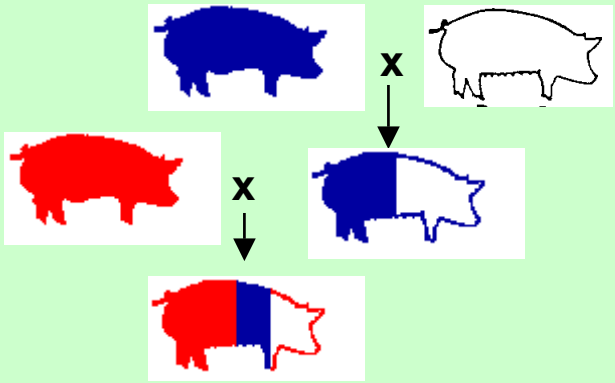


		Extra-gain per pig sold
⌘ Use of complementarity		+3.50 €
⌘ Use of direct heterosis:		
On growth	+37g	+0.80 €
On feed consumption	-0.11	+1.40 €
On litter size at suckling	+0.5	+1.25 €
Total		+3.45 €
⌘ The maternal heterosis is not used		

Total extra-gain per pig sold = +6.95 €

The two-generations crossbreeding

- involving 3 breeds -

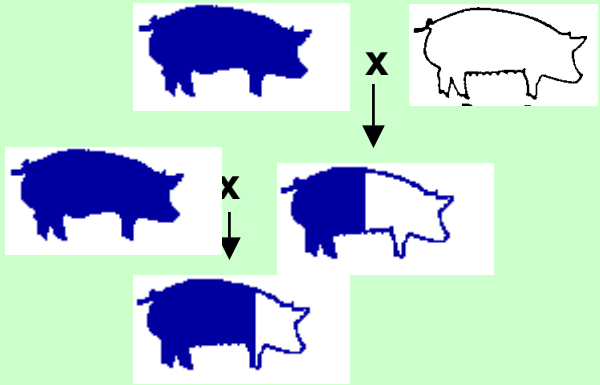


		Extra-gain per pig sold
⌘ Use of complementarity		+3.50 €
⌘ Use of direct heterosis:		
On growth	+37g	+0.80 €
On feed consumption	-0.11	+1.40 €
On litter size at suckling	+0.5	+1.25 €
		+3.45 €
⌘ Use of maternal heterosis:		
On litter size at suckling	+0.84	+2.10 €
On age at sexual maturity	-12	+ 0.10 €
		+2.20 €

Total extra-gain per pig sold = +9.15 €

The two-generations crossbreeding

- involving 2 breeds (back-cross) -



Extra-gain per pig sold

⌘ No use of complementarity

⌘ Use of ½ direct heterosis:

On growth	+18g	+0.40 €
On feed consumption	-0.05	+0.70 €
On litter size at suckling	+0.25	+0.68 €
		+1.78 €

⌘ Use of maternal heterosis:

On litter size at suckling	+0.84	+2.10 €
On age at sexual maturity	-12	+ 0.10 €
		+2.20 €

Total extra-gain per pig sold = +3.98 €

Summary

Crossbreeding is an efficient way to:

- Find elswhere what is not available within the local populations
- Benefit from complementarity between breeds specialised for different traits

The values of the local population, the imported breed and their crossbred offspring are to be appreciated accurately, under the usual environmental conditions on farm

Crossbreeding leads to an extra-gain via heterosis:

- Especially for reproduction and fitness traits
- Direct and maternal heterosis

Crossbreeding plans require many exchanges of animals and so, an organisation and sanitary cautions