Breeding options and their future for organic production

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INDUSTRIALISED AGRICULTURAL SYSTEMS

- monocultures characterised by a lack of abiotic and biotic diversity

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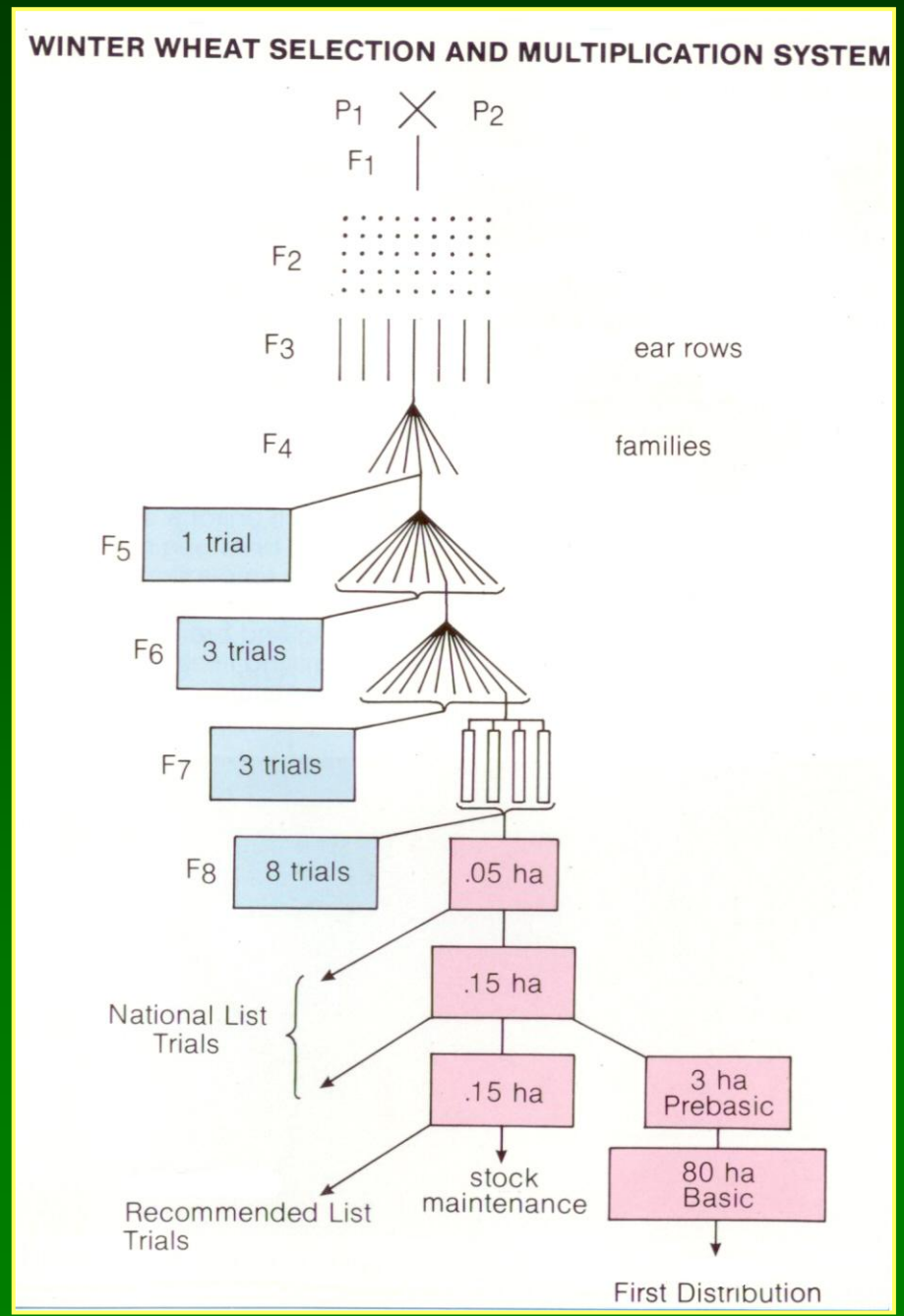
Weedy Winter Wheat

LOW INPUT SYSTEMS - characterised by abiotic and biotic diversity

PEDIGREE LINE BREEDING

- Reliant on choice of P1 and P2.
- Breeder selection of traits.
- Generally narrow and idiosyncratic genetic base.



Monocultural demands of P1 and P2 and selection criteria.

Crop characteristic	Corresponding features of P1 and P2 and subsequent selection criteria
Intense competition within the crop	Capacity to accept crowding
Capacity to respond to high fertility	Little increase in the mutual competition among plants as they respond to fertiliser
All controllable factors ameliorated so use light to the best advantage	Effective disposition of the foliage for the utilisation of light
High harvest index	Only a part of the crop is of significant value

Therefore the pedigree line breeding approach is most useful when traits are easily defined and parents are easy to identify.

Achieved by concentrating on the use of fundamental resources without too much concern about variability in those resources and interactions with other organisms that alter access to those resources

- Light
- Water
- Nutrients
- CO_2

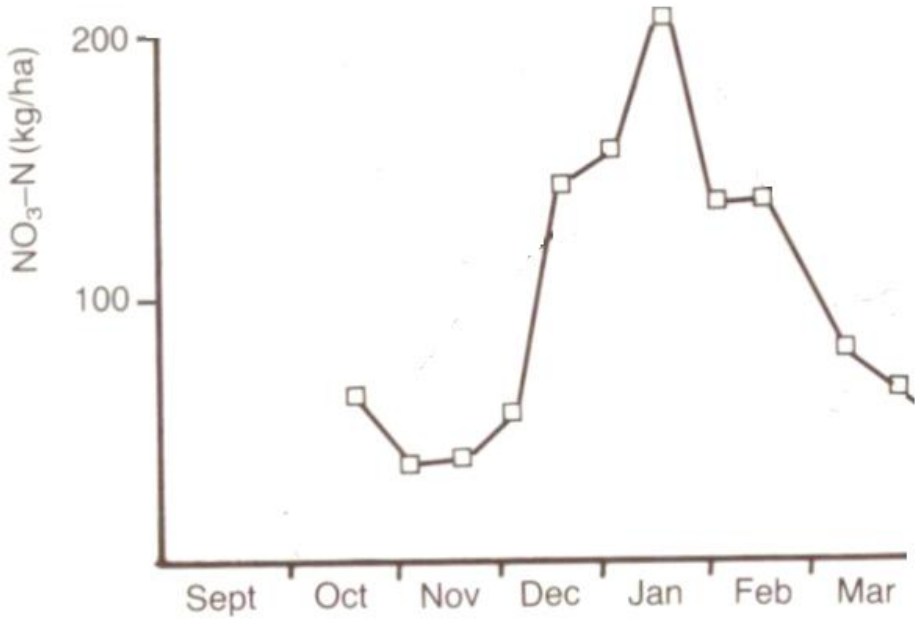
… But organic systems are characterised by abiotic and biotic diversity!

Abiotic and biotic interactions

Abiotic - nutrient availability and dynamics

Biotic - interactions with weeds, pests and diseases

Abiotic x Biotic!!



A heterogeneous crop of a single species – variety mixtures

Hereward/Malacca/Shamrock

But we are currently reliant on mixing varieties bred using the pedigree breeding system selected for monocultural use.

Is high yield in monoculture related to competitive performance in mixtures?

However, even with inappropriate varieties, variety mixtures show **ecological effects**:

- Complementation
- Compensation

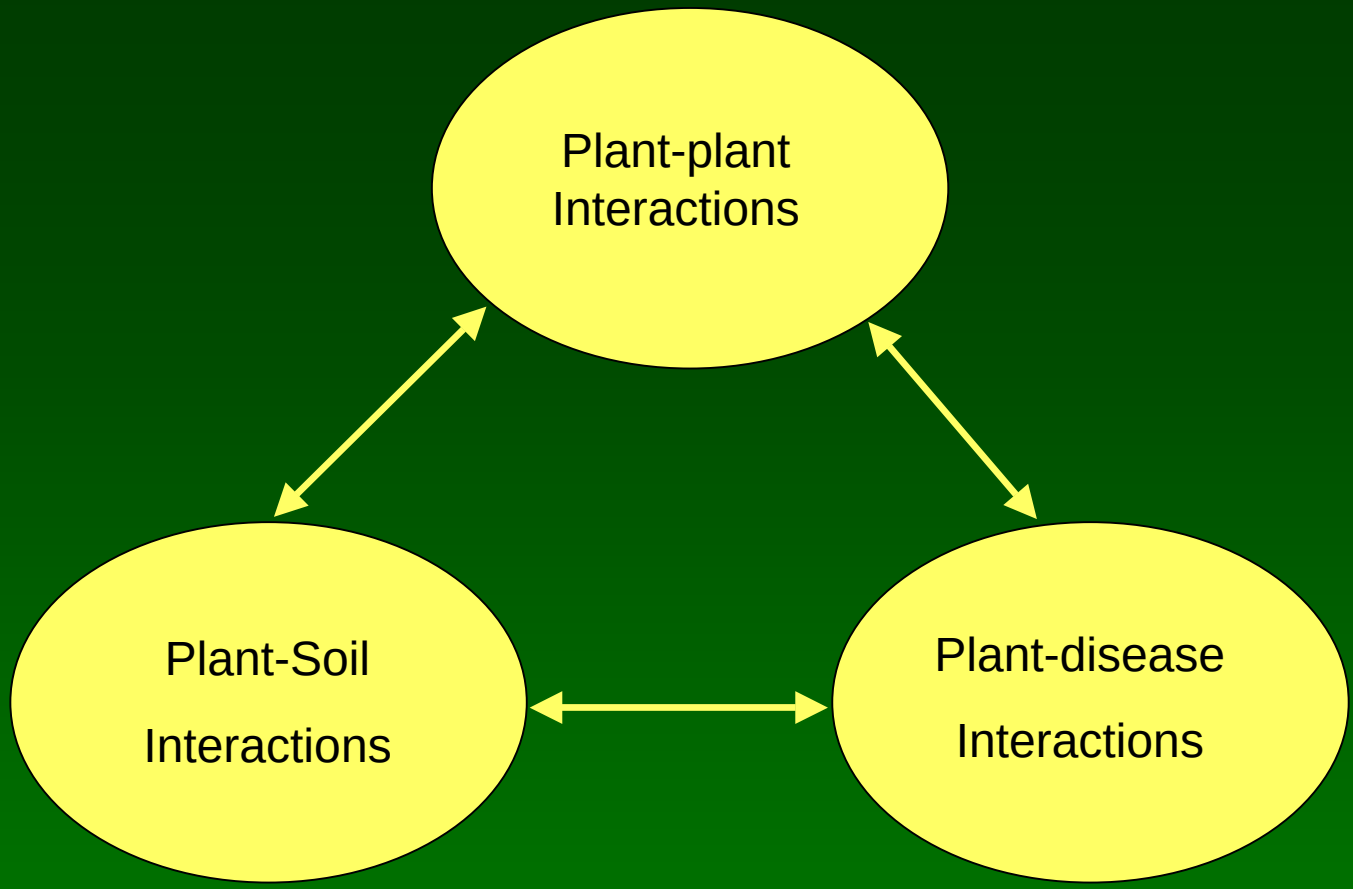
And **epidemiological effects**:

- Barrier effects
- Induced Resistance
- Dilution of susceptibles

Selection of pure lines for good ecological combining abilities:

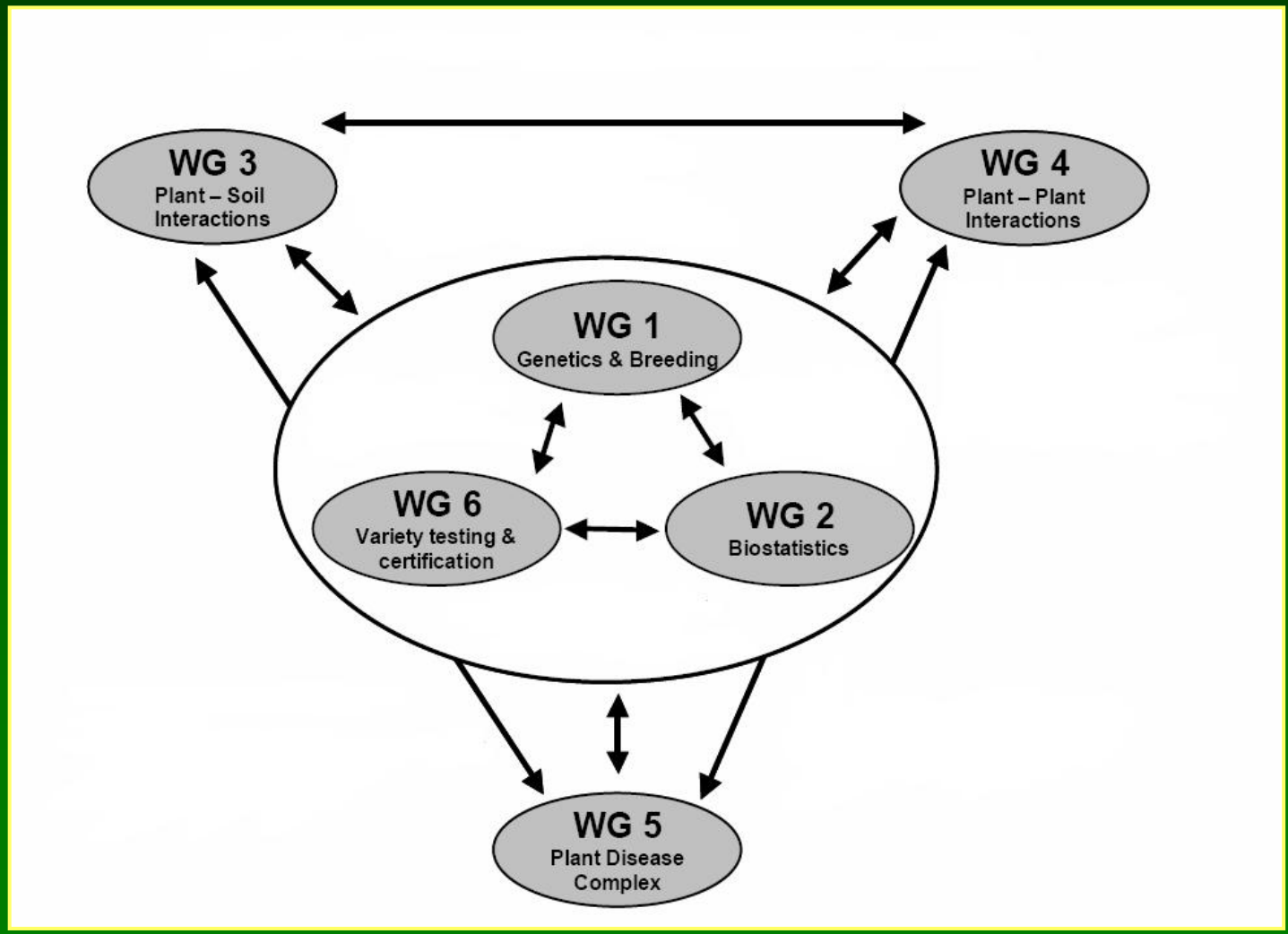
Passive Approach – one component in all possible binary combinations: **General Combining Ability**

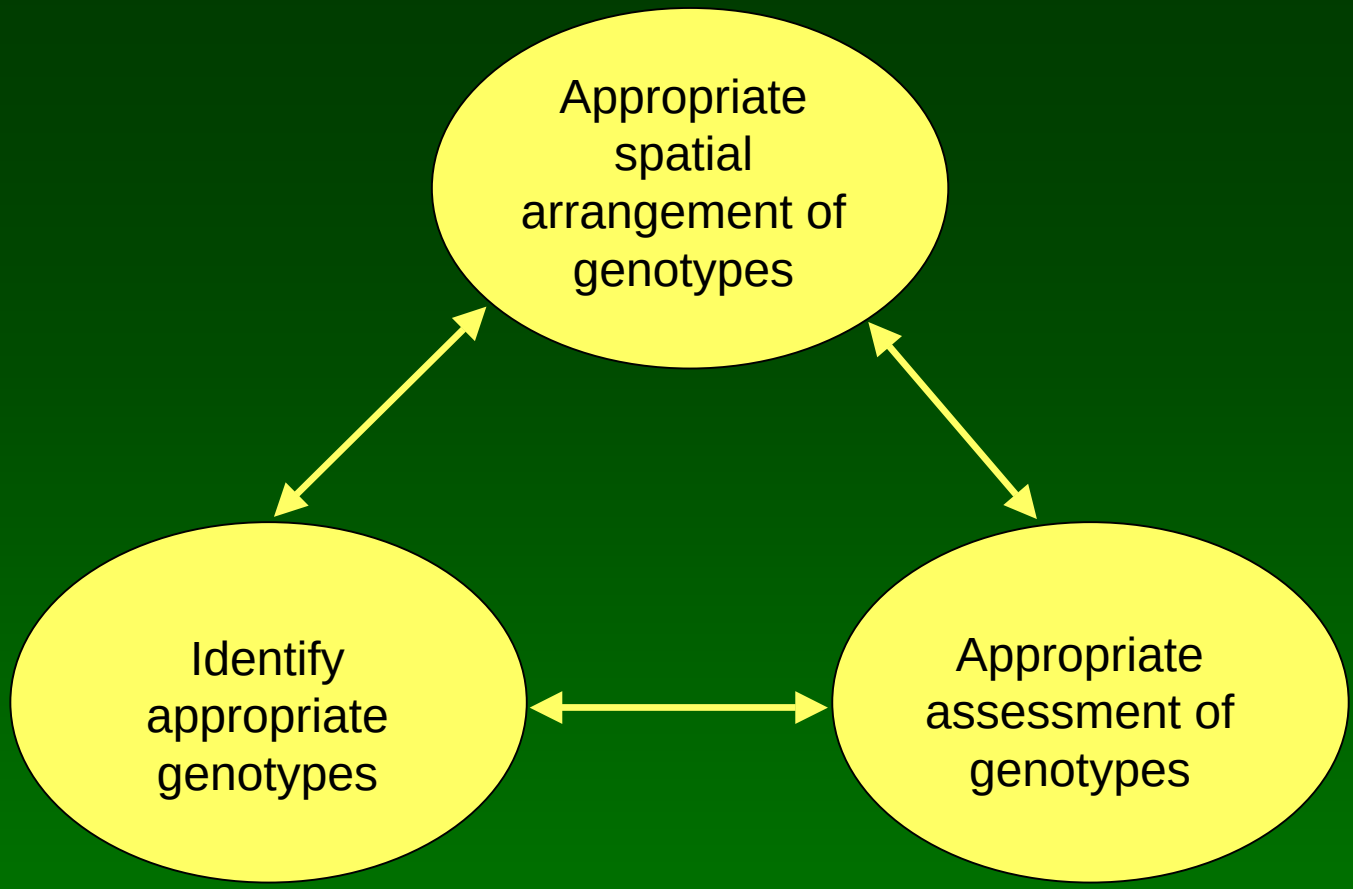
Active Approach – alternate cycle of ‘tester’ and ‘tested’: **Specific Combining Abilities**



Complex abiotic and biotic interactions in organic systems are therefore buffered by cropping heterogeneity

A systems level view of breeding approaches, closely linked to the spatial arrangement of that material and appropriate testing of that material



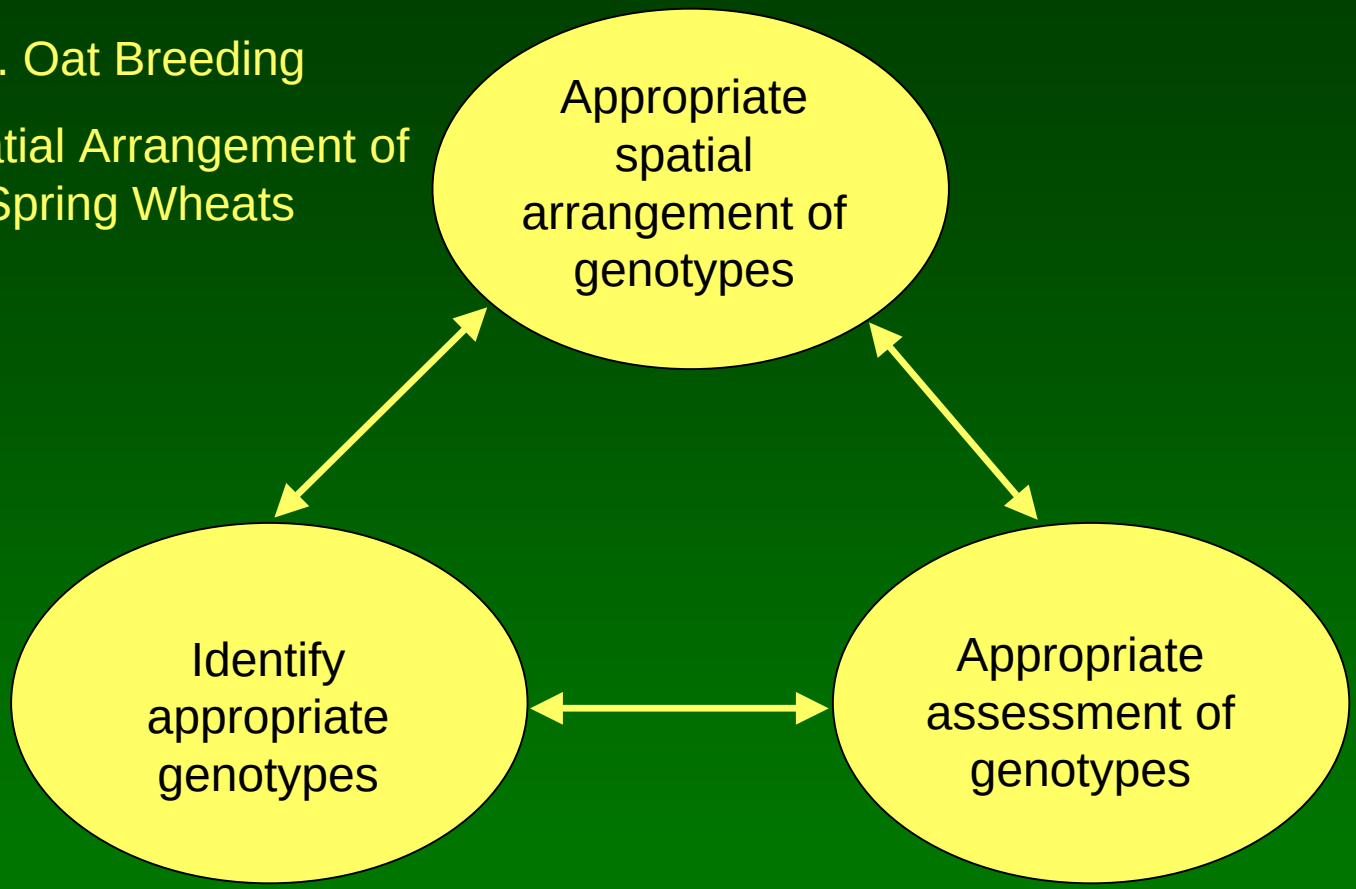


Systems level biology for organic systems must not operate separate from agronomic/socio-economic factors

EFRC Cereals Research Programme

3. Oat Breeding

4. Spatial Arrangement of Spring Wheats



1. Wheat Breeding

2. Oat Breeding

5. Participatory Variety Trials

6. System Level Genotype Assessment

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Wheat Breeding attempting to integrate:

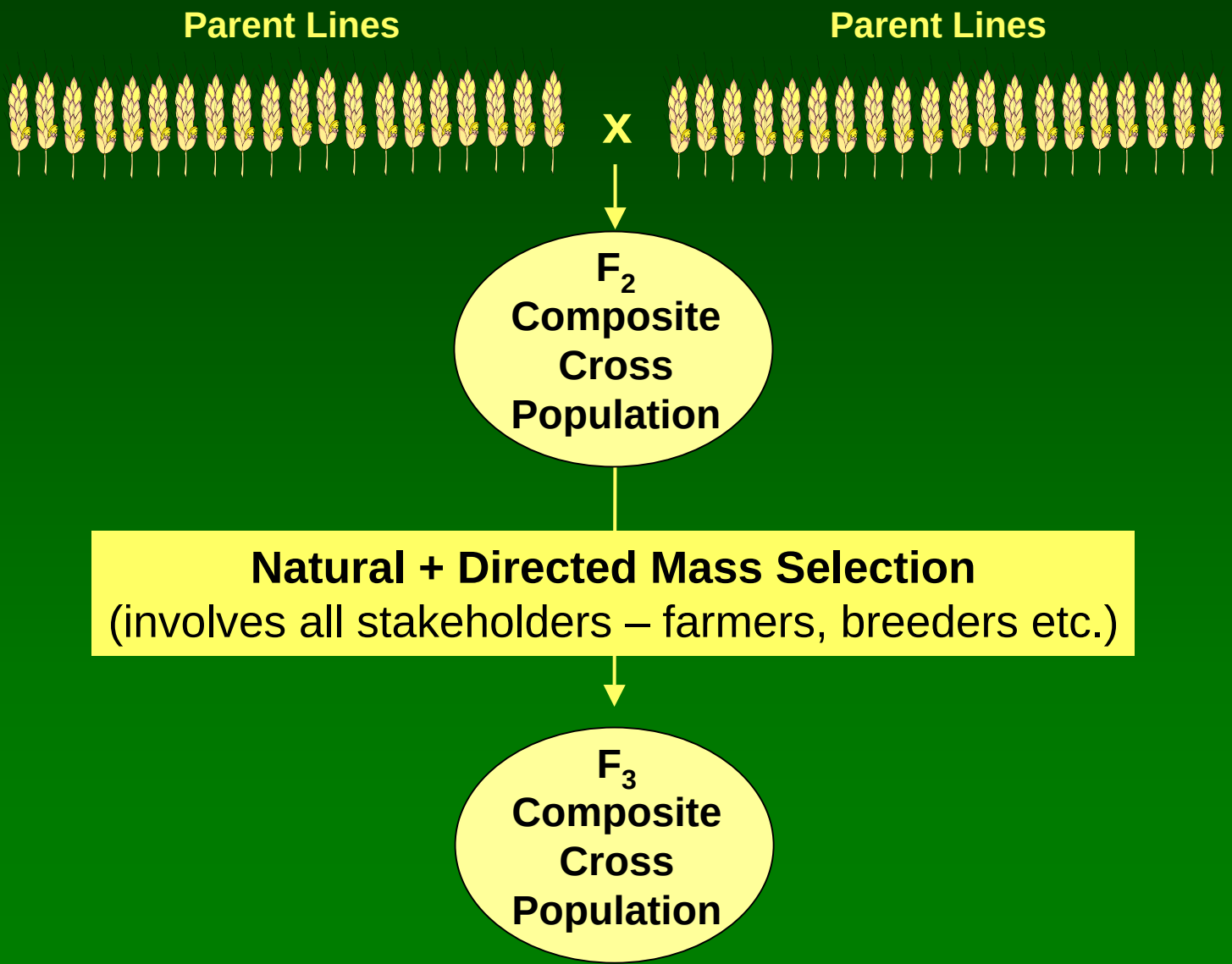
(1) ecology,

(2) epidemiology and

(3) evolutionary biology, as nature does (!),

By adopting an **evolutionary approach to plant breeding**

Composite Cross breeding process



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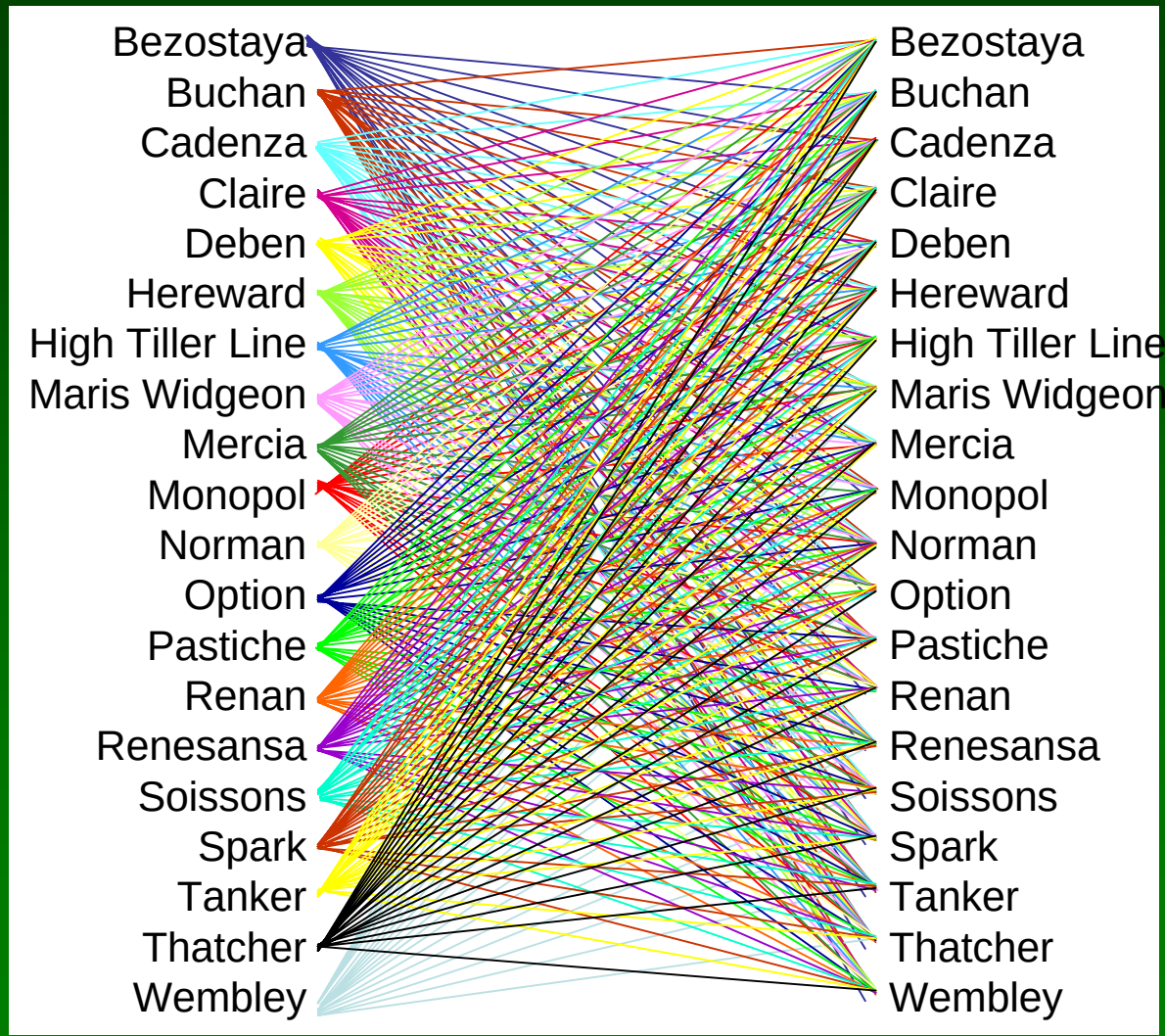
Selection of parent lines

High Yield Potential	High Quality Potential
1 Bezostaya	1 Bezostaya
2 Buchan	2 Cadenza
3 Claire	3 Hereward
4 Deben	4 Maris Widgeon
5 High Tiller Line	5 Mercia
6 Norman	6 Monopol
7 Option	7 Pastiche
8 Tanker	8 Renan
9 Wembley	9 Renesansa
	10 Soissons
	11 Spark
	12 Thatcher

+ 4 male sterile lines

Production of 190 Cross Combinations



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Composite Cross Populations

High Yield Population

High Quality Population

High Yield & Quality Population

High Yield Population + HMS

High Quality Population + HMS

High Yield & Quality Population + HMS

Yield Composite (Growth stage 65)

Wakelyns (organic)

Metfield (conventional)

Morley (conventional, CSS)

Summary

- Organic systems are characterised by abiotic x biotic diversity
- Cropping heterogeneity is one way to buffer for abiotic x biotic diversity
- Varieties derived for monoculture may not be appropriate for heterogeneous cropping systems
- The pedigree line breeding approach may be not well suited to systems level selection.