Development of new germplasm for low input environments

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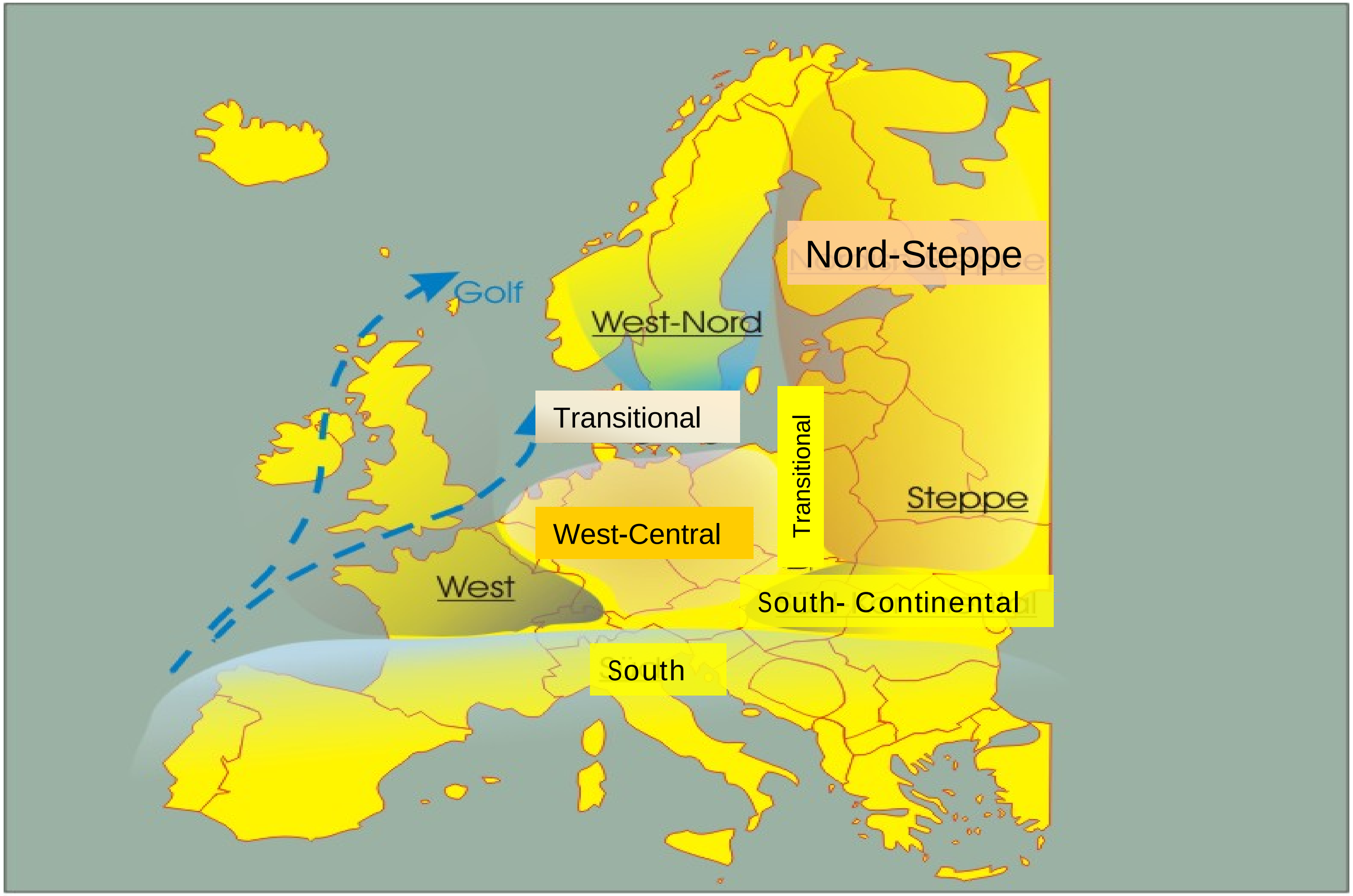
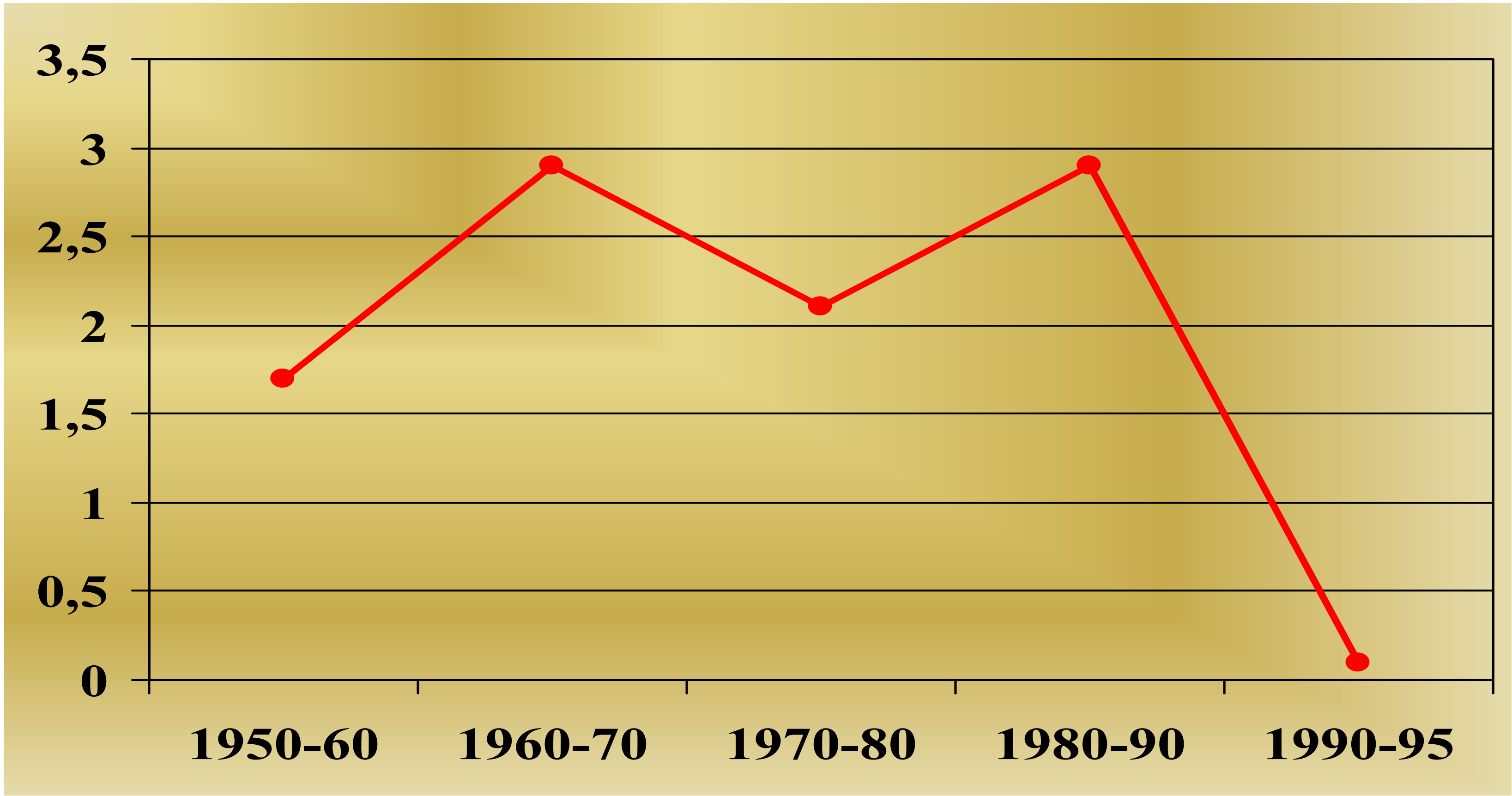
Adaptation map of wheat in Europe
(Feekes 1978)

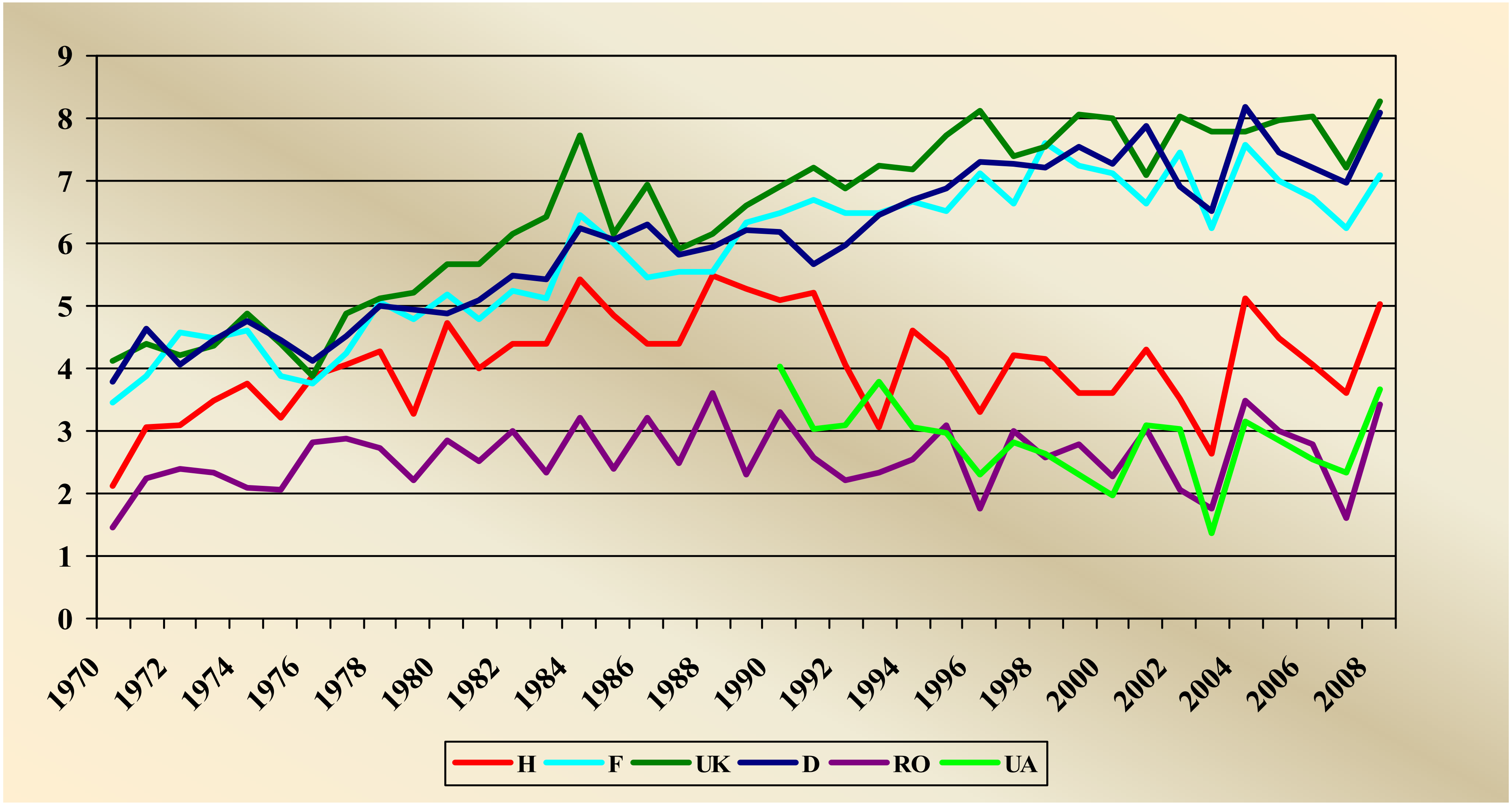


Increase in world wheat production during the second half of the 20th century (%)

(L.R. Braun 1998)

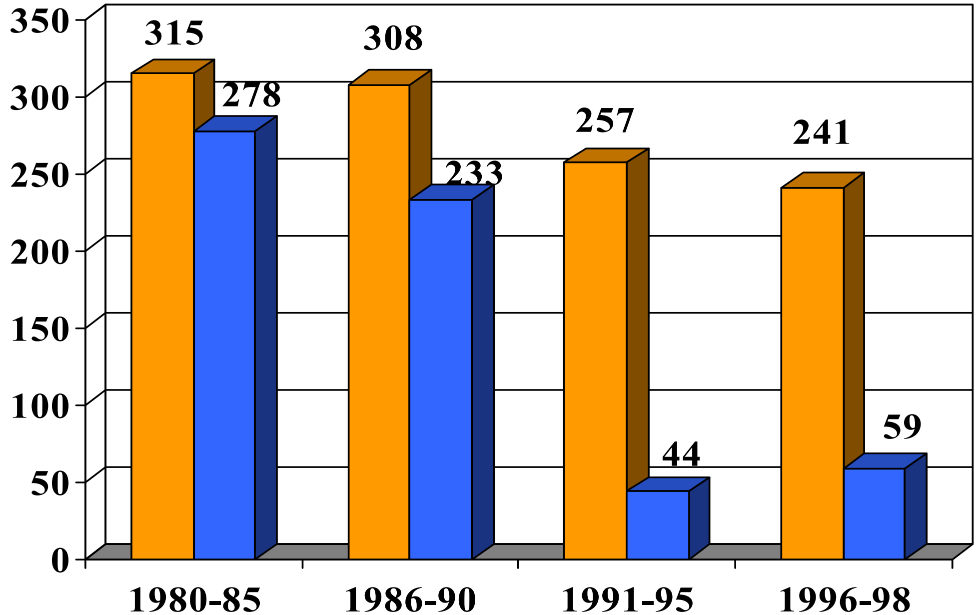


Wheat yield averages in some West- and East-European countries



Main constraints on yield improvement

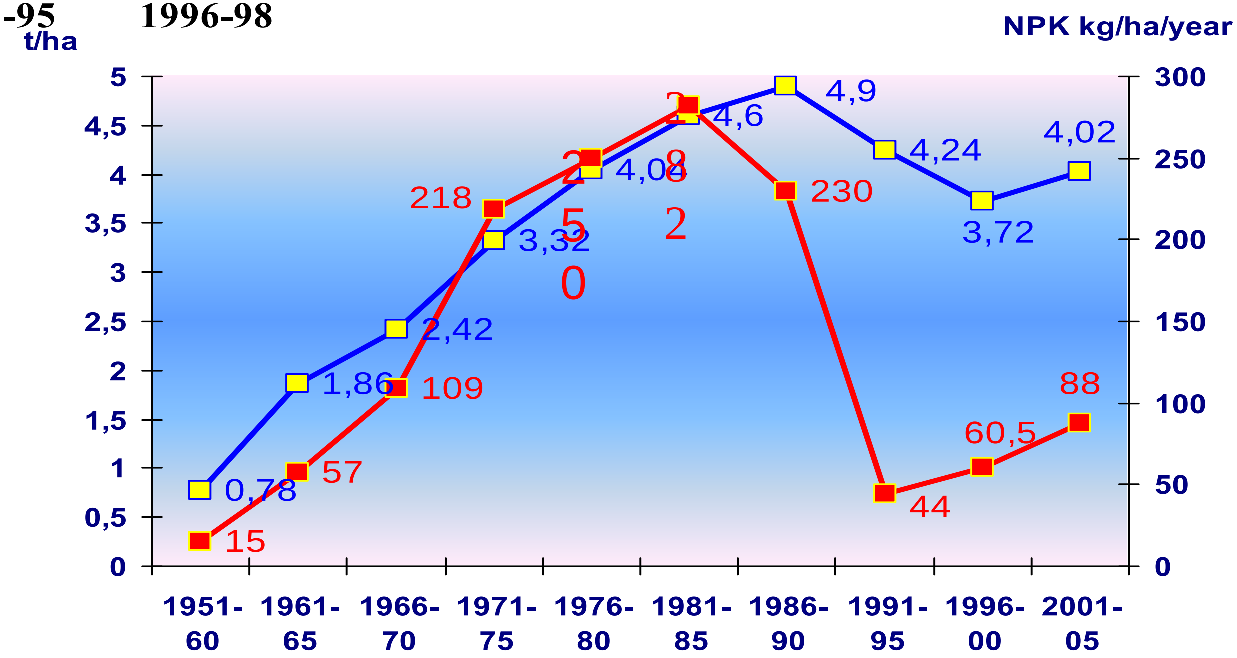
- **Yield versus yield stability**
- **Yield versus breadmaking quality**
- **Yield versus technical input limits**
- **Yield versus agroecosystems**



Low input technological environment

Average mineral fertilizer in EU15 and in Hungary 1980-1998 (kg/ha)

EU 15
Hungary



Changes in wheat yield and the level of fertilizer applied in Hungary *1951-2005*

Note: - red line: amount of fertilizers; - blue line: grain yield

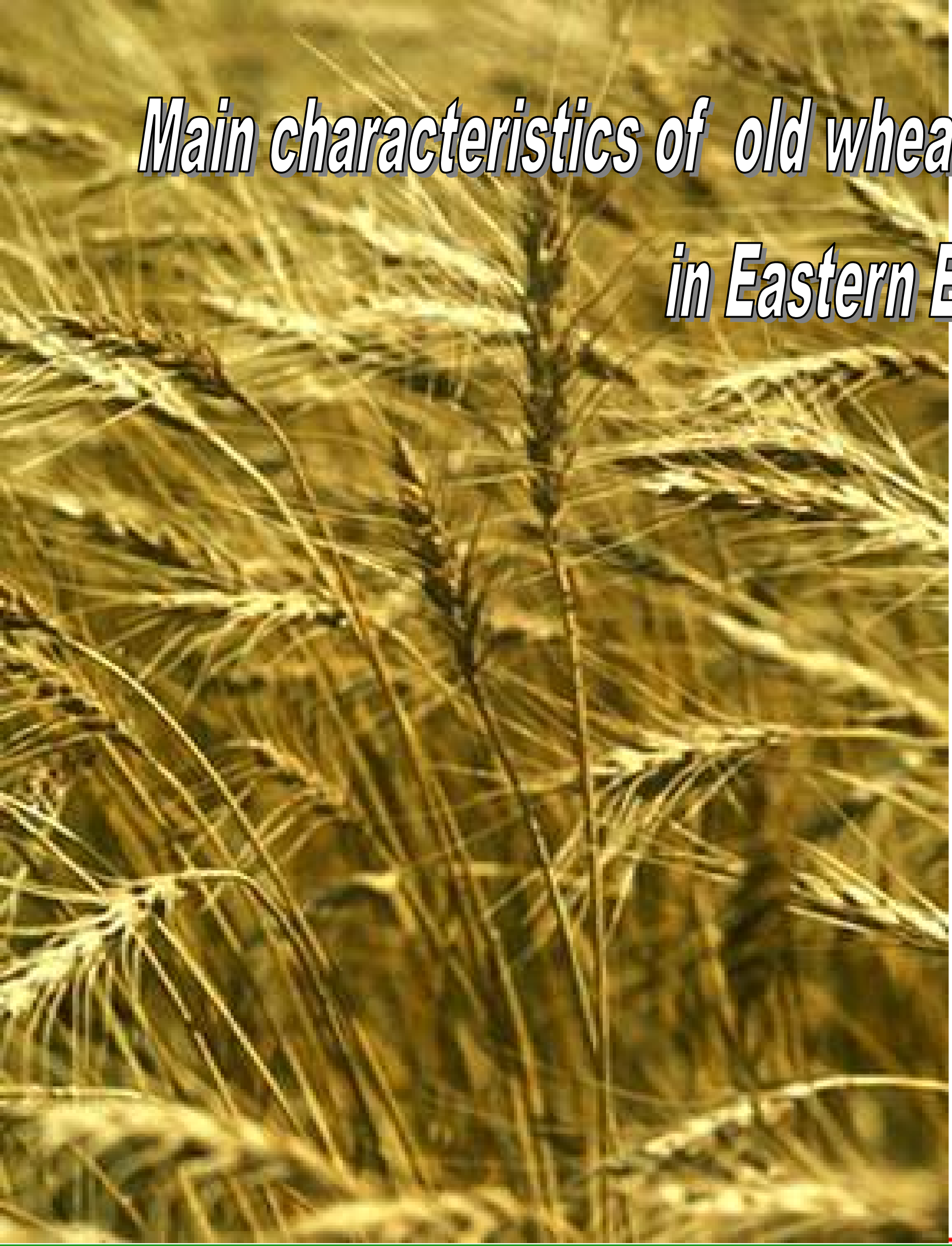
Main characteristics of wheat adaptable in Eastern Europe

- Smaller leaf size - flag leaf area
- Earlier flowering time
- Faster leaf senescence
- Lower rate and shorter duration of the grain-filling period as well as assimilate translocation to the grains
- Smaller grain size under dry environments
- Better tillering capacity but significant differences between main and side tillers
- Smaller number of spikelets per spike and grain per spike
- Plant biomass with smaller harvest index
- Taller plant height (Rht1 and 8) and better rooting system

Genetic resources for development new germplasm in low input environments

- Landraces, old varieties populations
- Wild and cultivated relatives
- Exotic lines and varieties
- Adapted lines and varieties

Main characteristics of old wheat varieties and populations in Eastern Europe



(Hankóczy, 1938)

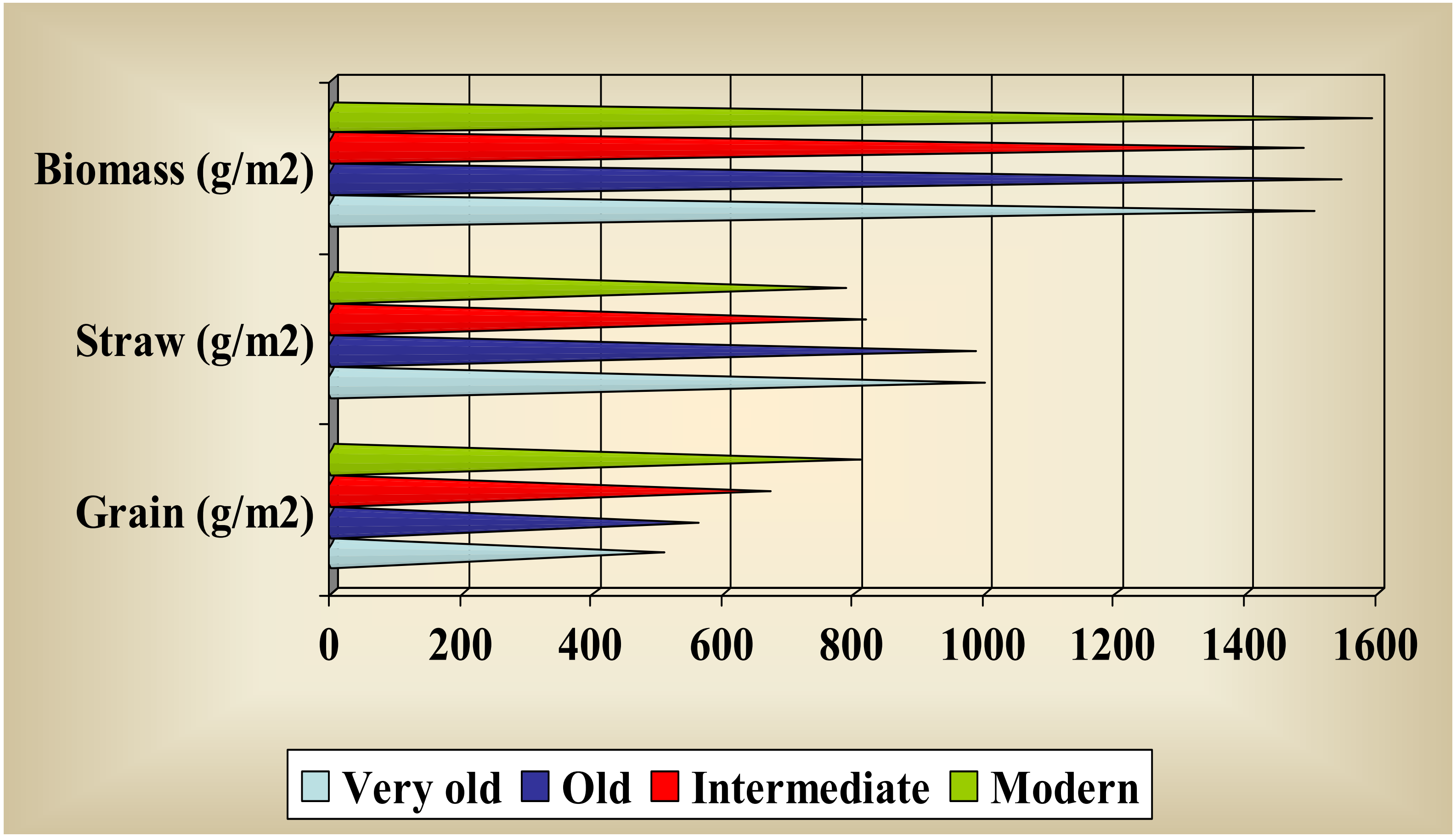
- Low yield potential
- Susceptible to fungal diseases
- Susceptible to lodging

but

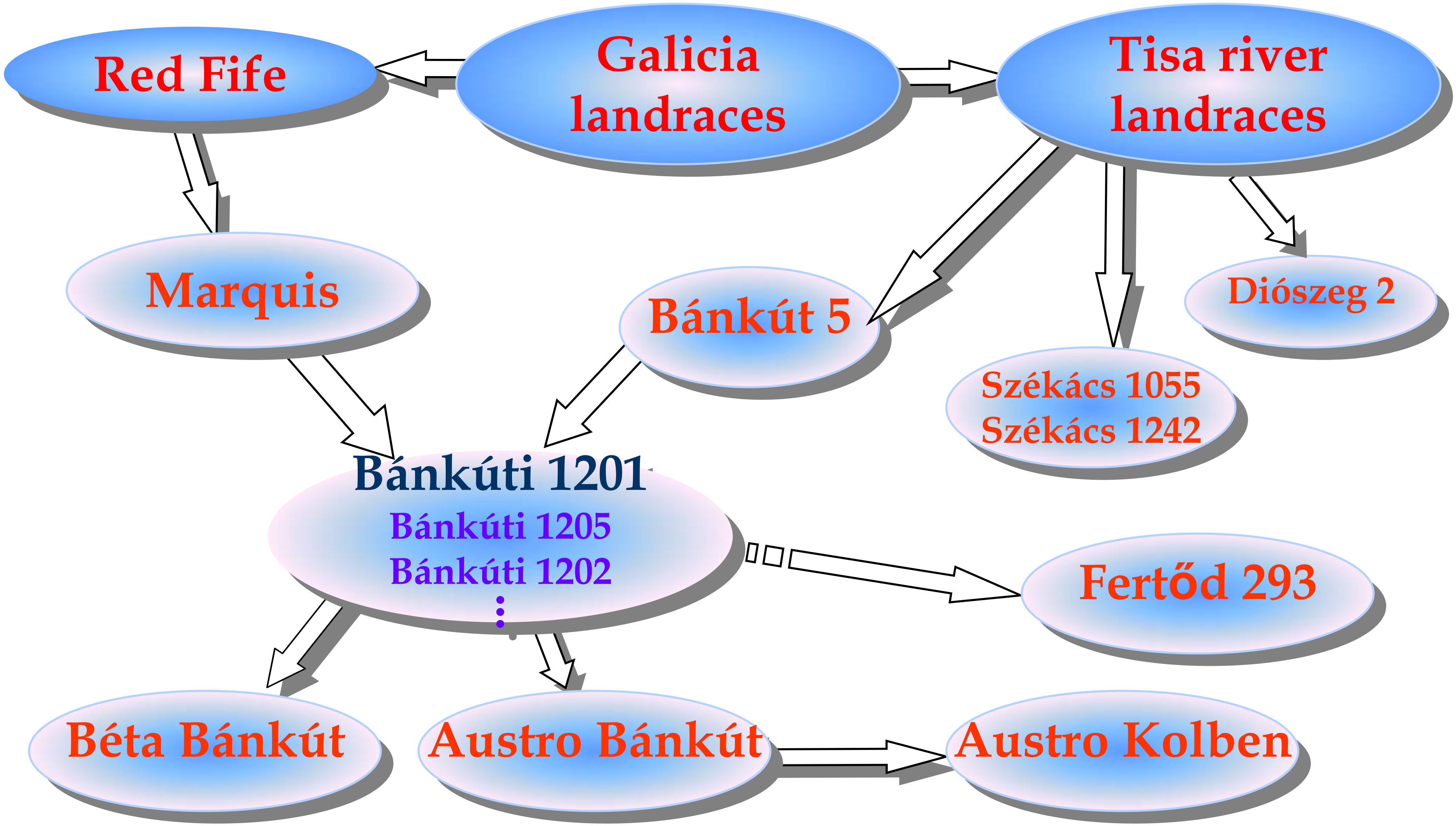
- Good milling and baking quality

Biomass production of wheat varieties

(Austin et al. 1989)



Genetic background of old landraces and varieties in Eastern and Central Europe



New strategy for the genebank research and germplasm development

- **Traditional tools: geographic origin, pedigree information, botanical and agronomical descriptions**
- **The efficiency of genebank collections for the analysis of allelic diversity with traditional methods is expensive and time-consuming**
- **Establishment of cost-effective core collections to represent the genetic variability of large collections using both phenotyping and genotyping evaluations**
- **Aim: 10% of the accessions should represent at least 70% of the variability in the entire collection *(Brown 1989)***
- **Selection of desirable recombinants using an optimum combination of phenotypic and genotypic data**

Breeders would like to work with useful agronomic traits/genes of old germplasm and not the whole plant

Introduction of wild and cultivated relatives

Wheat x rye chromosome substitutions and translocations

Riebesel (1920s and 1931s) Salzmünder Bartweizen 1BL/1RS

Katterman (1937) Zorba and Markus 1BL/1RS

Pm 8, Lr 26, Sr 31 and Yr 9

Sebesta (1976) Amigo 1AL/1RS

Gb2, Pm 17, Lr 24, Sr 24

Wheat x barley crosses for the improvement of drought resistance of wheat (Láng-Molnár et al.)

CGIAR
Generation Challange Program

Cultivating plant diversity for the resource poor

Study of drought resistance in controlled conditions in different environments

Use of wild relatives

T. monococcum

T. dicoccum

Exotic genetic resources for development new germplasm in low input environments

- Prebreeding and variety development
- New sources for abiotic and biotic stress resistance improvement
- Introduction new quality germplasm
- Use of intensive type of germplasm for yield improvement

Study of physiological traits to improve stress resistance and yield performance

- Studies of plant growth development patterns and sensitive crop growth stages to avoid stress is in progress
- The role of roots enabling plants to remain hydrated under drought and/or heat stress
- Regulation of transpiration efficiency during the drought and heat sensitive crop growth stages
- How does influence delay of leaf senescence the other adaptational traits under heat and drought stress?
- Stable development of the reproductive organs to increase yield performance under heat or drought stresses
- Study of the processes that increase the availability of assimilates to the developing spike and improve spikelet fertility
- Photosynthetic capacity and intra – plant competition between organs for assimilates
- Interaction of adaptational traits, possible change of plant architecture

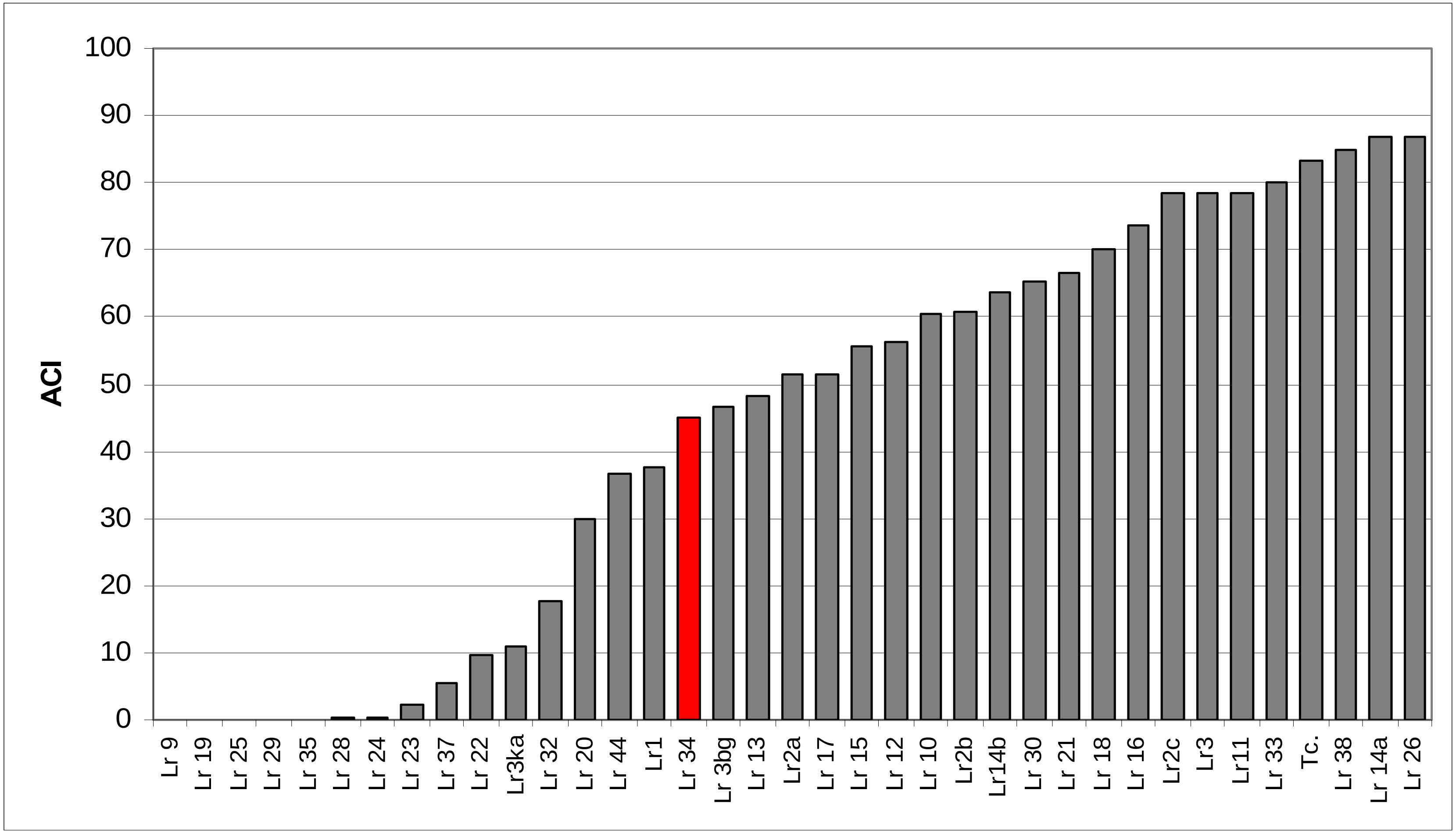
Challanges of climate changes in Eastern European low input environments

- Buffer unpredictable variation in water supply in different growth stages
- Sprouting resistance against heavy rainy periods during ripening time
- Tolerance to sudden changes in temperature: avoid spike sterility, seed abortion effects in low temperature
- Adaptation to warmer nights during the grain filling period without the loss of assimilates that is associated with dark respiration

Main considerations for breeding stress resistance

- Types and frequency of stress factors dominant in the region
- Type of parasites (facultative or obligate)
- Genetic mechanisms of resistance
- Available genetic variability for breeding
- Breeding methodologies
- Background of wheat cultivation technology
- Agroecological environment

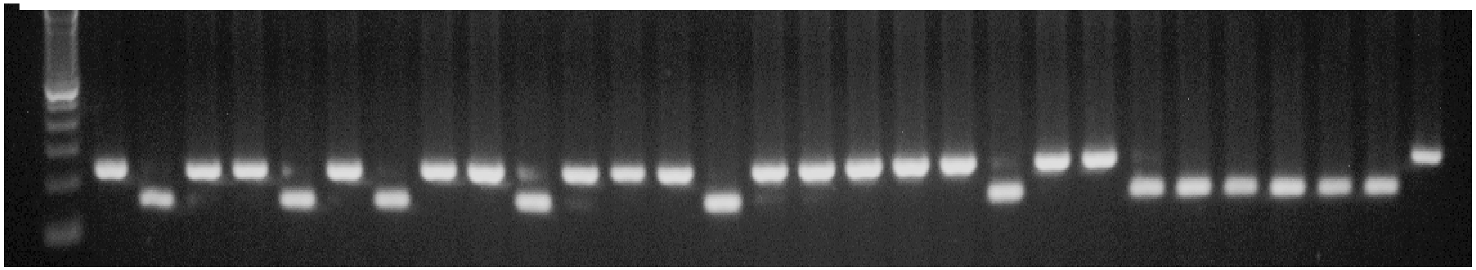
Effectiveness of the Lr34 gene for partial leaf rust resistance breeding (Vida et al 2008)



*ACI = severity% * constant of the host response

Identification of Lr34 gene in breeding germplasm

Origin	Total number of genotypes	No. of genotypes with Lr34
Martonvásár	129	35 (27.1%)
Other	97	29 (29.9%)
Total	226	64 (28.3%)

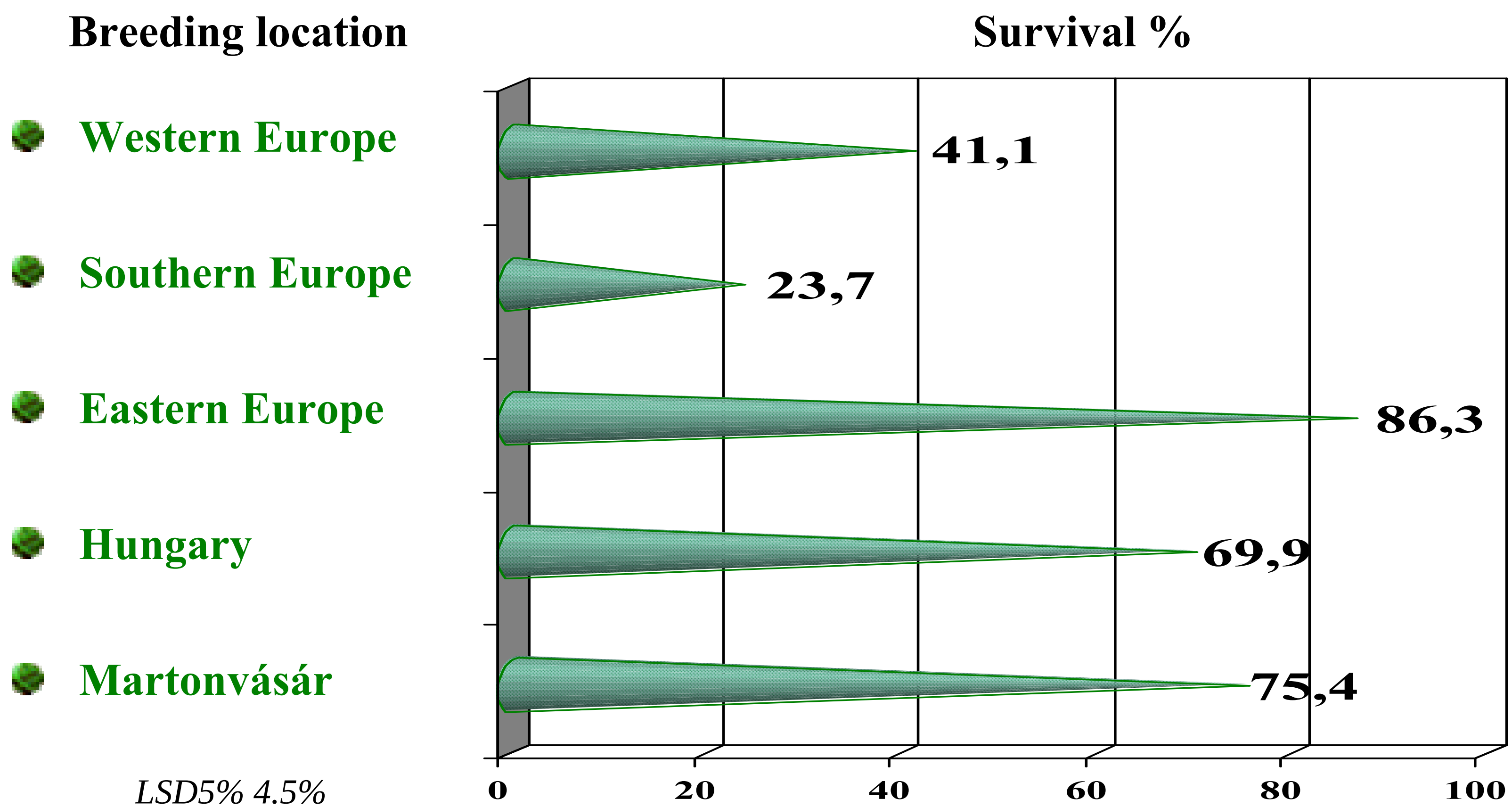


csLV34 STS marker Lagudah et al, 2006

M. 100 bp DNA ladder; 1. Mv Magdaléna; 2. Mv Laura; 3. Mv Zelma; 4. Tommi; 5. Ukrainka; 6. Ellvis; 7. Mv12-04; 8. Mv233-05; 9. Mv Vekni; 10. Mv Táltos; 11. Mv Amanda; 12. Tiger; 13. Mv08-08; 14. Mv222-07; 15. Maximus; 16. Mv320-07; 17. Ravenna; 18. CF99007; 19. Mv21-07; 20. LUT53656; 21. BR02-028; 22. Atrium; 23. Jiana; 24. Mv Gorsium; 25. Mv09-04; 26. GK-Kapos; 27. Litera; 28. Positive control - Frontana; 29. Negative control - Thatcher.

Main characteristics of Eastern European wheat adaptable to stressed environments

Mean frost resistance of varieties on the basis of site of origin



LSD5% 4.5%

Intensification of breeding methodologies for yield improvement

- Increase in the number of crossing combinations
- Maximum exploitation of the genetic variability of segregating populations in different ecological environments
- Marker assisted selection: biochemical, molecular markers
- New phenotypic tools for selection
- A vast improvement in testing methods
- Shortening of the breeding process

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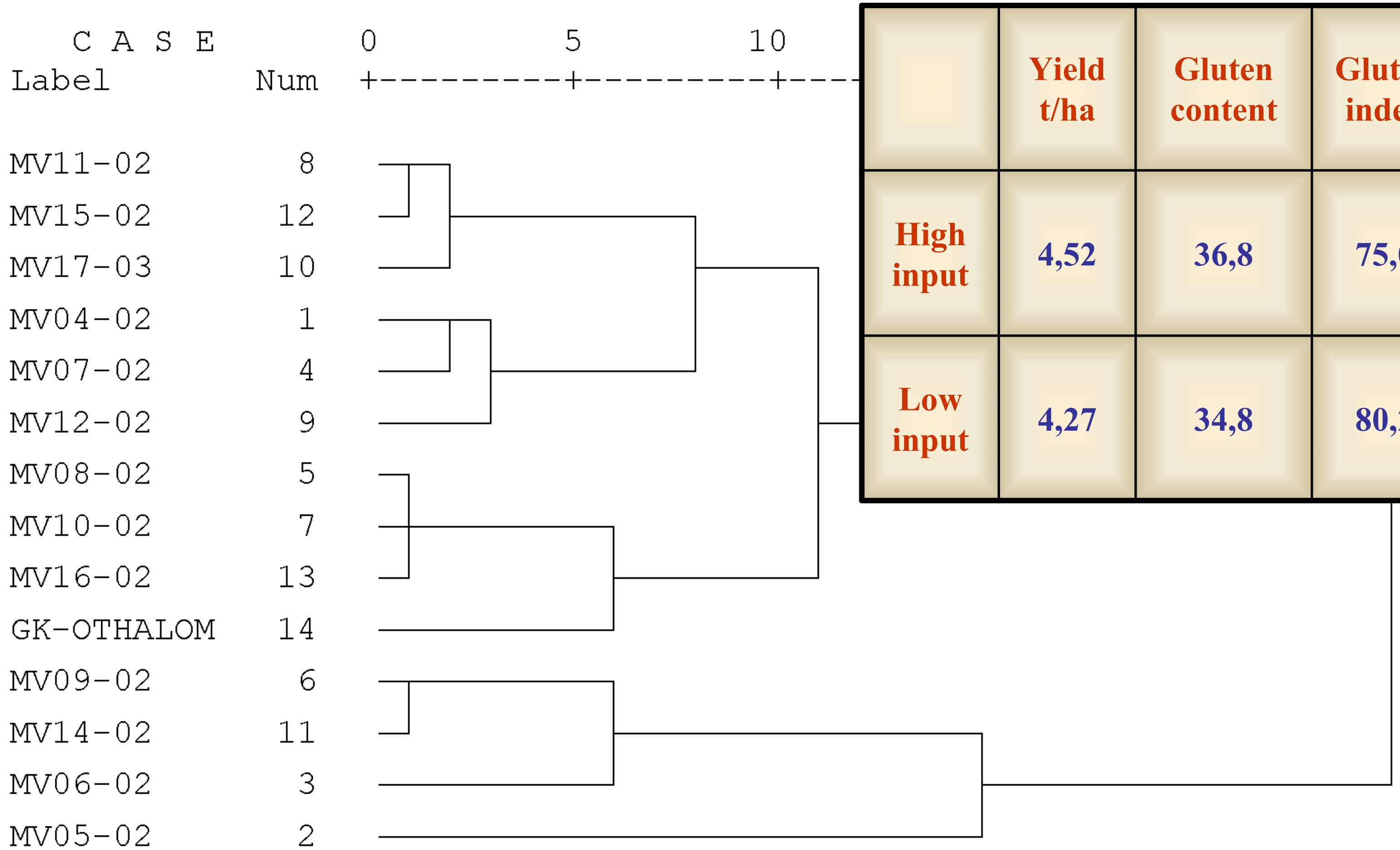
Reaction of wheat lines tested under high and low input environments in Martonvasar, Hungary (Bedő et al 2005)

Dendrogram using Ward Method

Rescaled Distance Cluster Combine



	Yield t/ha	Gluten content	Gluten index	Farinograph value
High input	4,52	36,8	75,0	72,5
Low input	4,27	34,8	80,2	79,1

Alternative ways:
Hybrid wheat development under low input environment

Aims

- Yield and yield stability improvement
- Integration of yield and quality improvement

Questions

- Heterosis in yield under low input conditions : determine heterotic groups adaptable under low input environments
- Yield and technological quality stability of hybrids
- Better stress resistance
- Biomass production
- Heterosis in plant height
- Variability for pollen production and seed setting
- Seed production and economic aspects

The competitiveness of wheat in low input environments with genotypes in other regions of the World

- **Solutions for the yield disadvantage**
  - production technology oriented breeding for low input conditions and economically viable options

- **Stability under extreme wheather conditions and other adverse climate change effects**
  - less vulnerability of wheat systems to climate change impacts
  - multiple stress resistance

- **Exploit quality and market differentiation**
  - high protein content and better protein quality
  - improved bioactive compounds