

PLANT BREEDING FOR AGRICULTURAL DIVERSITY

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The importance of biodiversity for ecosystem dynamics and structure

• Greater number of terrestrial plant species can lead to greater ecosystem productivity and resource use

• Greater diversity can lead to greater ecosystem predictability and temporal stability



Tilman et al. Cedar Creek Biodiversity Experiment, Minnesota.



(Agro)Ecosystem Services:

The productivity and stability of ecosystems is important because agroecosystems need to:

- 1. Provide services to support agricultural production
- 2. Provide services that contribute directly to the quality of life of humans
- 3. Provide services that contribute towards global life-supporting functions



... Therefore should aim to maintain and increase agrobiodiversity, but monoculture dominates modern agricultural ecosystems





Wheat Ideotype Design for Monoculture

Crop characteristic	Corresponding features of crop ideotypes
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

After Donald, (1968)



Wheat Ideotype Design for Monoculture





A heterogeneous crop of a single species – variety mixtures



But we are currently reliant on mixing varieties bred using the monocultural ideotype



However, even with inappropriate varieties, variety mixtures show (1) ecological effects:

- Complementation
- Compensation

And (2) epidemiological effects:

- Barrier effects
- Induced Resistance
- Dilution of susceptibles



Heterogeneity also provides (3) evolutionary dilemmas



After Priestly, 1978

In mixtures –

Pursue maximum success on any one component?

Or

Attack as many components as possible?



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**



The neo-Darwinian view of the process of evolution:
(1) The initial generation of variability
(2) Recombination
(3) Differential reproduction
(4) Isolation in space and time

Evolutionary plant breeding repeatedly harnesses all four stages of the evolution process Suneson (1956)



Composite Cross breeding process





Selection of parent lines

High Yield Potential High Quality Potential

- 1 Bezostaya
- 2 Buchan
- 3 Claire
- 4 Deben
- 5 High Tiller Line
- 6 Norman
- 7 Option
- 8 Tanker
- 9 Wembley

- 1 Bezostaya
- 2 Cadenza
- 3 Hereward
- 4 Maris Widgeon
- 5 Mercia
- 6 Monopol
- 7 Pastiche
- 8 Renan
- 9 Renesansa
- 10 Soissons
- 11 Spark
- 12 Thatcher

+ 4 male sterile lines



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



Adaptation versus Adaptability





However, breeding for agricultural diversity needs:

(1) shifts in legal and administrative frameworks.

(2) appropriate marketing

(3) adaptation of genotypes to particular production systems requires <u>farmer participation</u>