Heritabilidade e Melhoramento

A proporção da variação fenotípica que é atribuível a factores genéticos é chamada de **Heritabilidade** de uma característica: é uma medida da proporção da variação fenotípica controlada apenas por factores genéticos (ou seja independente do ambiente)

H = variação genética/ variação fenotípica

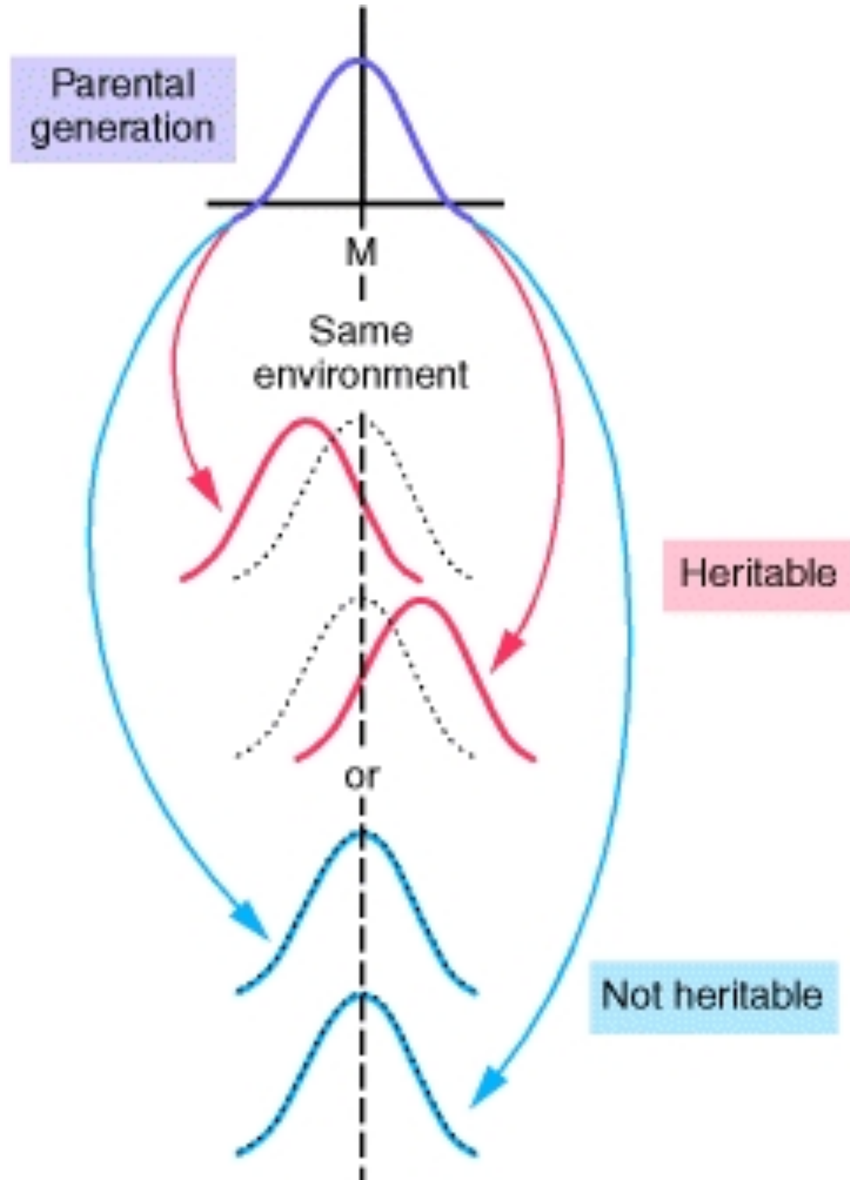
H pode variar entre

0 - *inexistência de controlo genético* *e*

1 - *variação causada somente por factores genéticos*

Infelizmente a maioria das Heritabilidades para as variedades cultivadas são bastante inferiores a 1.

Testar a heritabilidade de uma característica numa determinada população



Heritabilities of crop characteristics

Characteristic	Crop	Heritability
Yield	Soybean	0.03–0.58
Yield	Maize	0.14–0.28
Seed protein	Barley	0.53
Seed weight	Sunflower	0.33–0.60
Seed oil	Sunflower	0.40–0.75
Lodging	Soybean	0.43–0.75
Maturity	Soybean	0.75–0.94
Heading date	Barley	0.75

Heritability

Any particular phenotype can be modeled as the sum of genetic and environmental effects:
Phenotype (P) = Genotype (G) + Environment (E).
Likewise the variance in the trait – Var (P) – is the sum of genetic effects as follows:
$Var(P) = Var(G) + Var(E) + 2\,Cov(G,E)$.
In a planned experiment $Cov(G,E)$ can be controlled and held at 0. In this case, heritability is defined as:

$$H^2 = \frac{Var(G)}{Var(P)}$$

H^2 is the broad-sense heritability. This reflects all the genetic contributions to a population's phenotypic variance including additive, dominant, and epistatic (multi-genic interactions), as well as maternal and paternal effects, where individuals are directly affected by their parents' phenotype (such as with milk production in mammals).

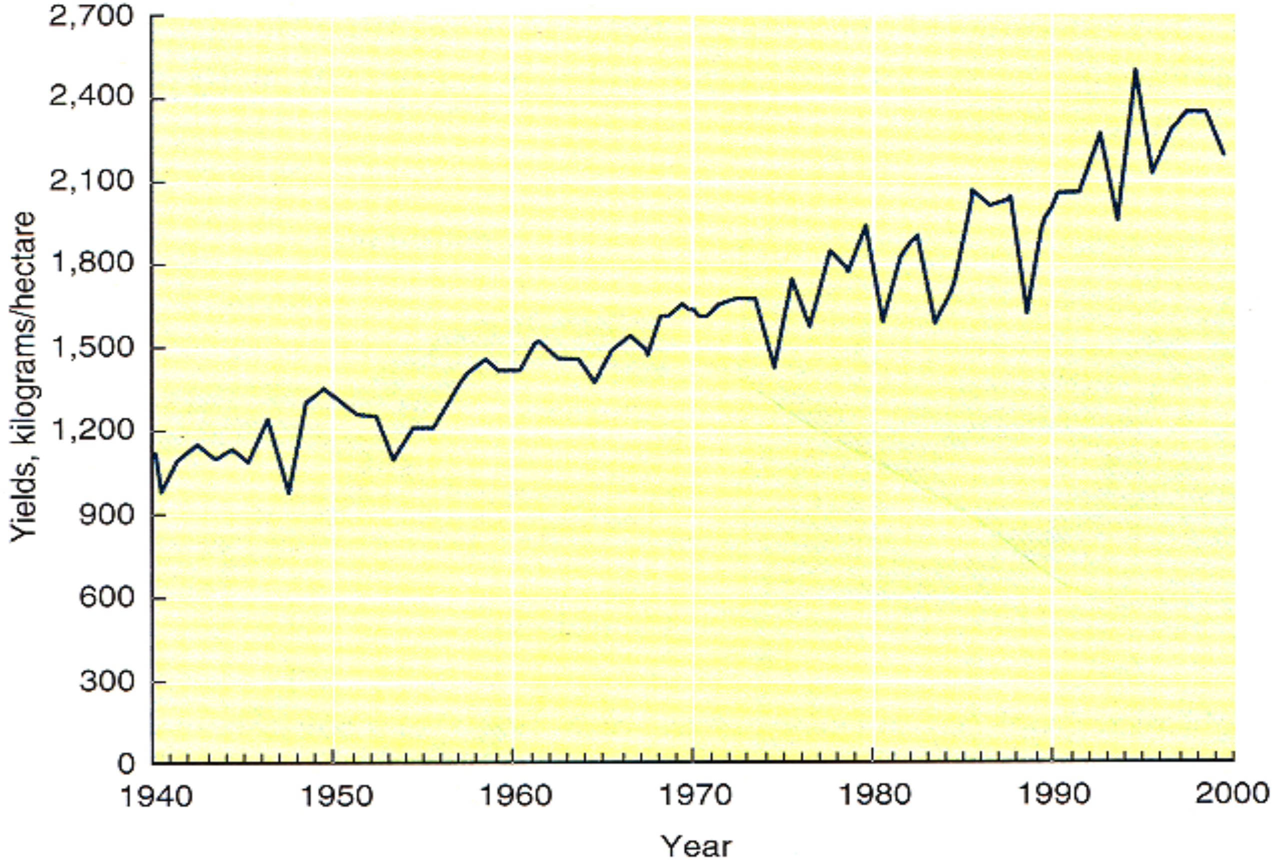
Acerca da Heritabilidade

A heritabilidade é específica para a característica, população e ambiente que se está a analisar.

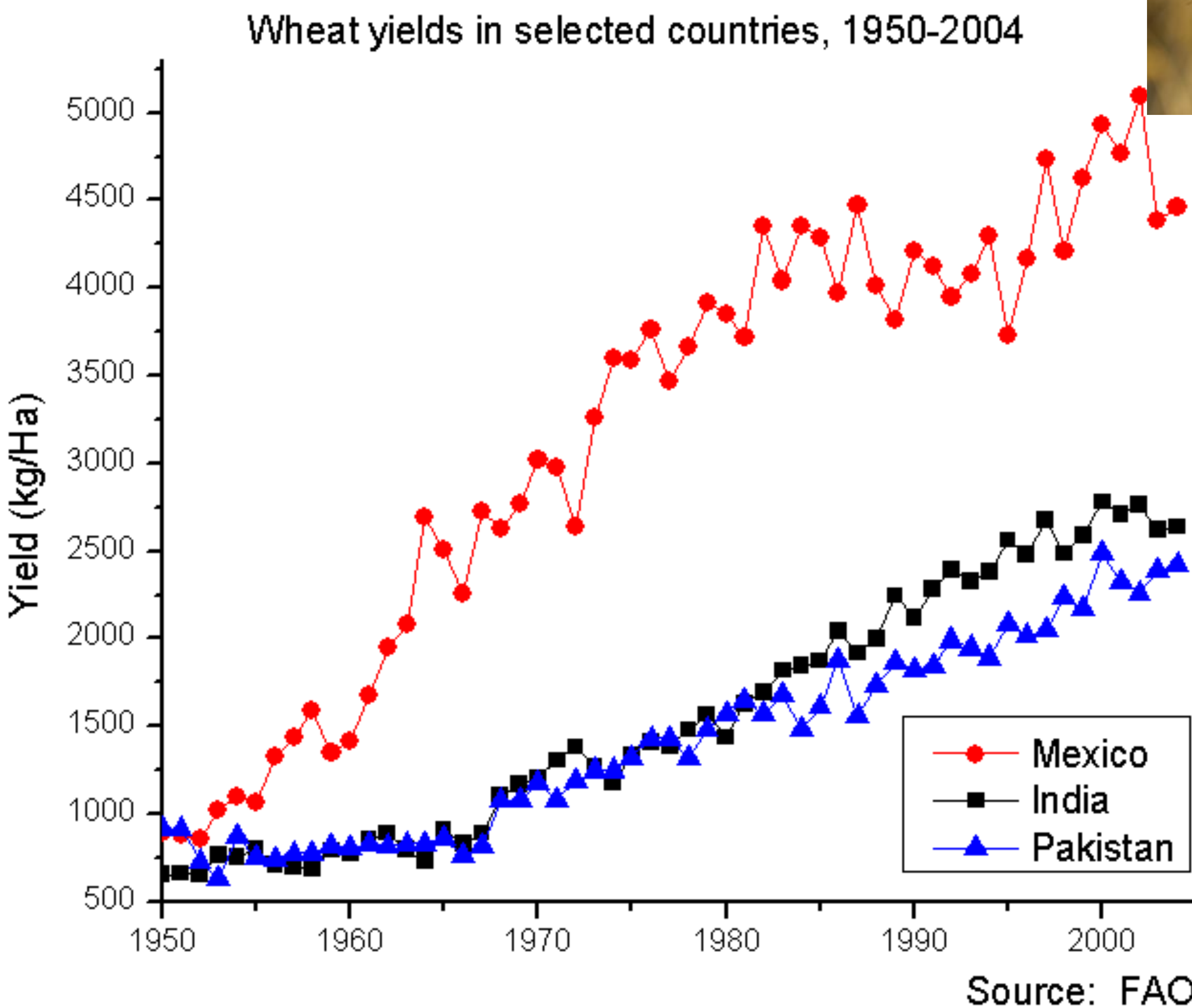
A estimativa é um parâmetro populacional, não individual.

A heritabilidade mede a proporção da variação fenotípica que resulta da expressão de factores genéticos.

Plant breeders are always trying to balance acceptable costs for parent selection, testing schemes, and expenses to maximize heritability and selection progress.



An example of the rigorous application of the principles of plant breeding to crop production is the steady increase in soybean yields in the US.


Wheat yields in selected countries, 1950-2004
Yield (kg/Ha)
5000
4500
4000
3500
3000
2500
2000
1500
1000
500
1950
1960
1970
1980
1990
2000
Mexico
India
Pakistan
Source: FAO

Fiquei aqui

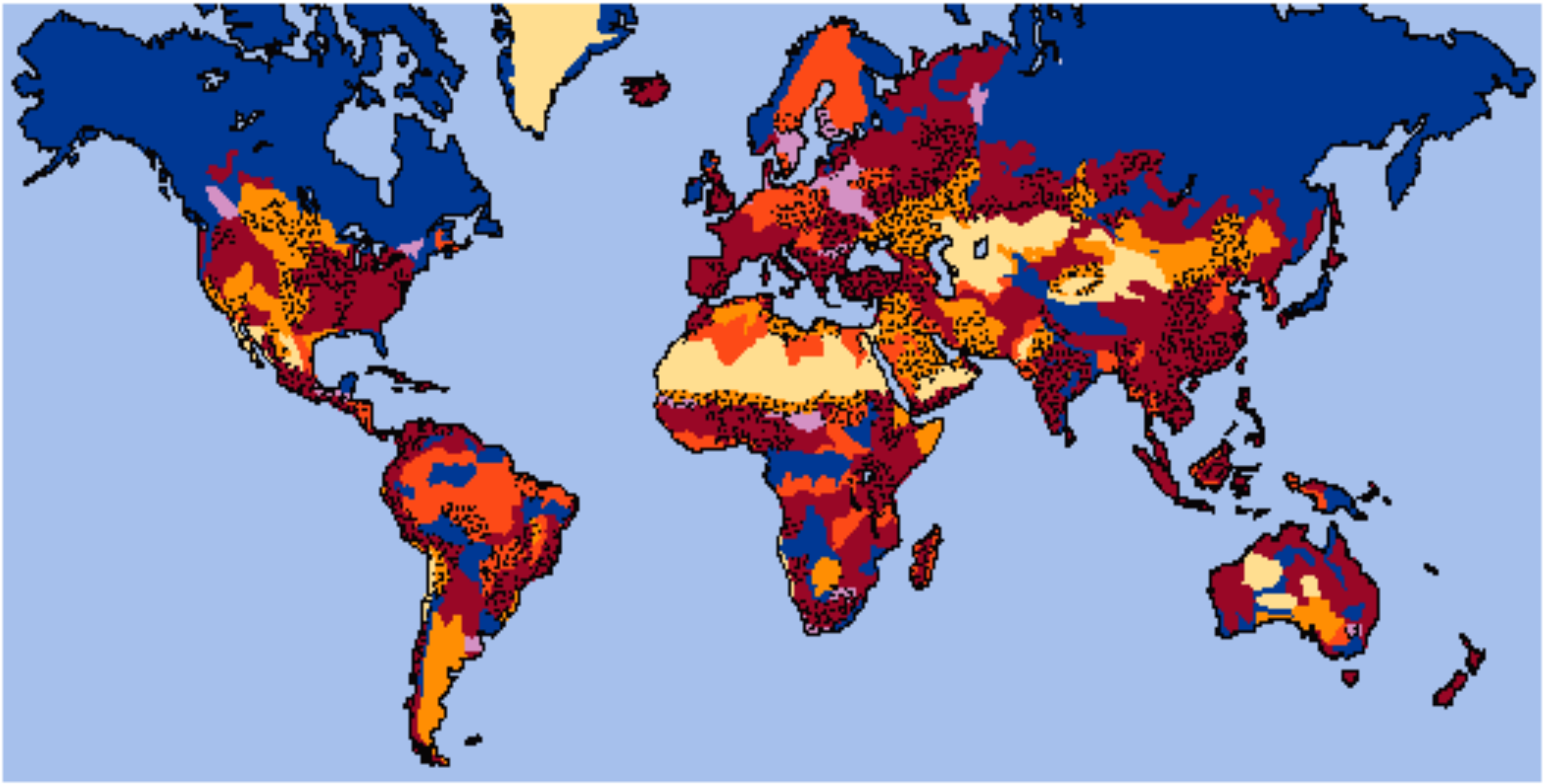
Os objectivos do melhoramento de plantas

- aumentar a Produtividade;
- melhorar a Qualidade.

É possível aumentar a Produtividade melhorando:

- a adaptação à estação do ano
- a tolerância aos factores bióticos – doenças e pragas
- a tolerância aos factores abióticos – secura, salinidade, frio…

Human-induced soil degradation in the world



Soil degradation types

- Water erosion
- Wind erosion
- Chemical deterioration
- Physical deterioration
- Severe degradation

Other symbols

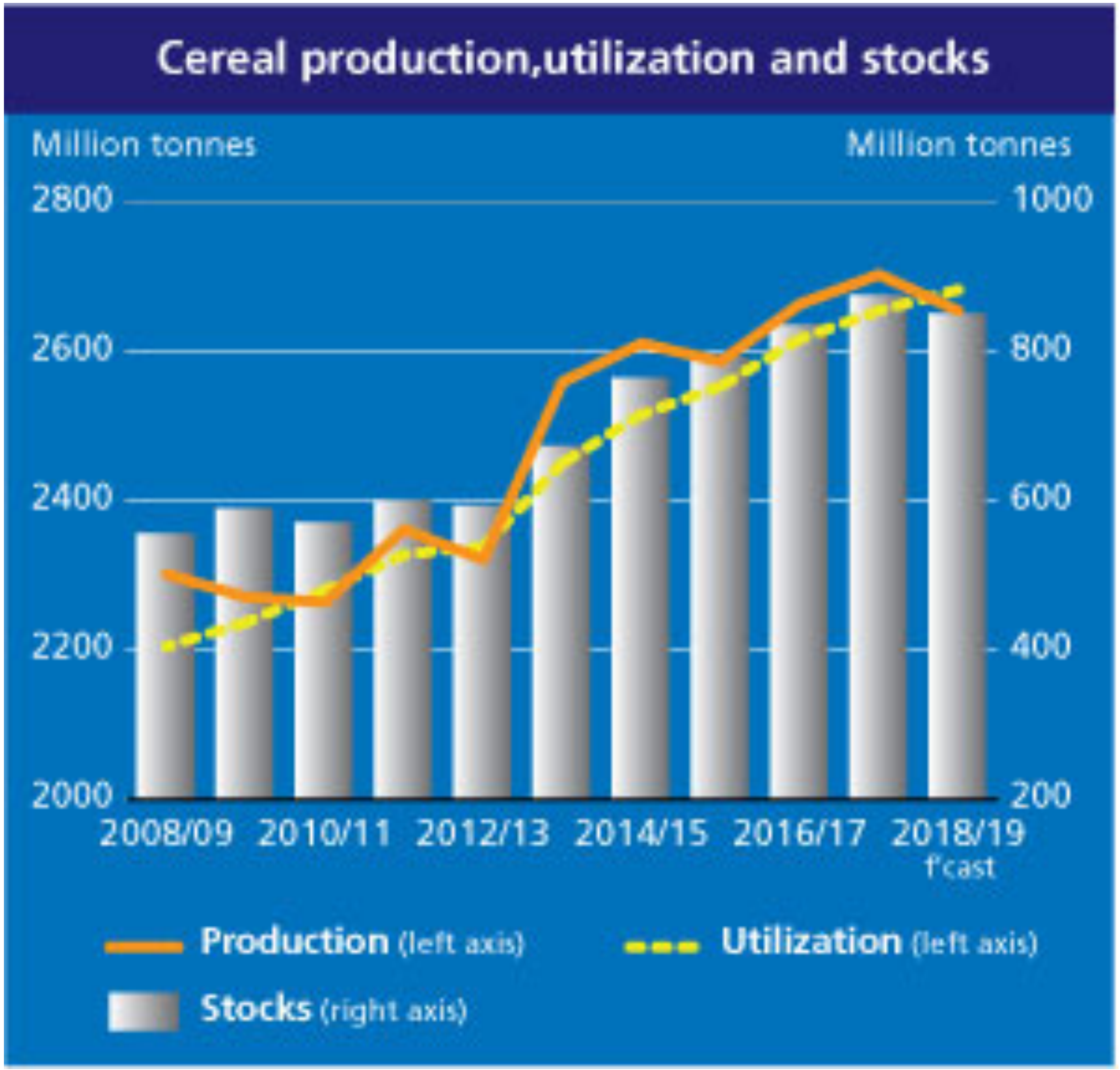
- Stable terrain
- Non-used wasteland
- Water bodies

Source: Oldeman *et al.* (1991)

Grain Harvested Area Per Person in Selected Countries and the World in 1950 and 2000, with Projection to 2050

	Grainland Per Person		
	Hectares		
Country	1950	2000	2050 (proj.)*
Australia	0.73	0.97	0.70
Canada	1.42	0.59	0.45
United States	0.51	0.21	0.15
Nigeria	0.26	0.15	0.06
Ethiopia	0.26	0.11	0.04
Mexico	0.19	0.10	0.07
India	0.22	0.10	0.06
Tanzania	0.07	0.09	0.04
Pakistan	0.18	0.09	0.04
Bangladesh	0.20	0.09	0.04
Indonesia	0.10	0.07	0.05
China	0.17	0.07	0.06
Uganda	0.15	0.06	0.01
North Korea	0.14	0.05	0.04
Egypt	0.08	0.04	0.02
Dem. Rep. Of Congo (Zaire)	0.05	0.04	0.01
Malaysia	0.09	0.03	0.02
Rwanda	0.06	0.03	0.01
South Korea	0.10	0.03	0.02
Japan	0.06	0.02	0.02
World	0.23	0.11	0.07

Sources: Grainland area for 1950 from U.S. Department of Agriculture (USDA), Production, Supply, and Distribution (PS&D) Country Reports, October 1990; 2000 grainland data from USDA, PS&D, electronic database, updated October 2002; population data and projections from United Nations, World Population Prospects: The 2000 Revision (New York: 2001).



http://www.fao.org/worldfoodsituation/csdb/en/

A qualidade pode ser melhorada relativamente às:

- Características organolépticas - sabor, cheiro, cor e textura;
- Características químicas - teor em ferro;
- Características mecânicas - qualidade da fibra ou reologia da massa para pão;
- Características biológicas - valor alimentar ou conteúdo em vitaminas.

Racional do melhoramento vegetal

- Reconhecer as características que são importantes;
- Desenhar formas de avaliar as características desejáveis no material vegetal disponível que constitui a base genética do melhoramento;
- Encontrar a fonte dos genes ou variantes alélicas de interesse;
- Combinar os genes ou variantes alélicas de interesse em variedades melhoradas;
- Comparar as novas variedades com as cultivares já utilizadas;
- Tornar disponíveis e distribuir as cultivares melhoradas.

Técnicas de Melhoramento

Seleção Clássica – sem cruzamentos

Enxertia

Hibridação Clássica – com cruzamentos (abertos ou controlados)

Hibridação Inteligente – recurso a marcadores moleculares

Melhoramento por mutação – raios X, químicos

Di-haploidização

Salvamento de embriões – in vitro (“embryo rescue”)

Variação somaclonal – in vitro (natural ou induzida)

Engenharia genética - incluindo transferência horizontal

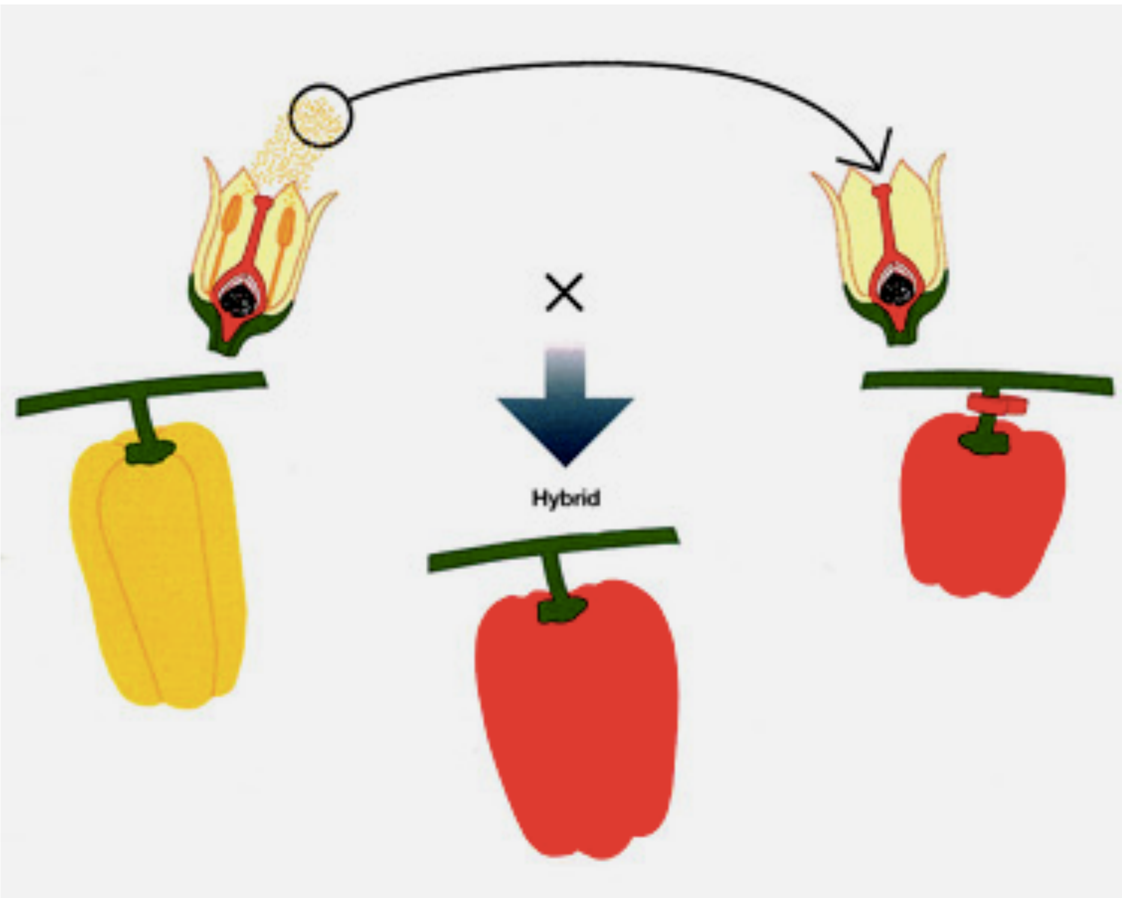
Edição de DNA

Melhoramento “clássico”

As técnicas “clássicas” de **Melhoramento** continua a ser fundamentais.

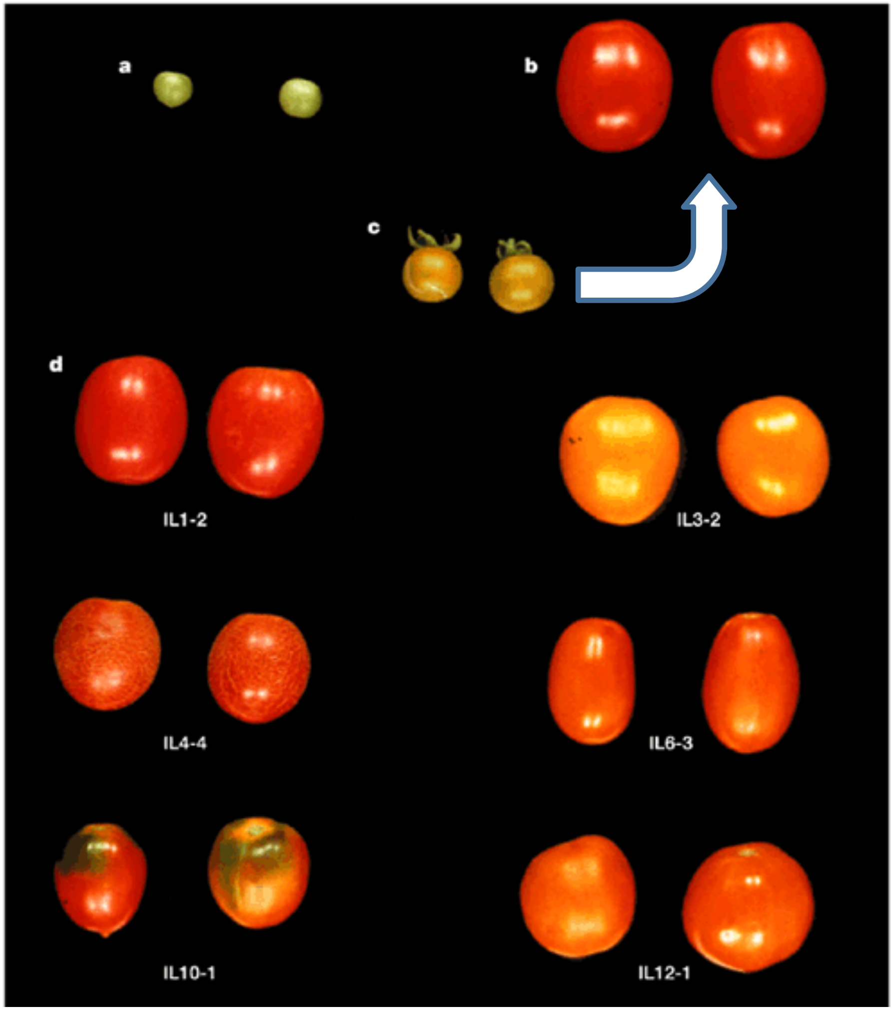
Sem elas *não há melhoramento* (qualquer que seja a denominação que se lhe queira dar).

Hibridação Clássica
"Breeding"



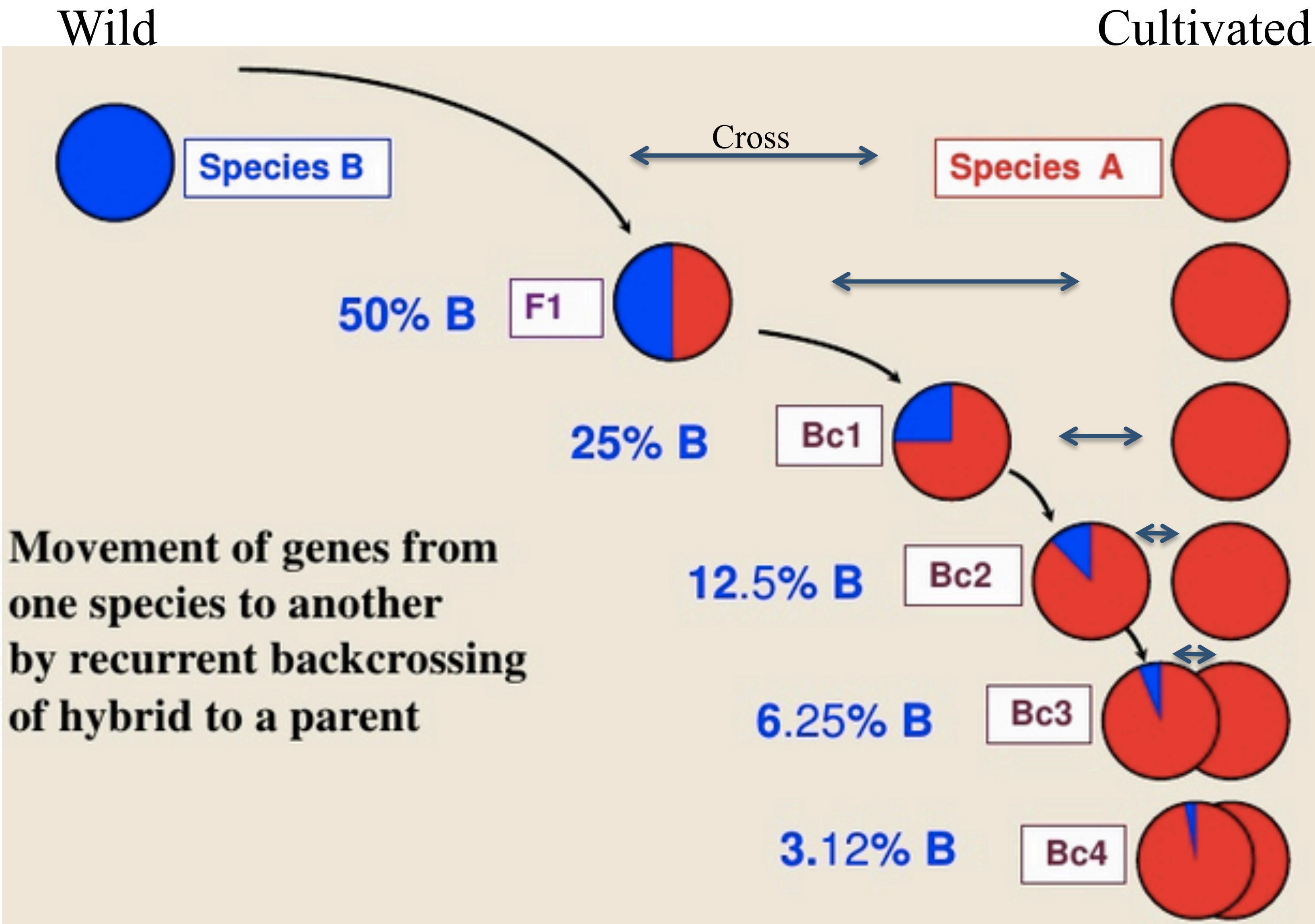
Emasculação

Introgressão



a | Green fruits of the wild species *Lycopersicon pennellii*, **b** | the lycopene-rich red fruits of *Lycopersicon esculentum*, **c** | their F_1 hybrid progeny, and **d** | six introgression lines (Ils).

Introgressão



Generation	Donor genes	Recurrent genes
Parent	100%	100%
F1	50%	50%
1st bc	25%	75%
2nd bc	12.5%	87.5%
3rd bc	6.25%	93.75%
4th bc	3.12%	96.88%
5th bc	1.56%	98.44%
6th bc	0.78%	99.22%
7th bc	0.78%	99.22%

Programa convencional de melhoramento

Generations		Evaluation/Selection/Testing	
P	Selected parents		
F_1	800 crosses		
F_2	2 million plants	Disease resistance	
F_3	400,000 plants	Disease resistance and Field characteristics	
F_4	12,000 lines		
F_5	1,200 lines	Disease resistance Yield Field characteristics Uniformity	
F_6	300 lines		
F_7	50 lines		
F_8	5 lines		Industrial uses Quality testing
F_9	3 lines		
F_{10}	2 lines		
F_{11}	1 line!		

A conventional breeding program for a new cereal starts with selected parents and careful hand pollination to produce 800 crosses. This F_1 progeny is uniform. Then, 2 million plants are grown (2500 from each parent cross) and evaluation begins. After 10 generations the breeder ends up with one line.

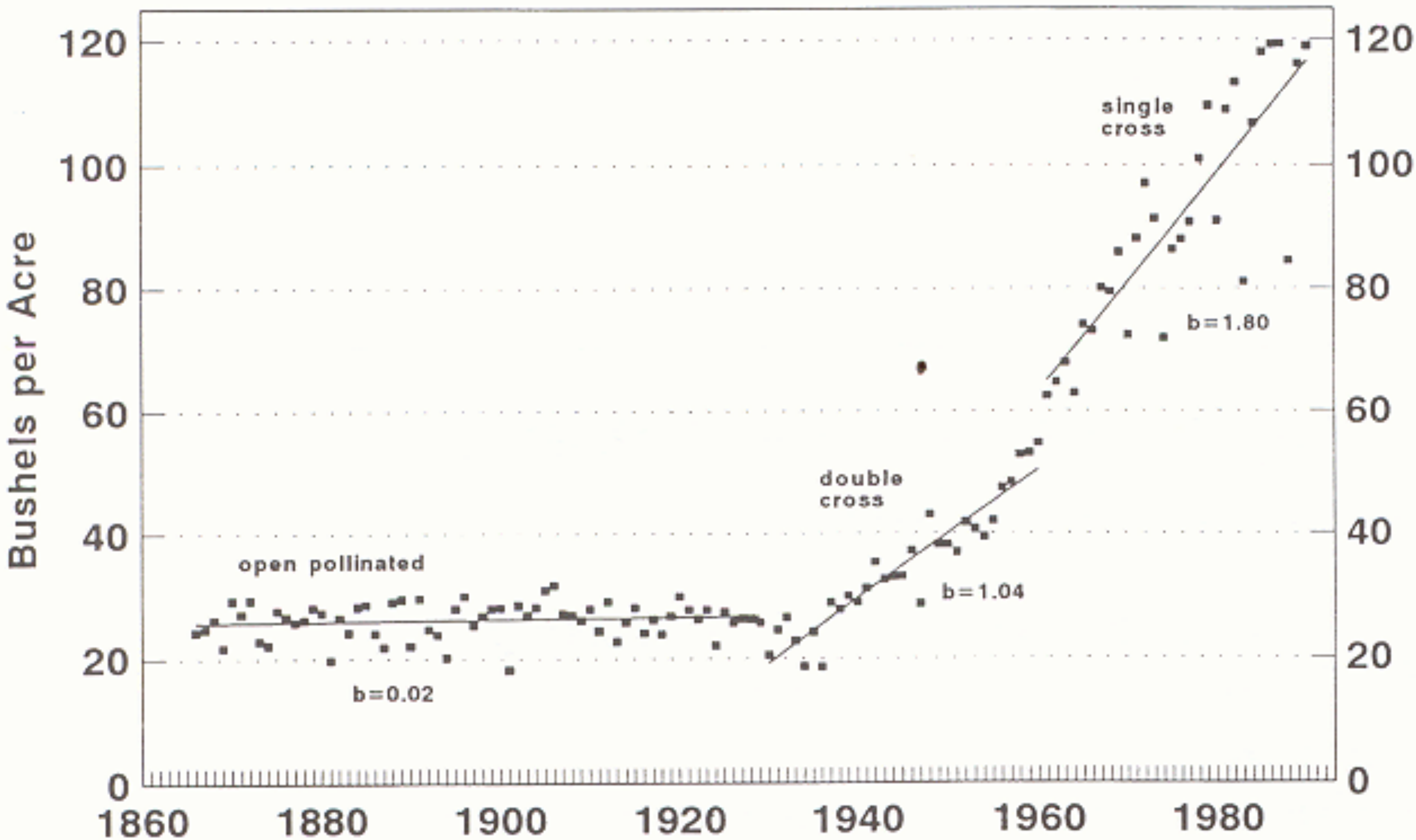
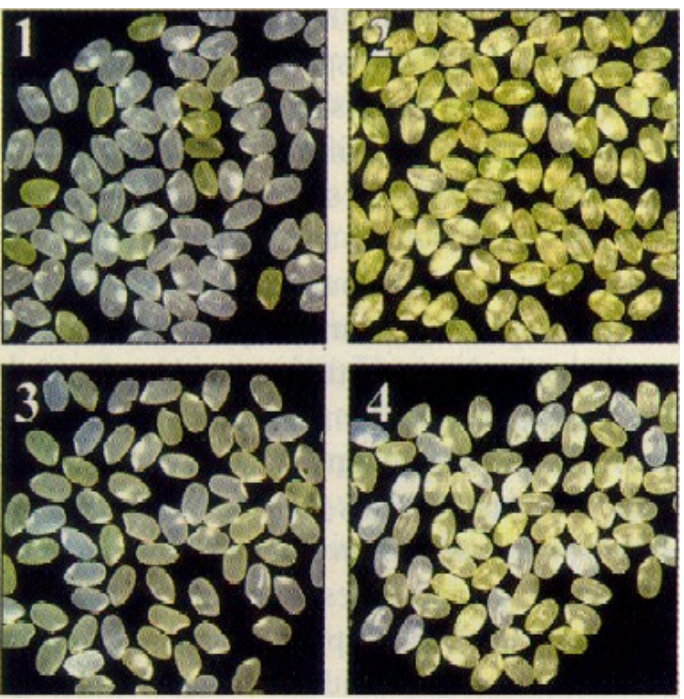


Figure 1 Mean grain yield of corn in the United States from 1860s to 1990s (1 bu/acre at 15.5% moisture = 53.0 kg dry matter/ha). (From Ref. 4.)

Melhoramento de precisão/ melhoramento molecular

Conjunto de tecnologias para melhorar as culturas e optimizar a produção e a qualidade alimentar

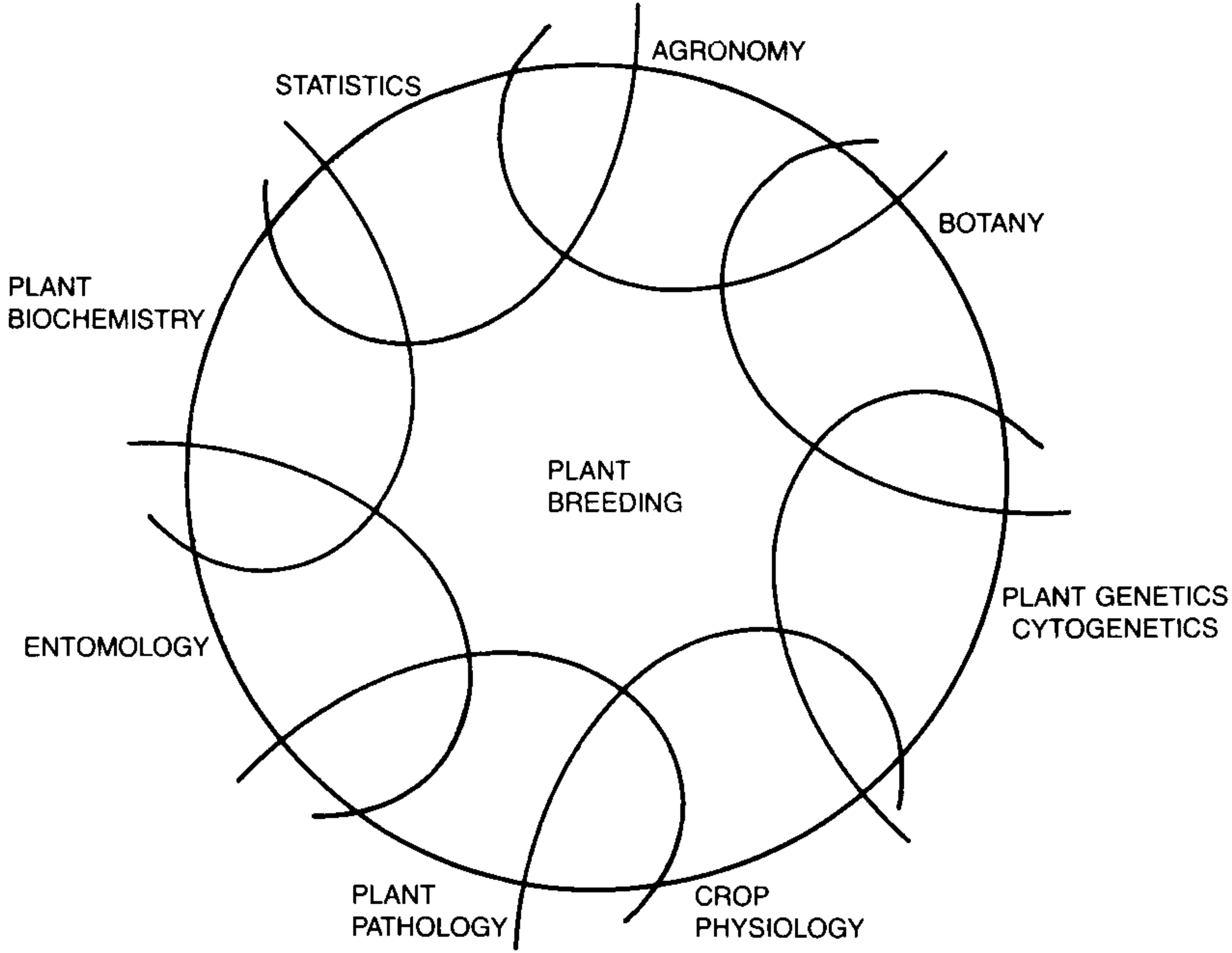


1 – Explorar a variabilidade alélica natural

2 – Alterar a informação genómica

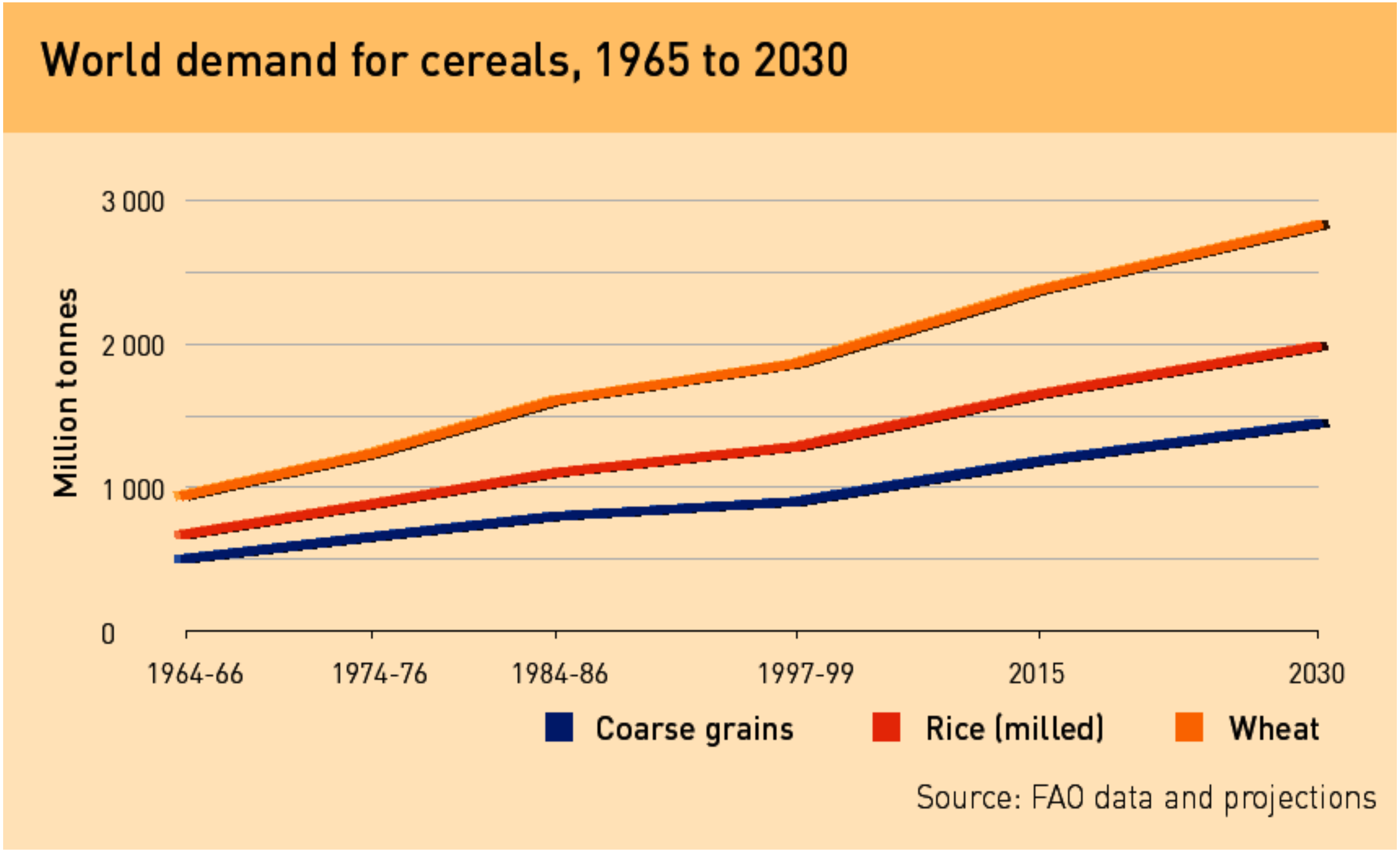
3 – Controlar espacial e temporalmente a expressão génica

4 – Controlar os mecanismos epigenéticos

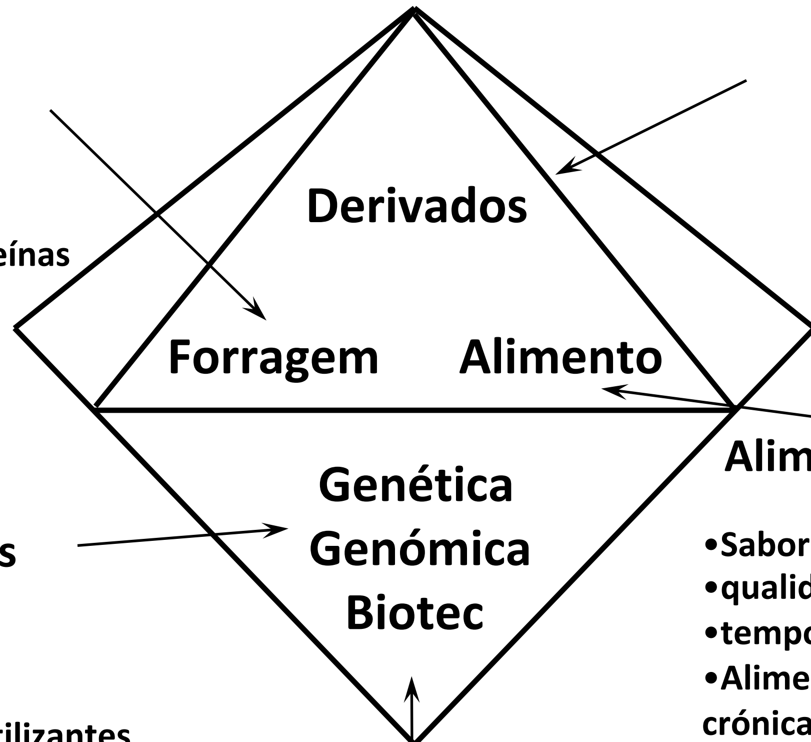


Overlapping relationship of plant breeding with other areas of knowledge. In breeding an improved crop variety, the breeder cooperates with specialists in many fields of plant science and provides them with plant genetic materials for study.

Procura: Cereais 1965-2030 (FAO)



Que melhoramento para o Milho?



Derivados

- Amino ácidos
- Vitaminas
- Amido
- Tolerância a alergénicos
- Antibióticos

Composição da forragem

- Digestibilidade
- ausência de micotoxinas
- total aproveitamento das proteínas
- agentes de saúde animal

Alimentação humana

- Sabor e aparência
- qualidades de processamento
- tempo de armazenamento
- Alimentos "funcionais" (evtitar doenças crónicas por falta de determinados nutrientes)

Constrangimentos adaptativos/ambientais

- rendimento
- adaptação
- eficiência do uso de fertilizantes
- tolerância a stresses
- factores agronómicos

Constrangimentos bióticos

- Pestes
- Ervas daninhas
- nemátodes
- doenças

Qualitative and quantitative variation in plants

A - Qualitative variation

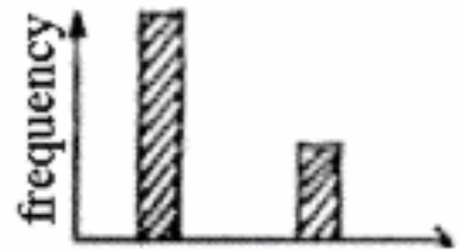
- **discontinuous variation**
- **classify & count plants**
- **determine phenotypic ratios**

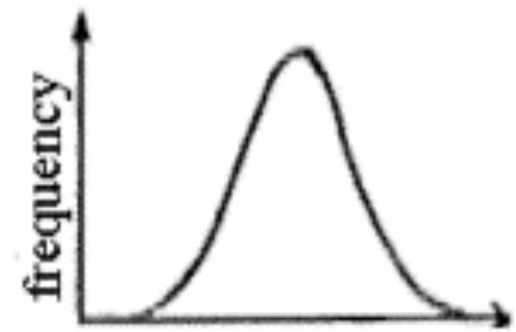
B - Quantitative variation

- **continuous variation**
- **measure the phenotype**
- **calculate means & variances**

Variação Qualitativa versus Quantitativa

Trait	Mode of inheritance	Environmental effects
Qualitative, Color Herbicide tolerance	Simple Mendelian (monogene)	Little
Quantitative, Productivity Drought tolerance	Complex (polygene)	Moderate to great





FIM

A review of (plant) genetics

(21 principles)

1. The raw material for genetics is variation among individuals.
2. Genetics is the study of genes through their variation.
3. Each cell of an organism contains at least 1 set of basic genetic information of that organism. That set is called a **genome**.
4. Each gene has a characteristic place (**locus**) on a **chromosome** in the genome.
5. In a **diploid** organism, there is 1 chromosome set derived from 1 parent and 1 chromosome set derived from the other parent. Therefore the chromosomes are in **homologous** pairs, and each locus may bear identical **alleles** (**homozygous**) or different alleles (**heterozygous**).

6. In crosses between discontinuous variants, genes can be identified by observing Mendelian **ratios** of **phenotypes**.
7. The phenotype of the heterozygote defines the **dominance** relationships of genes.
8. **Mitosis** partitions the chromosomes equally into daughter cells during somatic cell division. Meiosis halves the number of chromosomes during production of sex cells.
9. In **meiosis**, the members of a gene pair segregate equally into the meiotic products. This principle is sometimes known as Mendel's first law.
10. At meiosis, the **segregation** of one gene pair is **independent** of the segregation of gene pairs on other chromosome pairs. This principle is sometimes known as Mendel's second law.

11. Mendel's laws, in conjunction with random fertilization, generate standard genotypic and phenotypic ratios in the progeny.

12. A chromosome is essentially one long double-stranded molecule of **DNA**, and the genes are regions on this molecule.

13. A **gene** is a stretch of DNA that comprises a transcriptional unit. It consists of a sequence that is transcribed to a functional RNA product and regulatory sequences that enable **transcription** to occur.

14. DNA is a **double helix** consisting of 2 complementary strands of opposite polarity.

15. Genes exert their effects on phenotypes by expressing products that are either **proteins** or non-translated **RNA**.

16. Genes at different loci can interact with one another in exerting their effects on the phenotype. This interaction is called **epistasis**.

17. Gene interaction is revealed at the genetic level by observing modified Mendelian ratios in standard crosses.

18. The same gene can affect more than one phenotypic character. This is called **pleiotropy**.

19. Genes can change from one allelic form to another (gene **mutation**) and chromosome sets can change from one form to another (chromosome mutation).

20. Polyploids can originate as **autopolyploids** or **allopolyploids**.

21. Mitochondria and chloroplasts have their own unique circular DNA "chromosomes" distinct from nuclear DNA. This cytoplasmic DNA is usually inherited uniparentally.