Cap Dev Lectures series:

Breeding autogamous cereals - a complete lecture from *Parents to Farms*

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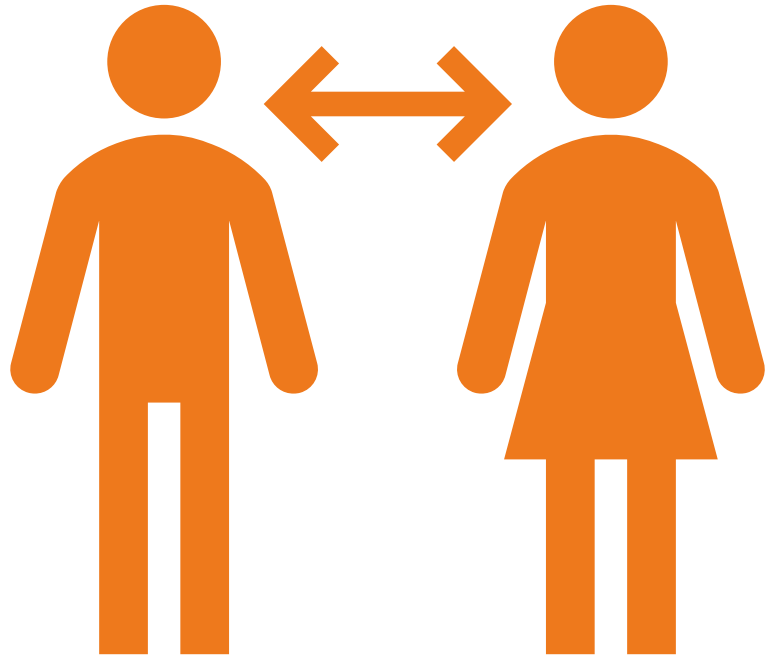
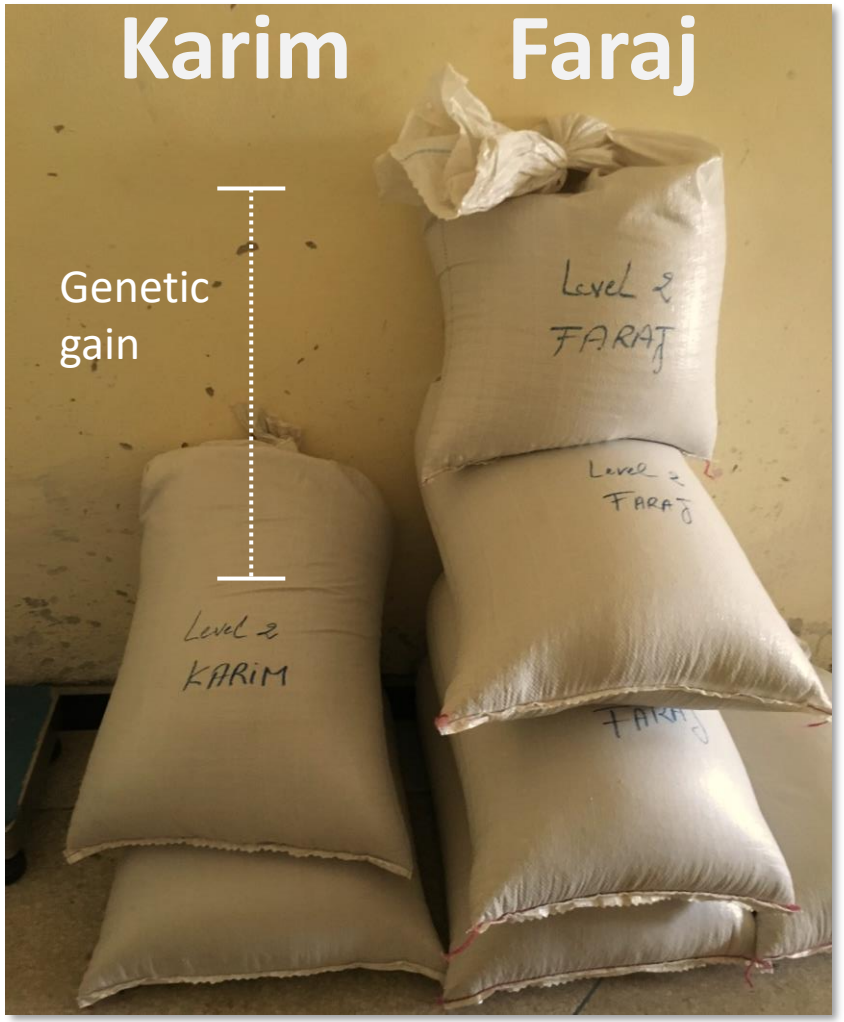
Lecture 1 – April 5th 2022

- **The general concepts of breeding for genetic gain**
  - The equation
  - Its components
- **Successful steps for parental selection**
  - Product profile
  - Parental sources
  - Top and back crossing
- **The steps for keeping pedigree record and reading it**
  - Rules of pedigree
  - Practical examples on genomic contributions

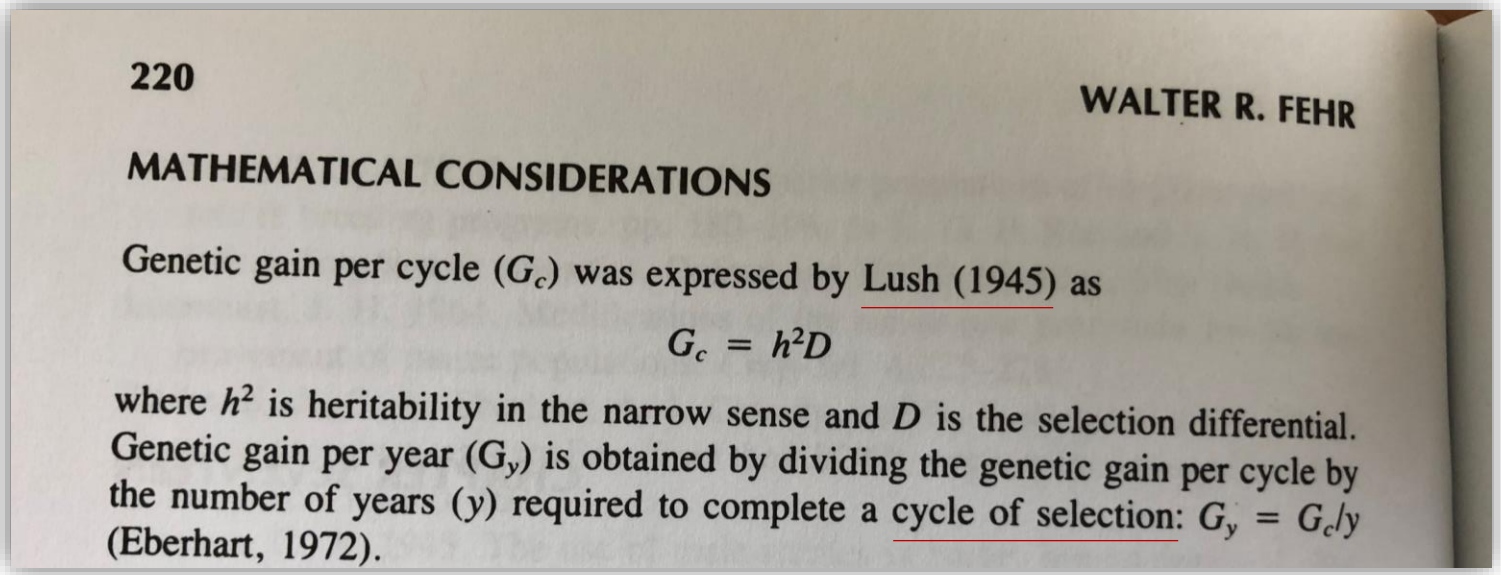


Genetic gain: the only true goal

- ***Phenotype = Genetic + Management + Environment***
- When Management and Environment are the same the difference between varieties is **Genetic Gain**



Genetic gain: the only true goal



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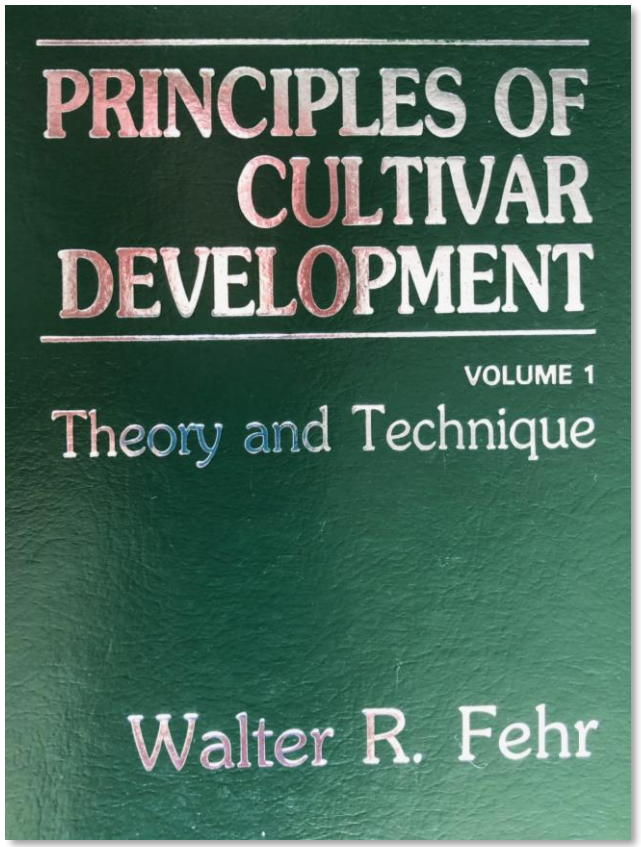
MATHEMATICAL CONSIDERATIONS

Genetic gain per cycle (G_c) was expressed by Lush (1945) as

$$G_c = h^2D$$

where h^2 is heritability in the narrow sense and D is the selection differential. Genetic gain per year (G_y) is obtained by dividing the genetic gain per cycle by the number of years (y) required to complete a cycle of selection: $G_y = G_c/y$ (Eberhart, 1972).

h^2 = heritability
D = selection differential
Y = years required to complete a cycle



The breeder equation

$$\text{Genetic gain}_{\text{year}} = \frac{\text{Accuracy} \times \text{Heritability} \times \text{Selection intensity}}{\text{Recycling time in years}}$$

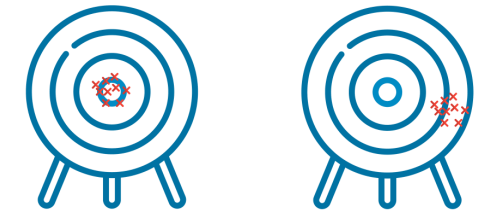
The breeder equation

Good accuracy and good precision

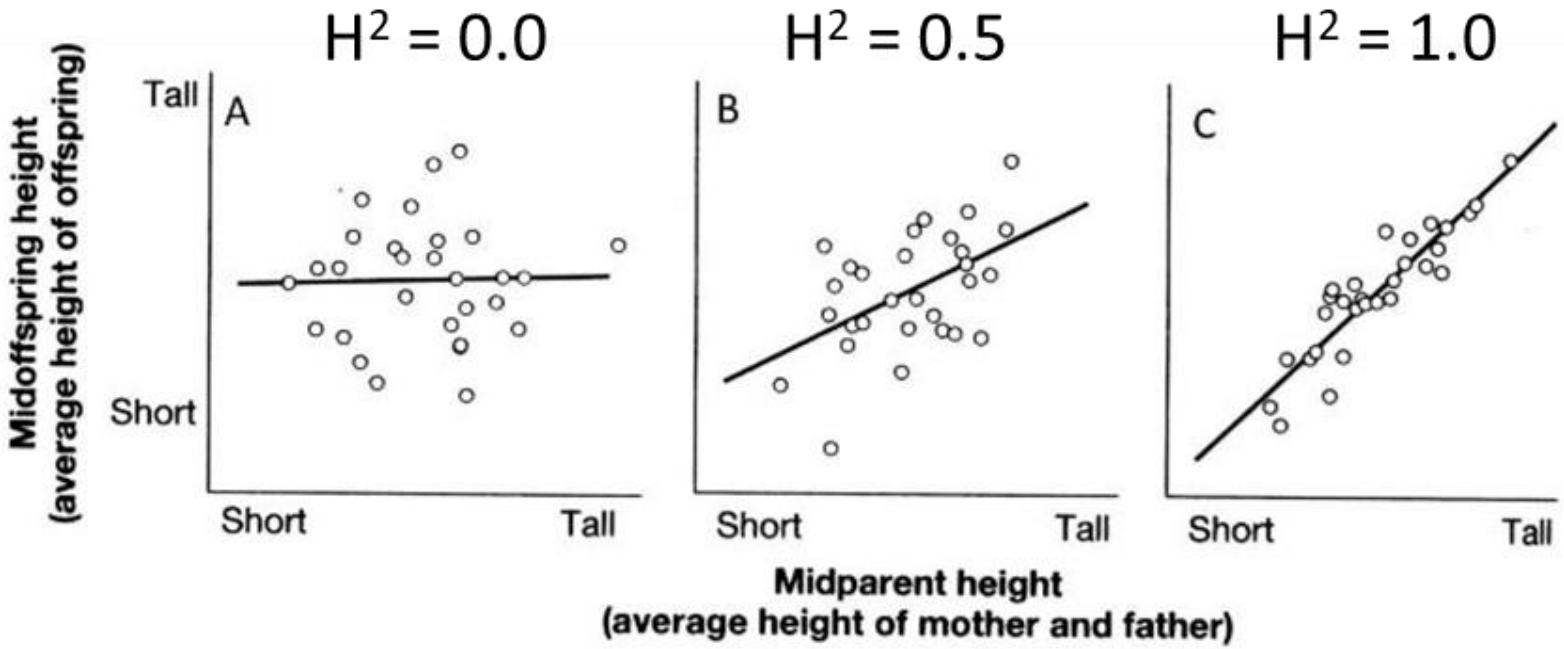
Bad accuracy but good precision

Accuracy: how close to the actual value

The breeder equation

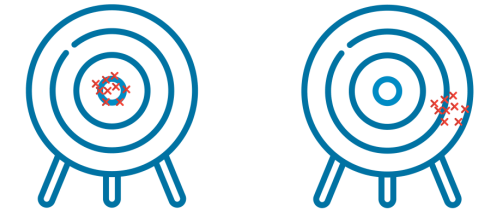


Accuracy: how close to the actual value



Heritability: how likely to move a trait from parents to off-spring

The breeder equation



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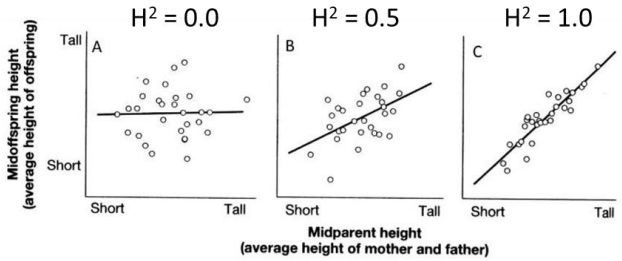
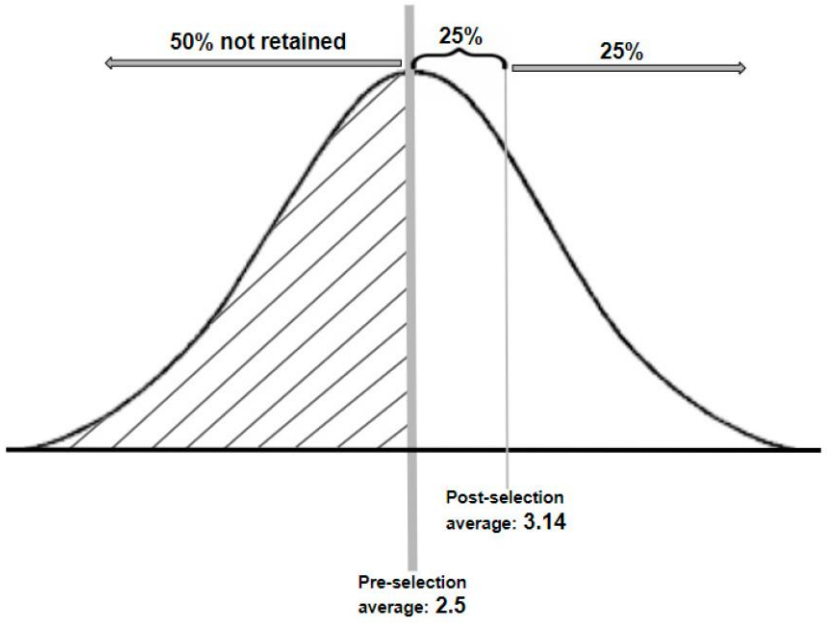
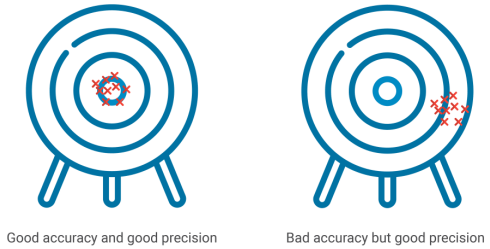


Heritability: how likely to move a trait from parents



Selection intensity: what proportion of the progenies is advanced each cycle

The breeder equation



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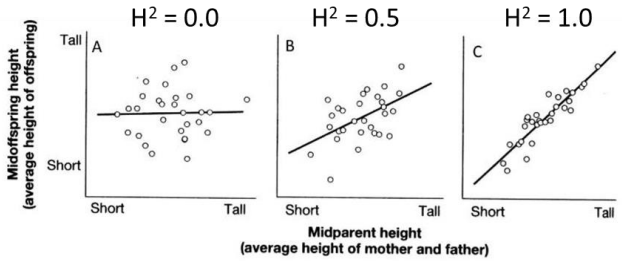

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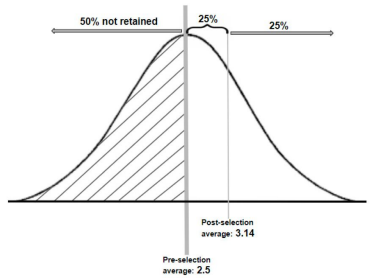


Selection intensity: what proportion of the progenies is advanced each cycle

$$\text{Genetic gain}_{\text{year}} = \frac{\text{Accuracy} \times \text{Heritability} \times \text{Selection intensity}}{\text{Recycling time in years}}$$

Recycling time in years: how many years between crossing and re-crossing

Improving GG based on the breeder equation

$$\text{Genetic gain}_{\text{year}} = \frac{\text{Accuracy} \times \text{Heritability} \times \text{Selection intensity}}{\text{Recycling time in years}}$$

Accuracy: depends on tools and selection methods

Heritability: depends on the evaluation methods used

Selection intensity: depends on the breeding scheme used

Recycling time: depends on the breeding scheme used

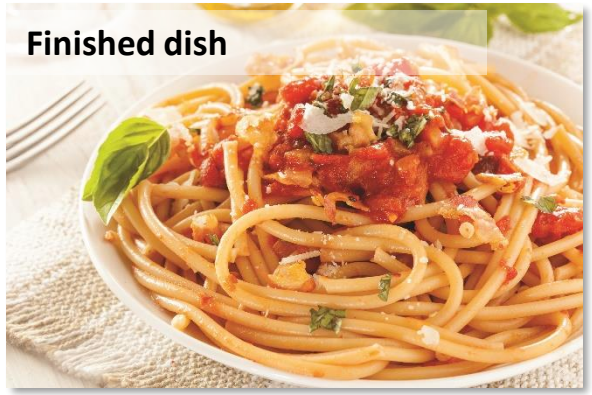
The pipeline

Create diversity

Positive selection to homozygous state

Field testing

Release variety



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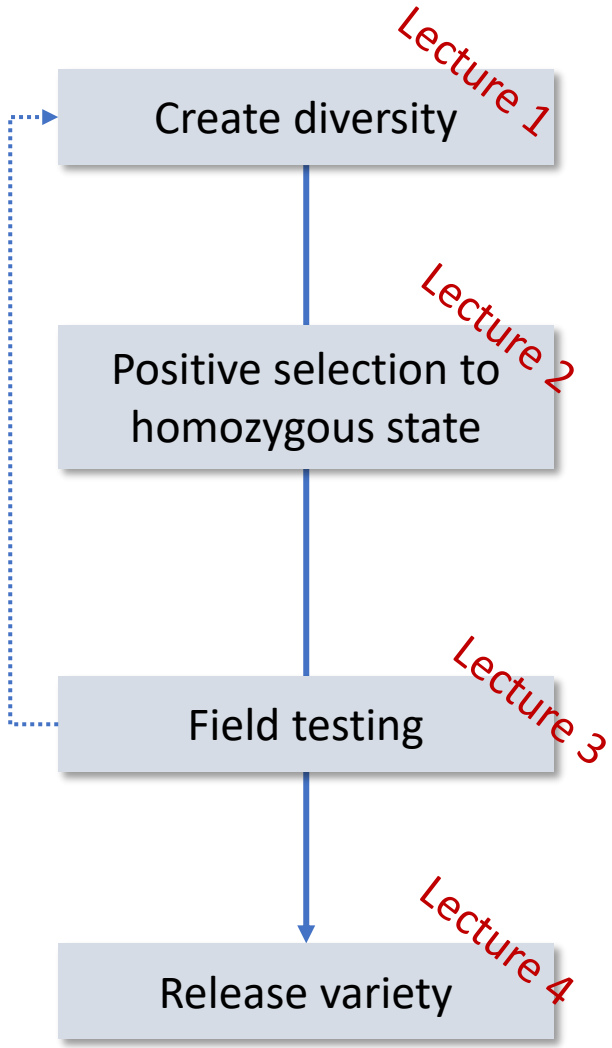
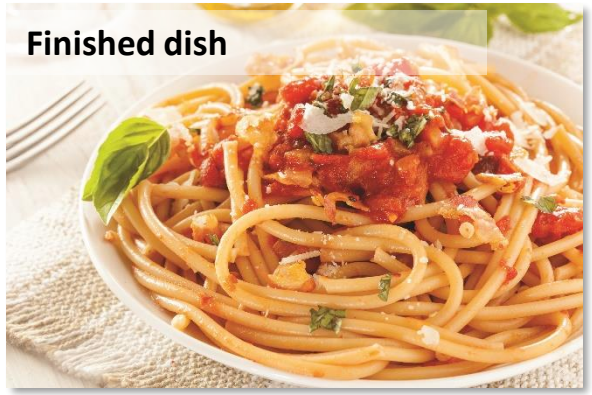




What does a breeder want?

- Use Mendel Laws to release superior varieties
- ..

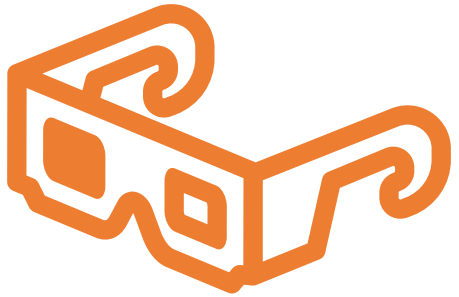
Blind breeding vs guided breeding

	Parent 1	Parent 2	Parent 3	Parent 4	Parent 5	Parent 6
Yield	↓ 5	↓ 5	→ 10	→ 10	→ 15	↑ 20
Drought tolerance	↑ 10	↓ 5	↑ 10	↑ 10	→ 7	↓ 5
Heat tolerance	↑ 20	→ 10	→ 10	↓ 5	→ 10	↓ 5
Disease resistance	↑ 10	↑ 10	↑ 10	↓ 5	→ 7	↓ 5
Top quality	↓ 5	↓ 5	↑ 10	↑ 10	↑ 10	↓ 5
Landrace	↑ 1	↓ 0	↓ 0	↑ 1	↑ 1	↓ 0

- Which parents should we cross?

Defining a product profile

- **Declare clearly the goals**:
  - Top yielding line with good quality and resistance to diseases



Defining a product profile

- **Declare clearly the goals**:
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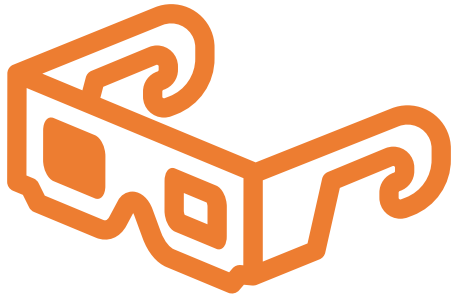
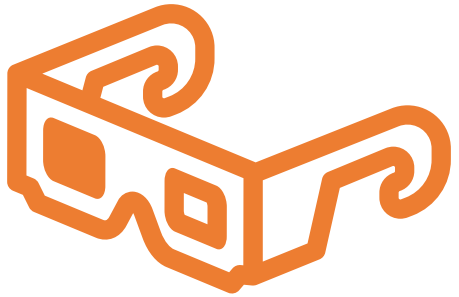
  - Top yielding line with good quality and resistance to diseases adapted to irrigated conditions



Defining a product profile

- **Declare clearly the goals**:
  - Top yielding line with good quality and resistance to diseases
  - Top yielding line with good quality and resistance to diseases adapted to irrigated conditions
  - *Line with 10% higher yield than 'Karim' under rainfed conditions, with grains as large as 'Tomouh', and resistance to Hessian fly matching 'Faraj'*



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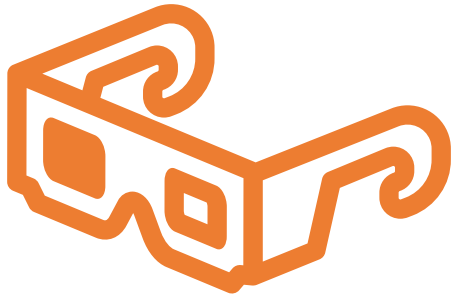
- **Make it achievable:**
  - The super mega variety does not exist
  - You can only combine what two parents already have
    - What you do not have you need to do pre-breeding for..



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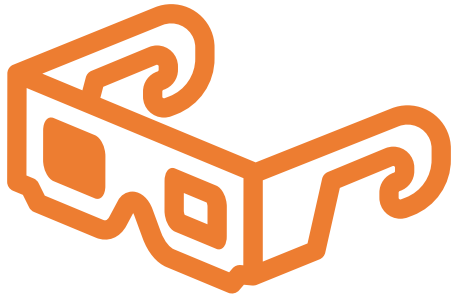
- **Make it achievable:**
  - The super mega variety does not exist
  - You can only combine what two parents already have
    - What you do not have you need to do pre-breeding for..

- **Set a precise timeline:**
  - 3 years – it is already in stage 2 yield trials
  - 5 years – it is already in stage 1 yield trials
  - 10 years – you have the two parents for it



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Top quality	↓ 5	↓ 5	↑ 10	↑ 10	↑ 10	↓ 5
Landrace	↑ 1	↓ 0	↓ 0	↑ 1	↑ 1	↓ 0

- Which parents should we cross?

Line with 10% higher yield than 'Karim' under rainfed conditions, with grains (quality) as large as 'Tomouh', and resistance to (disease) Hessian fly matching 'Faraj'

Blind breeding vs guided breeding

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- Which parents should we cross?

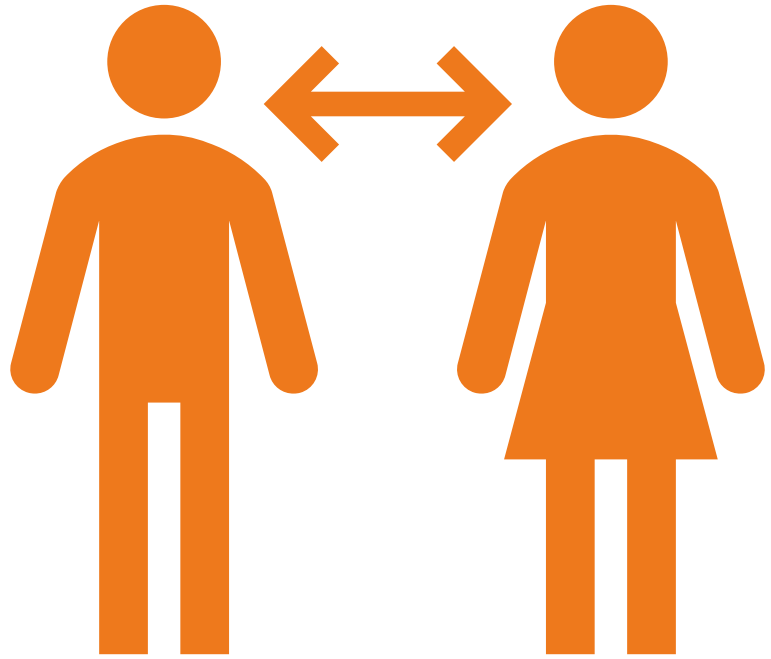
Line with 10% higher yield than 'Karim' under rainfed conditions, with grains (quality) as large as 'Tomouh', and resistance to (disease) Hessian fly matching 'Faraj'

Where should we get our parents from?

- Elites of the breeding program
- ..

What cross would you make?

- Would you cross two top yielding lines?
- How about two disease resistant lines with low yield

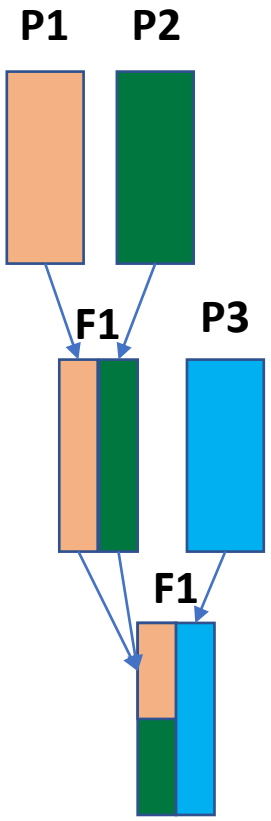


Two and three ways crosses

- Combining two parents ensures each contributes 50% of their genome to the progenies
- How about three?

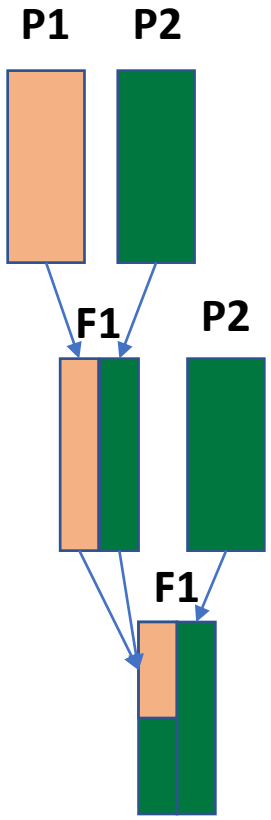
Two and three ways crosses

Top cross



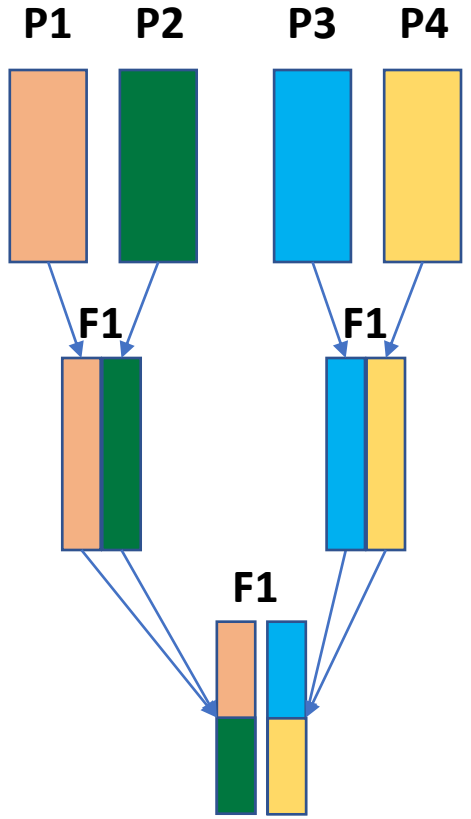
P1 & P2 > 25%
P3 > 50%

Back cross



P1 > 25%
P3 > 75%

Four ways cross



P1, P2, P3, & P4 > 25%

Two and three ways crosses

- When would you use a 2 ways cross for?
- A top cross?
- A back cross
- A four ways cross?

Two and three ways crosses

- What changes in term of genomic contribution if we make the new cross in F2 or F3, instead of F1?
- Why would it be better / worst?

Pedigree: rules to follow

Pedigree Format

A standardized recording system is used for crosses made in the Bread Wheat Program. If parent A is pollinated with parent B and the F1 is pollinated with parent C, its pedigree would be designated as A/B//C. Subsequent crosses with parental materials D, E, F, and G used as males are indicated using a number in the following fashion:

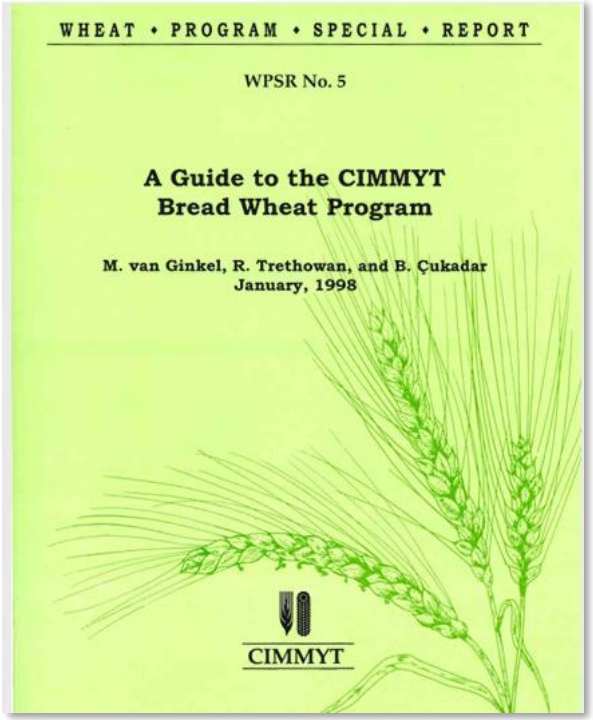
A/B//C/3/D/4/E/5/F/6/G

The female is designated by listing it first (on the left) followed by the pollen parent (on the right). Thus, A is the female parent and B the pollen parent in the first cross. The line A/B is the female and C the male parent in cross two, etc. Thus, if subsequent parents (C, D, E, F, and G) would have been crossed alternately as female and then as male, rather than always as a male as in the first example, that cross would have been denoted as follows:

G/6/E/4/C//A/B/3/D/5/F

Backcrosses are designated with an asterisk (*) and a number indicating the dosage of the recurrent parent. The asterisk and the number are placed next to the crossing symbol that divides the recurrent and donor parents. The following are examples involving backcrosses:

- A is the recurrent parent: A*2/B
- B is the recurrent parent: A/3*B
- A/B is the recurrent parent: A/B*4//C/D
- C/D is the recurrent parent: A/B//5*C/D



Pedigree: rules to follow

Ouassara1//Terbol975/Geruftel2

1. Ouassara1 male/female, ratio of genomic contribution?
2. Terbol975 male/female, ratio of genomic contribution?
3. Geruftel2 male/female, ratio of genomic contribution?

Pedigree: rules to follow

Plc/Ruff//Gta/Rtte

1. Plc male/female, ratio of genomic contribution?
2. Ruff male/female, ratio of genomic contribution?
3. Gta male/female, ratio of genomic contribution?
4. Rtte male/female, ratio of genomic contribution?

Pedigree: rules to follow

Ouassara1/3/Korifla/AegSpeltoidesSyr/3/Amedakul

1. Ouassara 1 male/female, ratio of genomic contribution?
2. Korifla male/female, ratio of genomic contribution?
3. Aeg speltoides male/female, ratio of genomic contribution?
4. Amedakul male/female, ratio of genomic contribution?

Pedigree: rules to follow

Ouassara1/3/Korifla/AegSpeltoidesSyr/3/Amedakul

1. Ouassara 1 male/female, ratio of genomic contribution?
2. Korifla male/female, ratio of genomic contribution?
3. Aeg speltoides male/female, ratio of genomic contribution?
4. Amedakul male/female, ratio of genomic contribution?

Pedigree: rules to follow

Bicrederaa1/Azeghar2//Icajihan25/3/Korifla/AegSpeltoidesSyr//Amedakul

Mrb3/Mna1//Ter1/3/ICAMORTA0459/Ammar7/4/Beltagy2/5/Korifla/AegSpeltoidesSyr//Amedakul

Mrb3/Mna1//Ter1/3/ICAMORTA0459/Ammar7/4/Beltagy2/5/MorlF38//Bcrch1/Kund1149/3/Bicrederaa1/Miki

Bezaghras*3/3/Mrb5/TdicoAlpCol//Cham1

Secondroue/3/2*Amedakul1/TdicoSyrCol//Loukos

Conclusion lecture 1

- The genetic gain equation drives all breeding decisions
- There are four major steps in breeding
- Parental selection can not be blind
- The definition of the goals (PP) is critical to decide breeding and pre-breeding decisions
- Different crossing schemes offer specific advantages
- Pedigree recording is critical to follow genomic contributions