WHEAT BREEDİNG METHODOLOGY

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Introduction

- Population growth, climate change and unsustainable use of natural resources have already a negative impact on food security in some regions of the world. In the absence of global commitment to build food systems adapted to climate change and ensuring food security while minimizing greenhouse gases emissions and sustaining our natural resource base, this negative impact is likely to increase and lead to global food shortfall and food price rises in the coming decades, resulting in undernourishment and poverty increase in the world's more vulnerable populations

- Expanded investments in sustainable agriculture to increase agricultural productivity per land area and to avoid losses in productive capacity, as well as promotion of healthier food diets and food waste reduction, are required to avoid an increasing gap between food supply and demand. Given the time lag between research and development and widespread applications, action is required now, both at national and international levels

- Rice, maize and wheat is essential for human civilization. With more than 215 million hectares planted annually, wheat is the most widely cultivated cereal in the world. It is the most important protein source and provides around 20% of global calories for human consumption. With around 130 million tones, annual global wheat trade is higher than that of maize and rice combined. More than 60% of wheat is produced in emerging and developing countries: China and India together produce nearly twice as much wheat as the USA and Russia combined.

- In North Africa and West and Central Asia, wheat is the dominant staple crop and provides 40 – 50% of all calories.
- Stable and reliable wheat production and the maintenance of prices at an affordable level are therefore paramount for global food security and political stability.

- Among the major staples, wheat is the only crop adapted to low temperatures that can be grown during the cool season, giving it a unique position in many important rotations with rice, cotton, soybean or maize.
- Farmers cultivating millions of hectares in developing and developed countries have no alternative to wheat as winter crop that can be economically efficient and that simultaneously provides a major dietary component

- While wheat is originally the most cold and drought tolerant crop among the major staple crops, it is unfortunately also the most sensitive to high night and day temperatures. Wheat yield models indicate that a 1°C temperature increase reduces yield potential of wheat by 10% in some parts of the world and that the wheat producers in South Asia and North Africa will be hit hardest by climate change. Experts from the Intergovernmental Panel on Climate Change (IPCC) report that an average temperature increase of 1.5-6°C by the end of this century is likely and the World Bank estimates that we are barreling down a path to heat up by 4°C if the problem of climate change is not tackled aggressively now.

- By 2050, scientists project that the world’s leading wheat belts: the U.S. and Canadian Midwest, Europe, Northern China, South Asia, Russia, and Australia–could experience, up to every other year, a warmer summer than the warmest one now on record. Wheat yield in 2050 could decline down to 27% compared with 2000 in some regions, reports the International Food Policy Research Institute (IFPRI), unless swift action is taken to limit temperature rise and develop crop varieties

- Considering that wheat production needs to be increased by around 60% by 2050 to meet the demand of a growing population with a changing diet, the challenges for wheat breeders and growers are tremendous. Current global investments in wheat improvement are too small to address these challenges properly. The main objective of the Wheat Initiative Network is therefore to co-ordinate global wheat research efforts so that, through international efforts, the progress needed to increase wheat production, quality and sustainability can be achieved, thus contributing to the global efforts towards food security and safety under changing climate conditions.

- Wheat in the world (source FAOSTAT)
- 217 million ha planted , 653 million tones produced and 144million tones traded in 2010 ,

making wheat the most widely grown crop, more than maize and rice combined

- 20,4% of total protein supply, making wheat the most important protein source (2009)
- 18,8% of total energy supply, wheat being second after rice for calories/capita/day (2009) representing 27% of total cereal production
- Oceania 3% Africa 3% Americas 17% Europe 31% Asia 45%
-

BREEDİNG

- **Changing of genetic composition with economically important traits.**
- **Science**
- **Art**

BREEDİNG AİMS

- Improvement of varieties preferred by new customers: Less yield but more income(Quality, New product etc. Small tomato, Water melon cubic shape)
- Resistance to disease
- Tolerance to insect
- Tolerance to stress
- (Cold ,Drought)

Breeder must know

Botanic: taxonomy, Morphology, Sexual production ,

Genetic: chromosome movement and heredity,

Plant physiology : adaptation to heat, drought sustainable fertilizer amounts

Pathology: resistant to disease, plant protection,

Entomology: tolerance to insect and biology of reproduction

Biochemistry: cooking, quality of floor and bread making , malt quality ,

Statistic: Compare varieties and lines in proper way.

Agronomy: To grow variety correctly.

Changes in the plant with Breeding

1- Big plant type

2- Big seed

3- Fast and uniform germination

4-Cereals resistant to shattering and compact spike type

5- Different color on seed and fruit.

6-Lost of unwanted characters (needle hairy parts)

7-Fruits without seed (lemon)

8-Flowers with long and many time opens.

9-Test of food and feed increased.

10-Self pollination increased.

11- Annual planting type increased.

Purpose of breeding

1-High yield

2-Resistance to drought, cold ,disease, insect, salt tolerance

3-High quality; Food for human and feed animal and industrial quality,

4-Uniform reappearing , maturing,

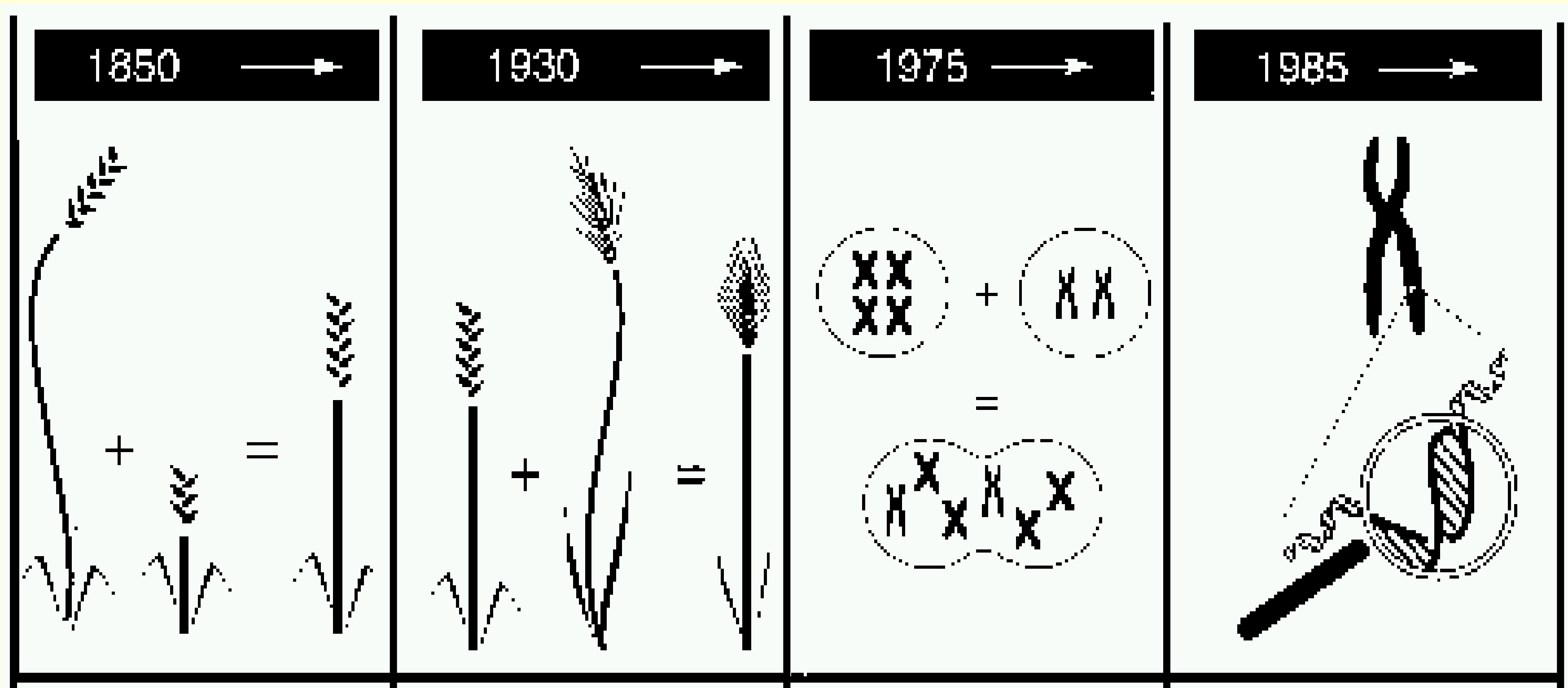
5-Plant type; plant high, hard and erect stem, sheltering, color of seed , number of leaf, tolerance to grazing.

6-Adaptation to soil type .

7- Mechanical suitability (Harvest planting)

8- Suitability to storage and transporting. Carrying.

Improvement of Plant B



Hand Hybridization	Hybrid Between spec.	Cell Fusion	DNA Tecnology

Breeding Methodology

1-**Inroduction**: Bringing from similar place

2-**Selection**; Taking suitable plant from variation

3-**Crossing**; To make hybridization for variation

4-**Poliploidy**; To doubling or multiplying main chromosome number.

5-**Mutations**; Changing chromosome structure by using chemical or atomic radiation.

6- **Chromosome transfer**; carrying chromosome inside a species or between species.

7- **Use of Male sterility**: For hybridization and heterocyst.

SELECTION

Evolution + Plant breeding :Improvement varieties

→

↓

Selection

“ selection of uniform material in side population”

***Selection only possible with genetic variability (different phenotypic and genetic material)**

***Selection can not make variation .**

Selection on self pollinated crops

Homozygote **Heterozygote**

AA, aa **Aa**

Homozygote plant % = $(2^m-1)/ 2^m$

$F_2=(2^1-1)/2=1/2= 0,50=\%50$

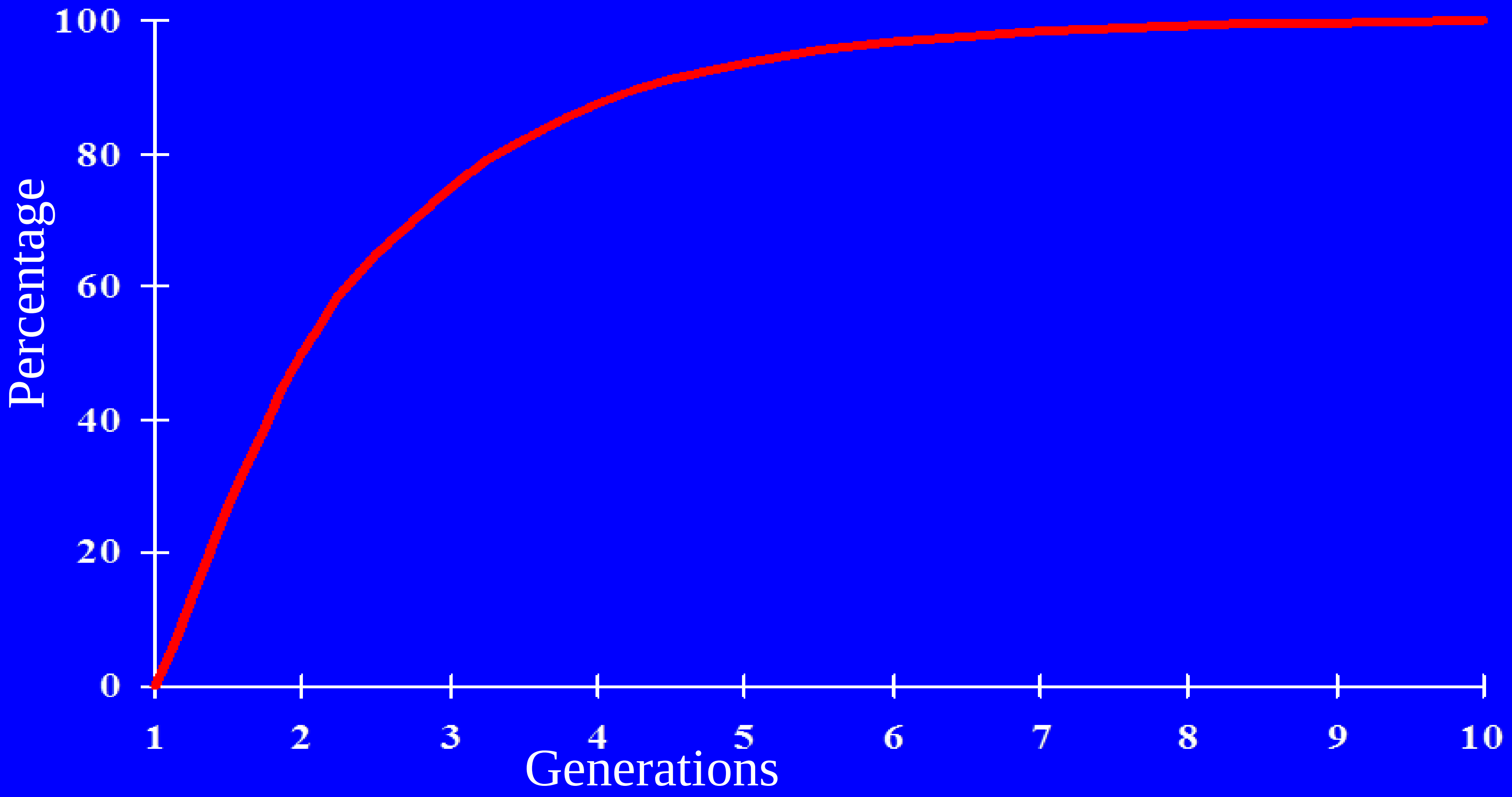
⋮

$F_6=(2^5-1)/ 2^5 =31/32=96.9=\%96,9$

% homozygote plant which has 1, 5, 10, 20 different gene pair

Selfing Generation (m)	Heterozygote gene pair number			
	n=1	n=5	n=10	n=20
1	0.50	0.031	0.001	0.000001
2	0.75	0.237	0.056	0.003
3	0.875	0.513	0.263	0.069
4	0.938	0.727	0.524	0.275
5	0.969	0.855	0.728	0.530
6	**0.984**	0.924	0.854	0.730
7	0.992	0.962	0.925	0.855
8	0.996	**0.981**	0.962	0.925
9	0.998	0.990	**0.981**	0.962
10	0.999	0.995	0.990	**0.981**

% Homozygote Plant



*Recombination of genes

İf parent has different gene the hybrid of it has different gametes and will result in different genotypic and phenotypic plants.

Mandel, Green-Yellow 3:1

Smoot-*Wrinkle* 9:*3*:3:*1*

Wheat has 21 haploid chromosome if each chromosome has 1 different gene after crossing two varieties

in F_2' 10 000 000 000 we can see different genotype.

in F_2' 4.398.046.511.104 different combination just 2 similar to their parents.

BREEDİNG METHODOLOGY IN SELF POLİNATED CROPS

PURE LINE SELLECTİON AND MASS SELECTİON

İN NATURE → mutation, Hybridization=genetic variations

Populations → Single plant homozygote or heterozygote

a) Mass Selection → of suitable plant → total harvest → no sib control → phenotype shows genotype (acceptation)

It is true for qualitative character (Awn , color, plant height)

Wrong for quantitative character (yield and quality) Phenotype can not show genotype.

Generally selection of varieties comes from local populations (Selection earliness ,disease resistance ,drought and cold resistance

Selection of more plants → Increase success.

Negative mass selection → remove unsuitable plants.

Positive mass selection → Take suitable plants .

Dominant gene and heterozygote plant%

homozygote (AA) heterozygote (Aa)

Formula $1/(2^n+2)$

3. Generation (F3) $1/(2^3+2) = 1/10$

This methodology is still used in vegetable and fruit breeding. In field crops can be used for visual selection such as Awn, plant height, spike color etc. (But yield and quality may be difficult ~~to~~ → select and visualize)

Mass Selection

1. **year**- select 300-400 plants with similar phenotype and harvest together.

2. **year**-Make yield trial with standard varieties to compare yield.

3-5. **years**-İf required do yield trial again and take observation and test the quality. Test adaptation to different conditions

6. **year**-Give seed for registration.

İf you wish to make more efficient selection Sib controlled selection is better (1)ı Select 300-400 suitable plant and harvest it separately. (2)Sow each plant separately. (3) Select desirable plant ad Mix all if it is better than original population register it (NEW WARİETY).

Mass selection can also be used for purification of mixed variety. (eg mechanical, mutation, late segregation)

b) Pure line Selection

İn a population there can be many homozygote plants . (Specially in local population or variety)

Select Pure lines from population (Spike or plant) separately. Than make observations and select best lines for agronomic traits and high yielding variety can be chosen. Register new variety.

. Genotypic observation can be seen better than mass selection.

.Can show normal distribution. The difference from median partly comes from environment and genotype.

Self pollinized crops;

1-Autogamic plant population can be used to produce **different genetic homozygote plants**.

2-With selection you can get **pure lines**. These lines can show **segregation** from original populations.

3-if original material is pure you can’t select different plant so you will not have any success.

Methodology of pure line selection:

1. year Local populations seeds are observed and best seeds are planted A sib is grown.
2. year A sibs are planted in row (each plant's seed planted seperately1-2 m 500-1000 entries). Visual observation can be taken (for cold tolerance, Maturity , tolerance to lodging , Resistance to disease etc.). After observation discard %10-20 entries . The selected plants are harvested separately these are B sibs.
3. year B sibs can be used for micro yield trials. Than observation can be taken. According to yield and observations % 20-30 plants are taken for C sibs.

4-5. years C and D sibs are planted as a yield trial and tested in different locations (climatic and soil differences) with more replication .

6. year More yield trials can be done and seed production can start.
7. year The best line or lines can go to candidate for registration.

Varieties can be mixed with spontaneous mutations or natural hybridization but we can keep the seed pure.

→ Variety maintainance ⇒ Selection from spike and plant

→ Multiline varieties (more than one line) Phenotype is similar genotype is different .

HYBRYD BREEDİNG AND PEDİGREE METHODS

Before, local Variety ⟶ Selection ⟶ Variety

Now, Hybrid ⟶ Selection ⟶ Variety

a)Purpose of breeding

Yield, Disease resistance, Cold tolerance , Resistant to drought, Quality etc.

b) Selection

Local variety X new variety or line with good yield and other desirable traits.

- Third parent can be necessary.

- Materials from other Countries and breeding programs may already have sources of desirable traits

HYBRYD BREEDİNG AND PEDİGREE METHODS

Plant selection starts at F_2' in pedigree breeding.

Observe each plant, one by one and take notes of yield disease, cold tolerance, drought resistance, plant type, etc.

In F2' you may not see desirable plant types, in F3' "good" types can be easily detected

Mono-factorial > homozygote recessive 1/4

Bi-factorial > homozygote recessive 1/16

Tri-factorial >homozygote recessive 27/64

Tetra-factorial > homozygote recessive 81/256

Formula: $(3/4)^n$ n:factor number

F_2' $(3/4)^2$=%56 F_{10} $(3/4)^{10}$=%6

during the selection if you can decide selecting 2 plants you must select plants which originate from different parents.

Bulk (Population) Methods

In bulk method until F5 you cannot do any selection (natural selection disease, cold, drought, vernalization daylight sensitivity)

when plants become more than 98% homozygote (F6-F10 generations) selection can be done.

Until F6 generation all seeds are harvest and plant for next generations are harvested again. In F6' generation homozygote plants are grown separately and these plants cannot segregate. From each family different number of plants are sown and each one is compared with check varieties to select best plants for next generation.

- **Bulk method is cheaper and easy than the Pedigree method.**
- **Data record and observation are reduced 10 fold as compared to the pedigree breeding method.**

Competition capacity in Bulk Method

P and Q two different populations

↓ ↓

W_p and Q_q sibs number two parents (1.0, 0.9)

The % of W and Q populations next generations.

$P_{n+1}=W_pP_n/T$ T= correction factors

P_1=1.0,5/T= 0,5/(0,5+0,45) = 0,526 P Type plants

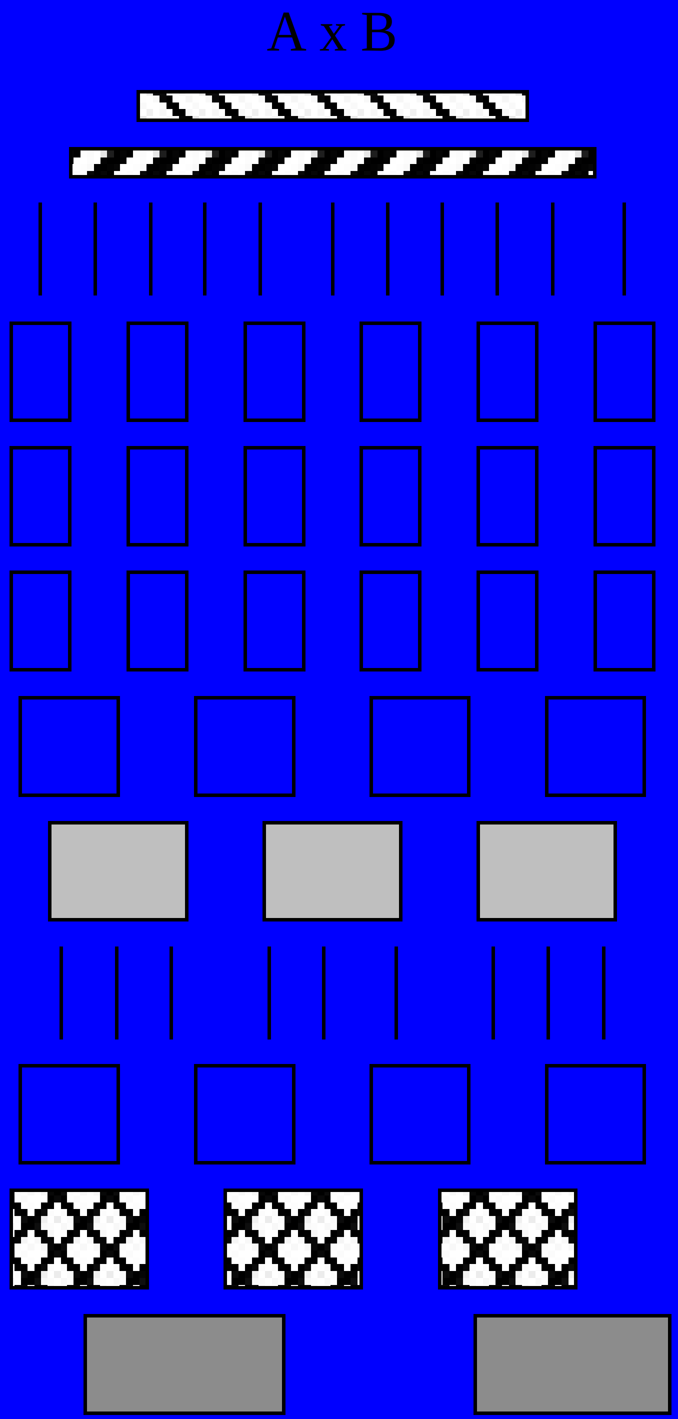
- P_1

Q_1=0,9.0,5/T= 0,45/(0,5+0,45) =0,474

P_2'de 0,5525 P_3=0,5784 P_4=0,6039

if W_p=1 Q_q=0,5 ,

$P_{1=}$0,67 P_2 =0,80 $P_{3=}$ 0,89 P_4 =0,94 .



Hybridizations parent

F_1 **F_1 grown as a population**

F_2 **From F_2 5000-1000 elite plants selected.**

F_3 **A sibs (from 5000-1000 elite plants sib)**

F_4 **Best 100-500 F_3 sibs are used for populations.**

F_5 **Partly selected populations grown as a bulk .**

F_6 **Partly selected populations grown as a bulk (in different locations)**

F_7 **Best 100-200 populations taken for yield trial.**

F_8 **The best 15- 20 populations shown separately and select 100 elite plants from each one.**

F_9 **A sibs from each 100 populations planted in a different plot.**

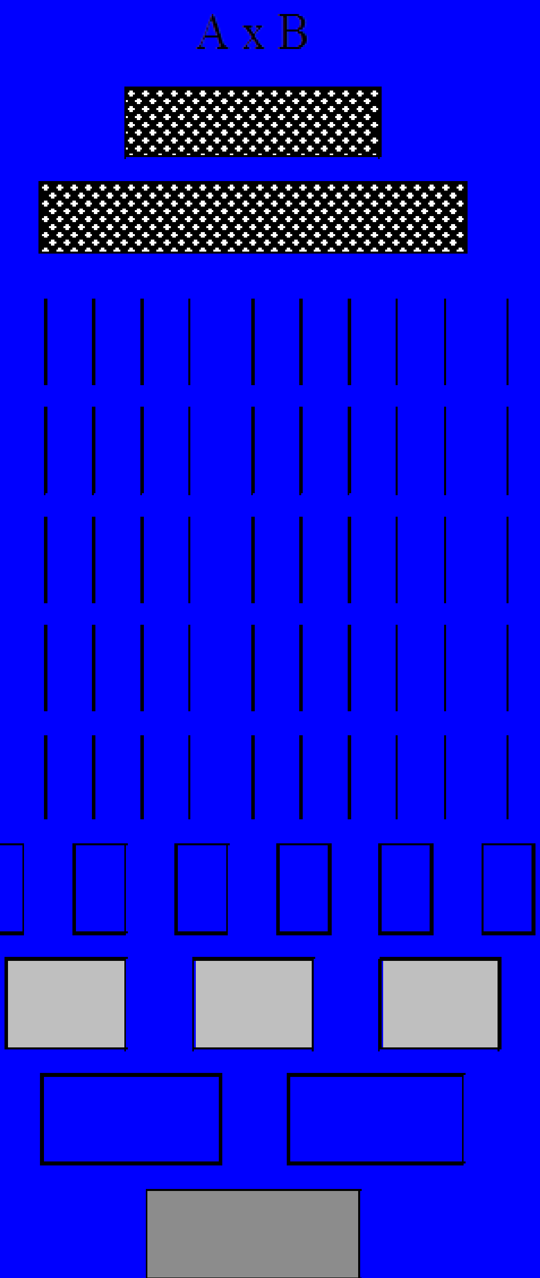
(20 x100 =2000) or (15x100=1500)

F_{10} **selected 100 best A sibs and plant a yield trial and get B sibs.**

F_{11} **C Selected around 20 b sibs and planted as a C sibs for yield trials.**

F_{12} **selected C sibs are taken for D sibs shown in different locations.**

Partially populations Methods



Crossing A x B variety

F_1 F_1’ production

F_2 10.000 F_2 plants shown , 1000 elite plant select .

F_3 Select 1000 A sib from 1000 F_2 elite plant.

F_4 Select 1000 A sib from 250 F_2 elite plant.

F_5 Select 1000 A sib from 100 F_2 elite plant.

F_6 Select 1000 A sib from 75 F_2 elite plant.

F_7 Select 1000 A sib from 50 F_2 elite plant.

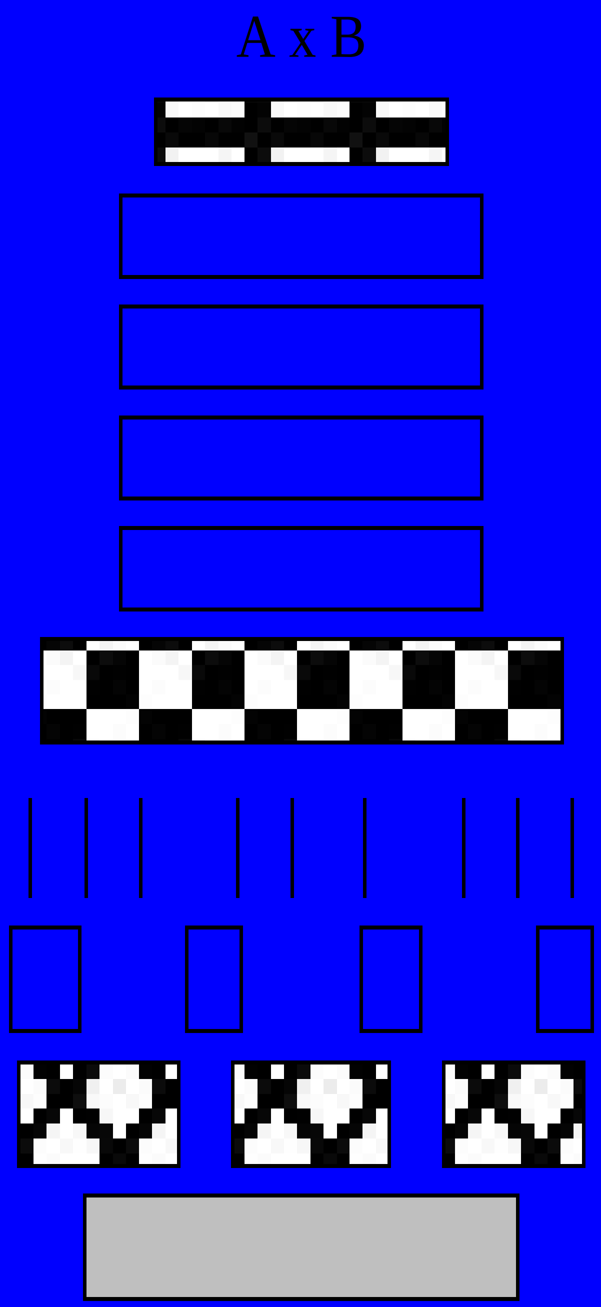
F_8 Select 250 B sib from 10 F_2 elite plant. (micro yield trial)

F_9 Select 50 C sib from 10 F_2 elite plant.

F_{10-11} Multi location yield trial on the selected lines.

F_{12} Best lines select for registration.

Pedigree Selection Methods



F_1 F_1 production

F_2 Population production

F_3 Population production

F_4 Population production

F_5 Population production

F_6 Elite plant selection (not row planting)

F_7 Seed of selected 250 plant sown (row planting) (A Sib)

F_8 Yield trial with B sibs.

$F_{9\text{-}11}$ Multi location yield trial, with B sibs

F_{12} Production of seed and registration

Bulk (Population) Method

CRİFC Wheat breeding   Diagram

AXB (Cross)

F1

F2 Bulk

F3 Bulk(Disease)Leaf steam rust (Stress)Heat Cold Drought micro Quality

F4 Bulk

F5 Spike

PYT Bulk(Disease)Leaf steam rust (Stress)Heat Cold Drought Quality and Yield

FIRST YEAR Y. T. Disease Yield micro quality

ADVANCE Y.T. Disease macro quality yield,

REGİONAL Y.T. Disease   stress test macro quality yield

CANDİDATE FOR REGISTRATION

CROSSİNG

Data record and observation are reduced 10 fold as compared to the pedigree breeding method

We need to know, disease, quality and stress response of parent lines in advance. Inheritance or heritability of traits to sib is also very important

Local x Local (100% Local)

Local x Introduced (50% Local)

(Local x Introduced) x Local (75% Local)

How much Earliness ?

How much Resistant to cold?

How much Resistant to cold and drought ?

How much tolerant to which disease?

Which insect Tolerance?

Daylight sensibility or insensibility ?

End-use product (Breed, Biscuit, Cake, Cereal , bulghur, Pasta)

Crossing Type

- Simple cross AxB
- Reciprocal cross AxB and BxA
- Triple cross AxB F1xC
- Back cross AxB F1x A or F1xB
- Double AxB CxD
- F1 x F1
-

Writing crossing data

- **A/B A/B//C A/B//C/D A/B// C /3/ D/E**
- **Tosunbey; EÇVD-12/KRÇ-66//CROW 'S'**
- **YA20688-0A-0A-0A-0A-9A-0A**

Eser; AGRI/NAC//LIRA

YA21269-0A-0A-0A-4A-12A-0A

Kızıltan-91 ÜVY 162/61-130//BYE*2/TE

YA03912 0A-17A-1A-3A-0A

Data on Crossing paper bag

Emasculation date 21 May

Emasculators name

Mather plant number or name.

Father plants number or name.

Crossing notebook

Registration number   YA 20688-0A-0A-0A-9A-0A

Registration code of foundation. YA00001

Crossing block data

F2 – F5 Segregation material data

Preliminary yield trial and yield trial data

Disease data , Quality data

Data for registration,

Breeder right data ,

Data for seed certification

Breeder seed: pre-basic/basic seed

Good breeder??

Good observer,

Medium intelligence(s)

Patience

HARD WORKER

Lucky.

- Breeder must know genetics/inheritance of characters.

- Genotype environment interaction is very important. Without adequate environmental condition selection will be wrong.

- Some characters (genes) can not show any difference in different environmental conditions. Color
- Shape
- Some characters can influence from Environment (yield plant height)
- These are Quantitative and control big group of genes.

Data for Crossing Block

- Entry number of crossing block 20
- Cross data Csm/ Grk 79 (Bayraktar)
- Pedigree YA 19484-0A-0A-2A-0A
- Origin 1991 ÖVD 125(OREGON/TUR)
- Leaf rust 30ms mr Avn: + -Long with teeth
- Stem rust 0 Yield: 2.4 -3.2 t/ ha
- Puccinia 0 Plant type: Erect/prostrate
- Plant height: 93, 95 ,98..Leaf : Small thin leaf/big tick leaf
- Damage of Sun pest little/big

Data for Crossing Block

Growing type. 2 (1-5) (1-10)1winter/spring (rosette/erect)

Date of spike emergence; 18/5, 17/5 ,24/5

Color of Spike White, Brown , red Black

Color of grain White, Red Ambar

Protein 12.8 11.9 13.1 Sds.27, 25,30

1000 Kernel Weight 34, 32, 28,

Hectoliter Weight 75,73,72

- Yield, Cold resistance, Resistance to lodging and quality.
- İs important agronomic characters controlled by many genes on many chromosomes.
- Color of awn , color of grain leaf controlled by less genes and simple heritance.

……………..!

Thank you
.TEŞEKKÜRLER