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Plant Breeding Potential to Improve Energy Crops for the Use in Biogas

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Crop plants



Vegetable oil



Starch

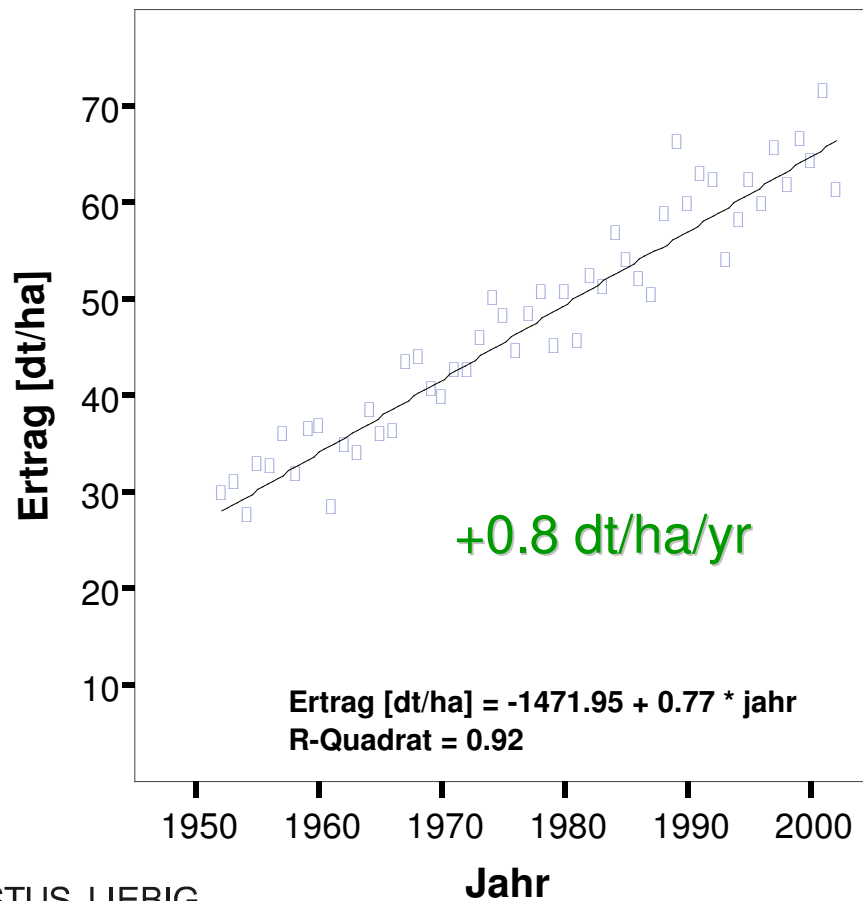




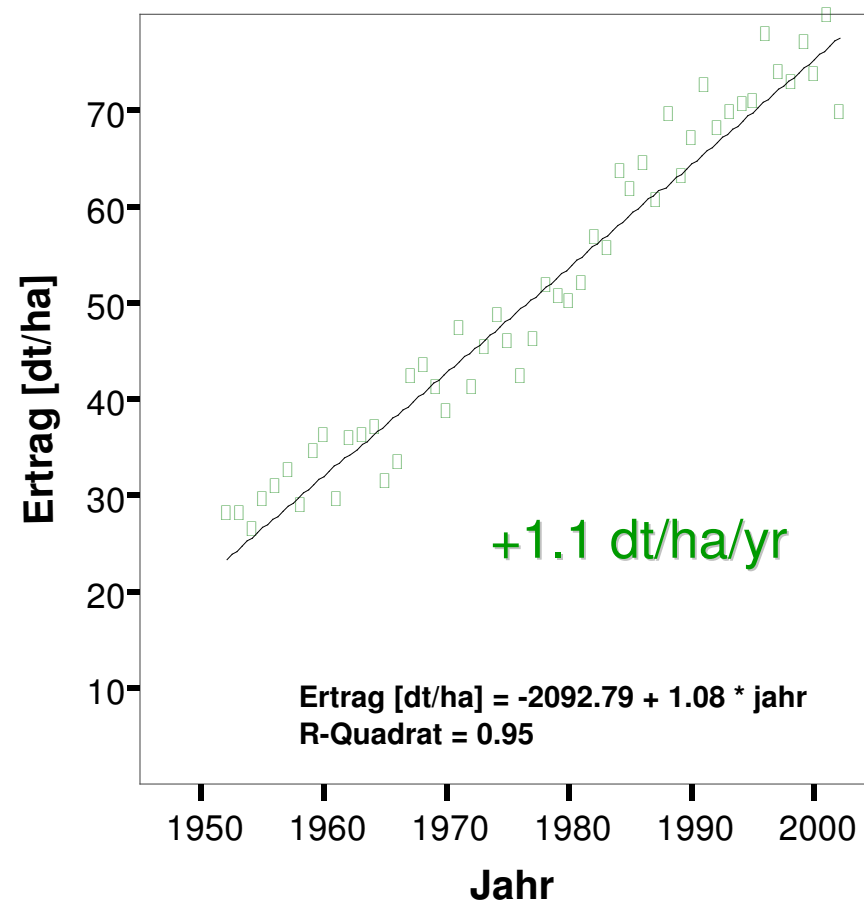
Breeding Progress

Grain yield on the farm level: „Besondere Erntermittlung“ 1952-2002

Winter barley



Winter wheat





Energy crops

Plants cultivated for energy production purposes:

- **Trees (wood)** => solid fuel, Biomass-to-Liquid (BtL)
- **Oilseeds (rapeseed)** => liquid fuel = Biodiesel (RME)
- **Cereals** (e.g. wheat, triticale) => Bioethanol
- **Grasses** as biomass source (e.g. Miscanthus) => Biogas
- **Silage maize** => Co-substrate for fermentation: Biogas

Crop Cultivation for Renewable Resources¹⁾

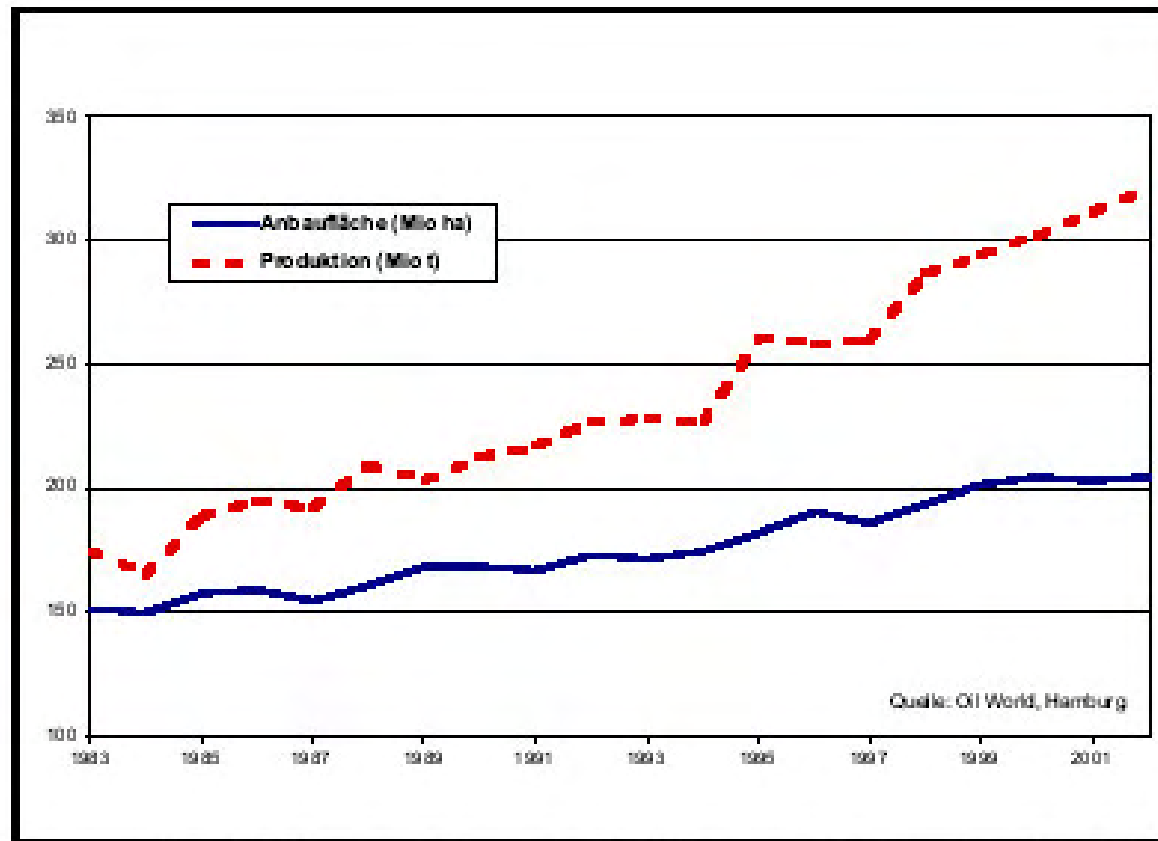


Raw Material	Basic area (ha) 2002*)	Set-aside area (ha)	5-years- increase (%)
Starch	125.000		101,6
Sugar	7.000		100,0
Rapeseed oil	320.000	344.930	357,2
Sunflower oil	20.000	4.080	104,4
Linseed oil	15.000	277	15,8
Vegetable fibre	2.000	0	49,7
Medicinals	4.000	400	90,9
Others		3.919	1911,7
Subtotal	493.000	353.606	
Grand total		846.606	190,3

¹⁾Germany; Source: BMVEL, Ref. 535 (2002); *)estimated

Global Production of Oil Crops

Oil seeds are globally produced on more than 200 Mio ha. Since the 1990s production has increased more than the cultivation area! Soybean is clearly the most important oil seed of the world.



<http://www.ufop.de/Bioproduktion.pdf>



Oilcrops for Europe

- Oilseed Rape

- Sunflower

=> Vegetable oil

=> Biodiesel (RME)



Genetic variation for height and biomass in oilseed rape
(dwarf cv. Lutin)

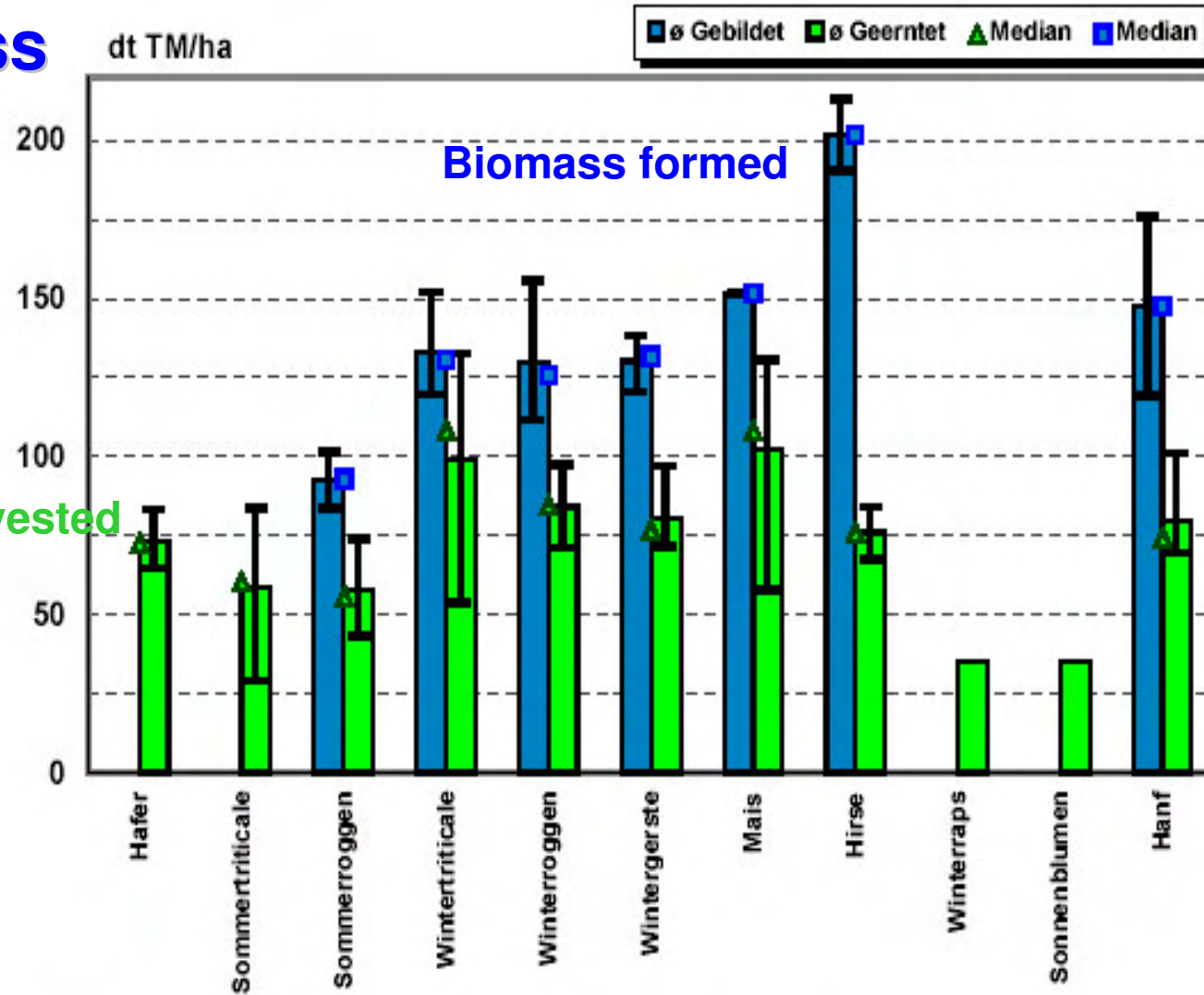


**Cereals (whole crop),
Grasses, etc.:**

=> Biomass => Fuel

Biomass Yield

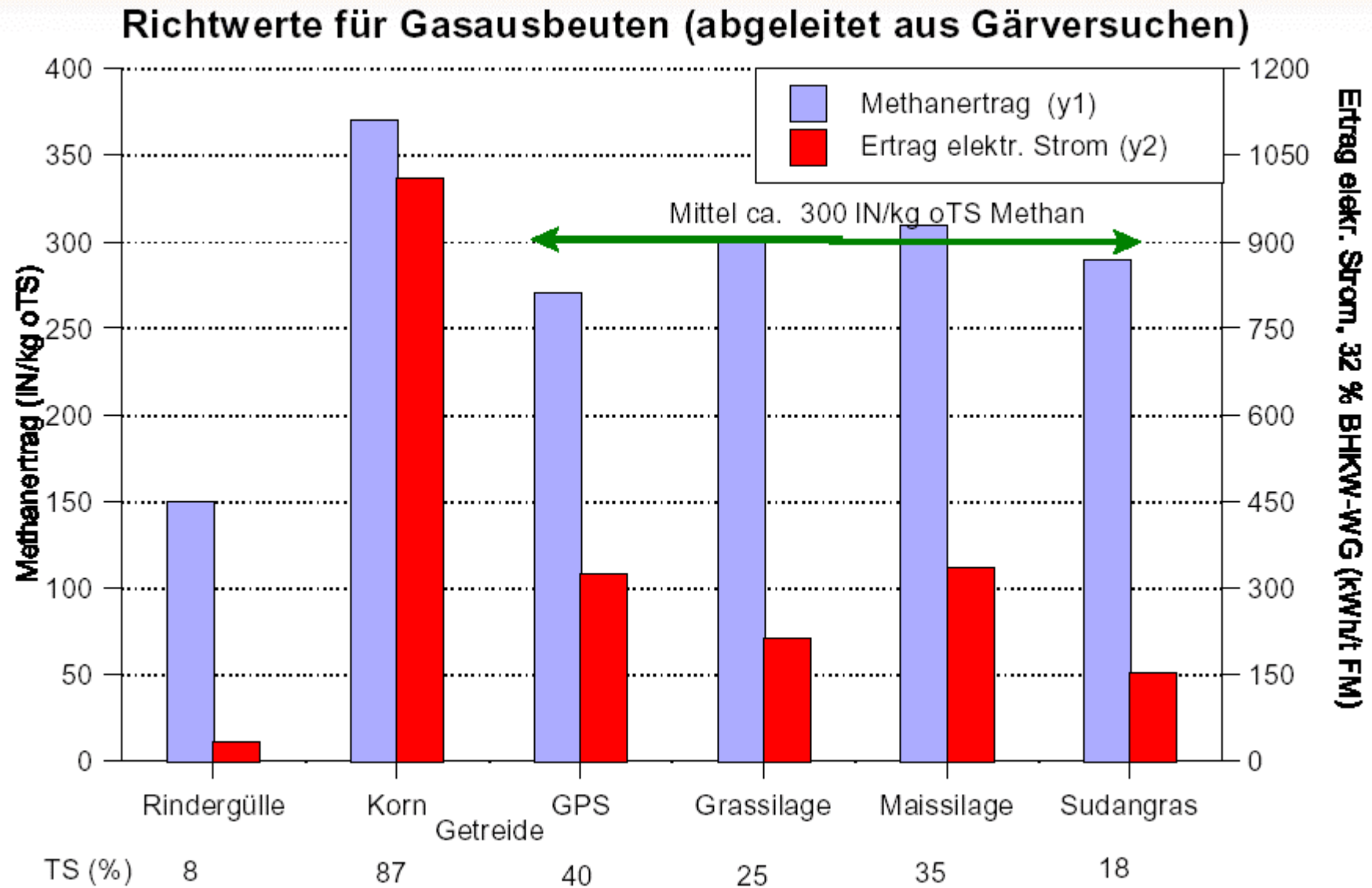
Biomass harvested



Means and range of biomass yield of annual energy crops, Germany 1994-96

Quelle: Jürgen Maier¹; Dr. Reinhold Vetter¹; Volker Siegle²; Dr. Hartmut Spliethoff², ¹Institut für umweltgerechte Landwirtschaft (IfUL), Müllheim, ²Institut für Verfahrenstechnik und Dampfkesselwesen (IVD), Universität Stuttgart: Anbau von Energiepflanzen - Ganzpflanzengewinnung mit verschiedenen Beerntungsmethoden (ein- und mehrjährige Pflanzenarten); Schwachholzverwertung. Abschlußbericht Ministerium Ländlicher Raum Baden-Württemberg, 1998

Estimated biogas and electricity yield





Silage maize (Energy maize)



=> Biomass => Biogas

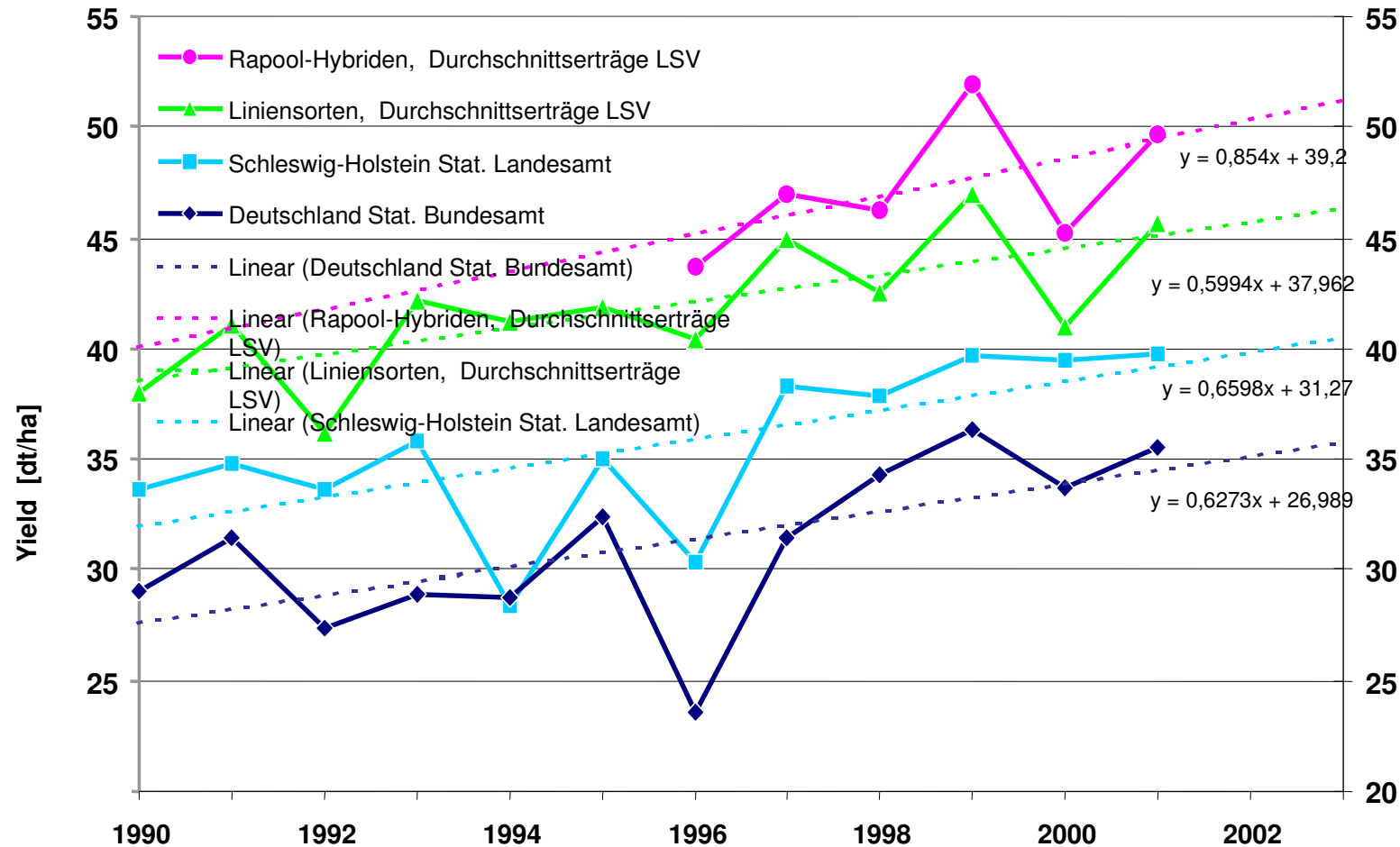


Breeding goals

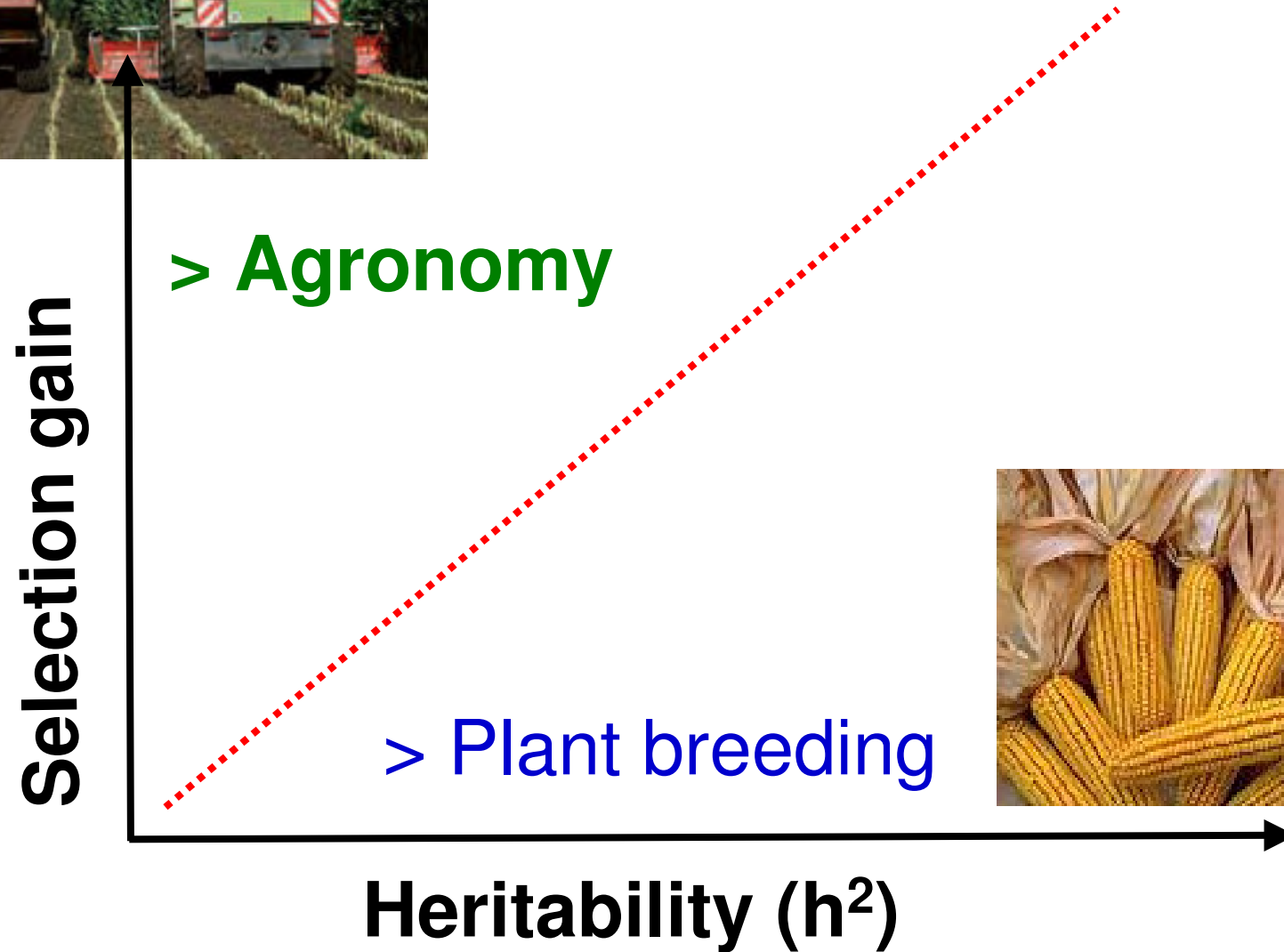
- Yield output
- Yield stability
- Product quality



Recent yield progress of winter oilseed rape in Germany



Source: NPZ 2001, Statistisches Bundesamt, Statistisches Landesamt, Landessortenversuche





Heritability and Gain of Selection

$$h^2 = s_g / s_p$$

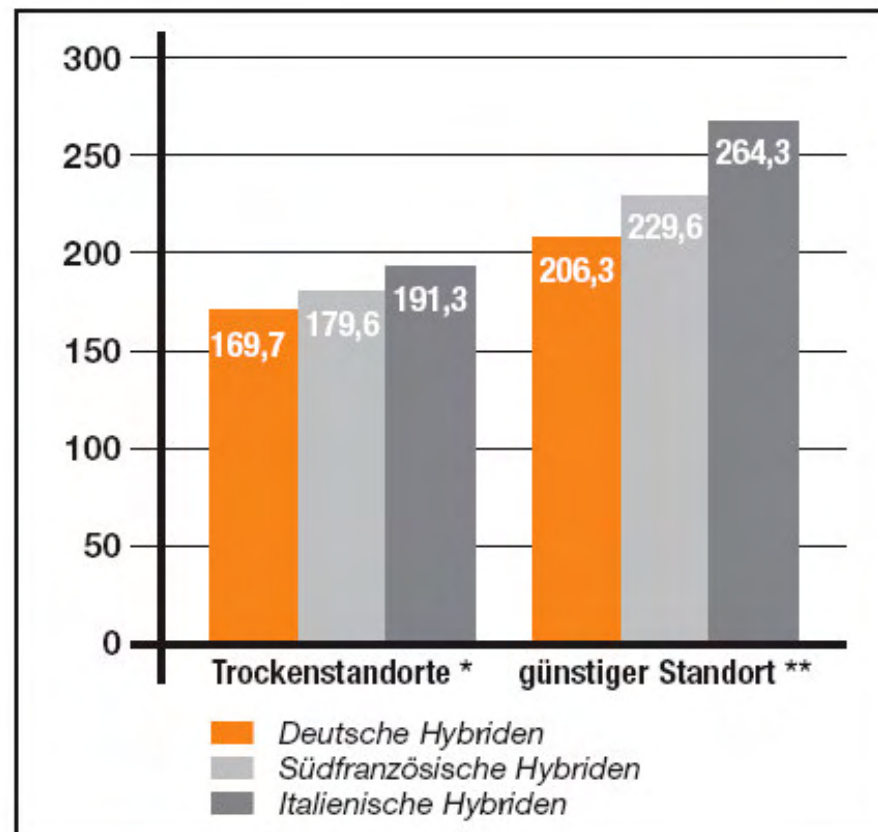
$$G = i \cdot h^2 \cdot s_p$$

G=Gain, i=selection intensity, h^2 =heritability,
 s_p =phenotypic standard deviation



Silage maize (Energy maize)

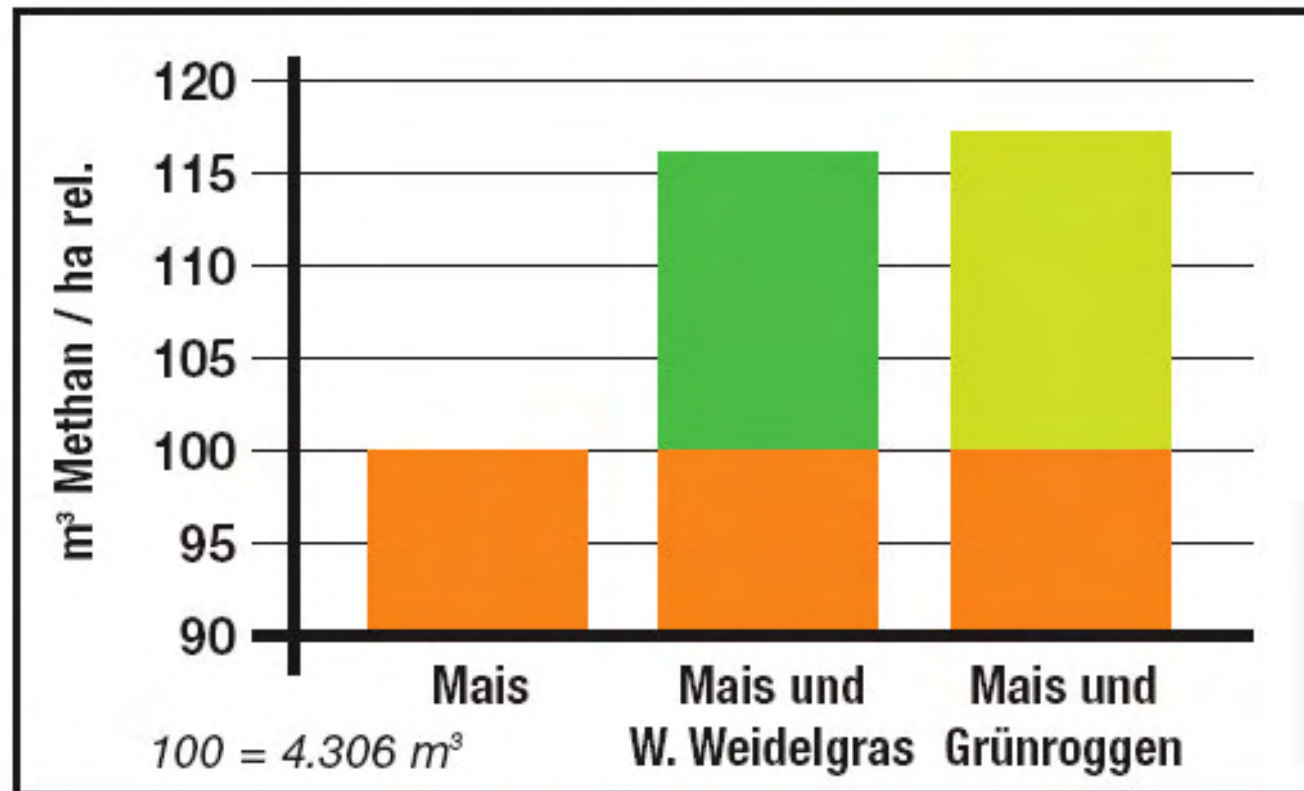
Biomass yield of different maize hybrid types (German, French, Italian varieties) at different locations (dry vs. favourable conditions)



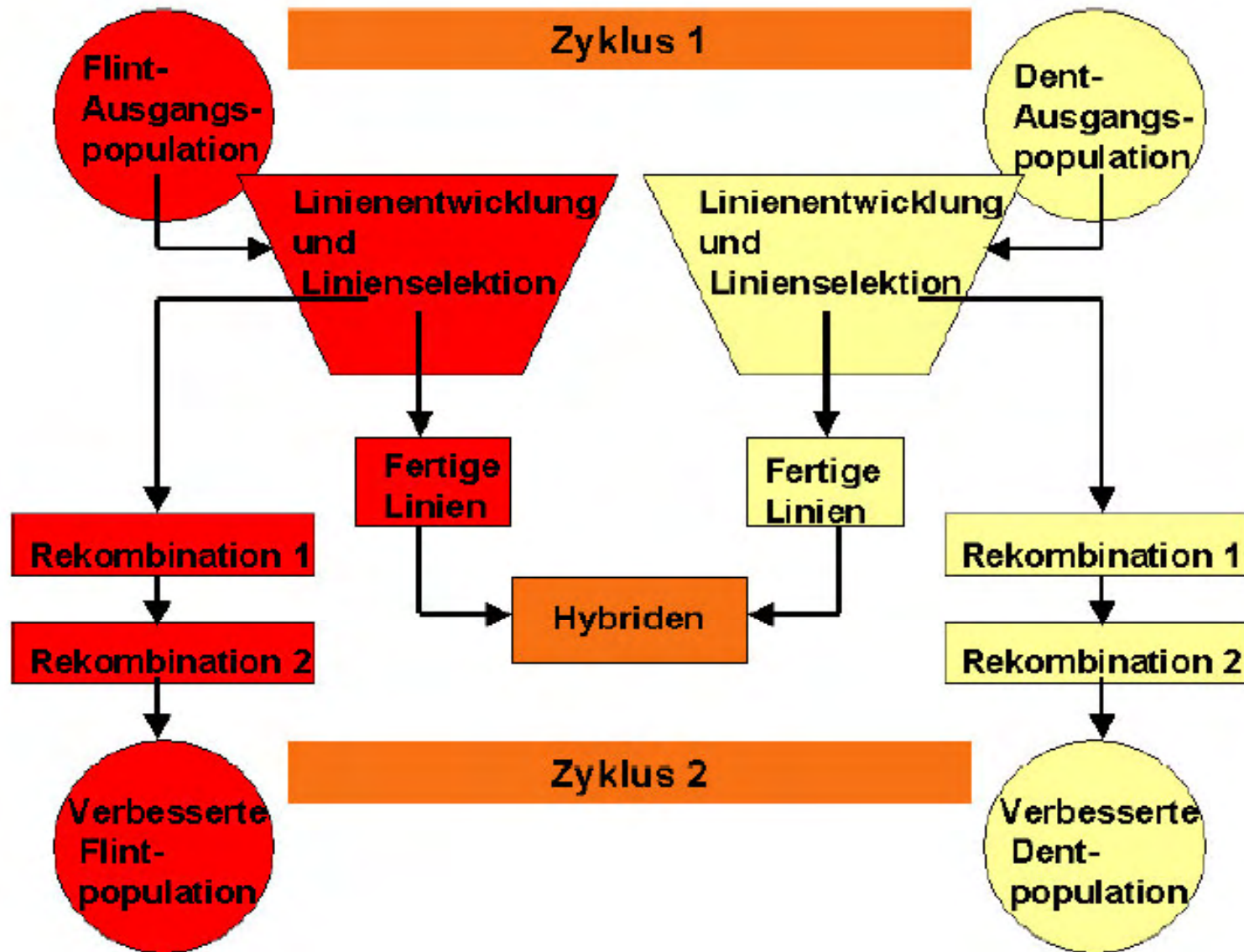
<http://www.kws.de/>



Effect of the previous crop – maize or mixtures of maize with Italian ryegrass and forage rye - on methane yield of maize



nach: GRÖBLINGHOFF und LÜTKE ENTRUP 2004



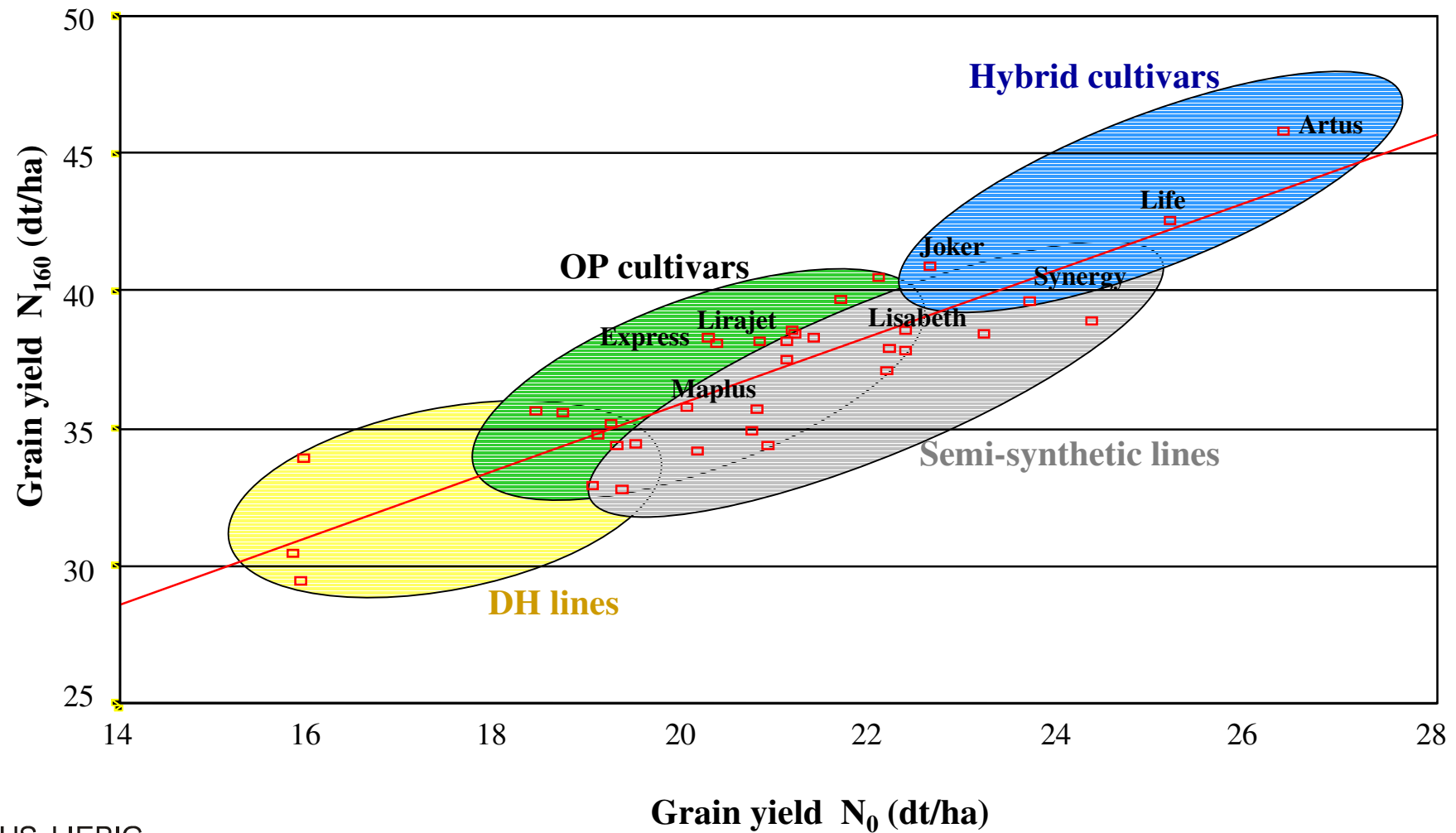
Schmidt, W.: Hybridmaiszüchtung bei der KWS Saat AG (Gumpenstein 2003)



Hybrid breeding



Grain yield of winter oilseed rape variety types at varying N-supply



Rapeseed

Molecular markers: AFLPs

E32M59

Mapping population:

F₂-Population:

Express 617 x 1012-98

22 Primer combinations

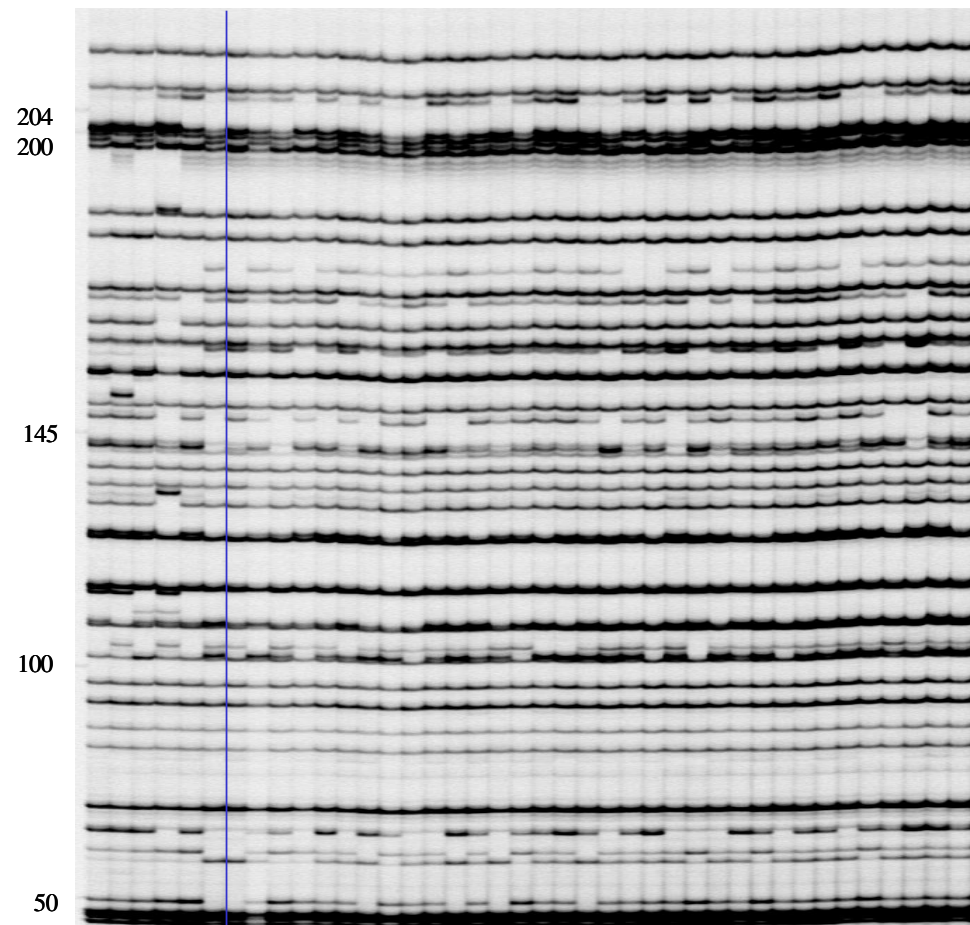
DH-Population:

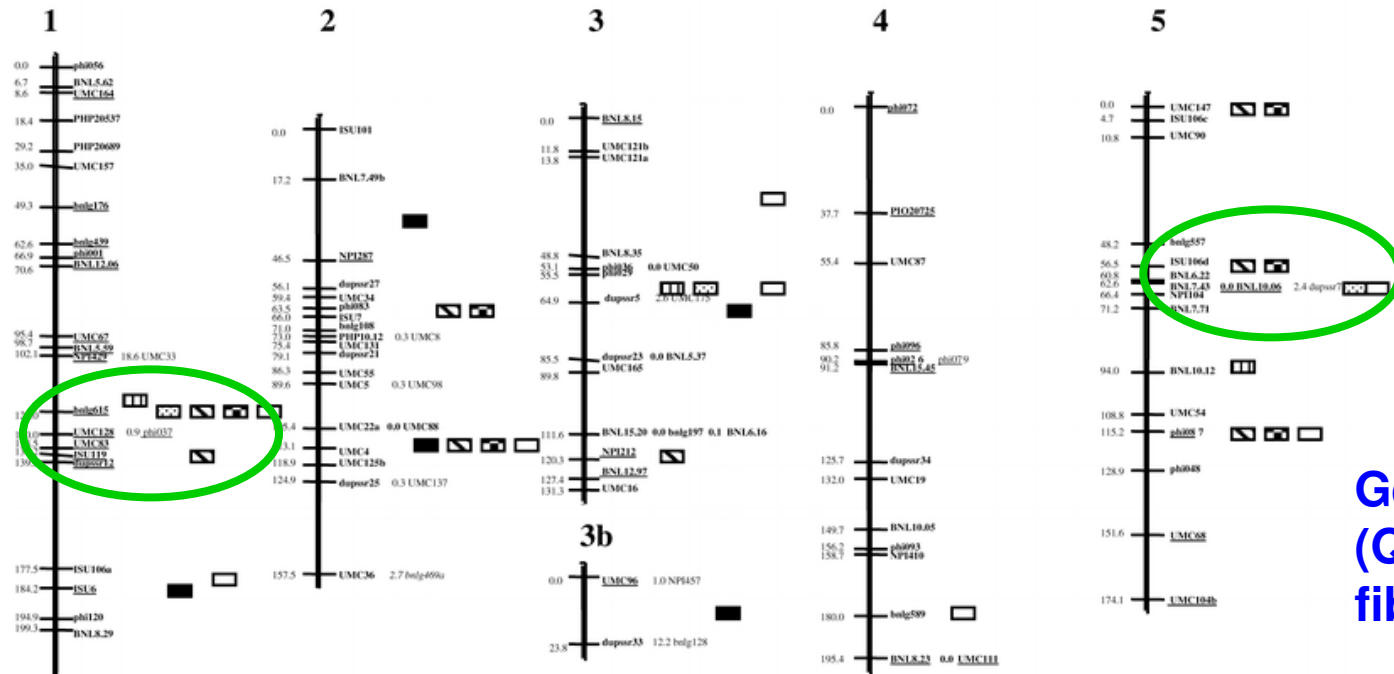
T-25629-3 x DH26-96

20 Primer combinations

DH 5.1
DH 11.4
DH 26-96
T-25629-3
Express 617
1012-98

F₂-Population





Genomic regions (QTL) relevant for fibre content

Molecular genetic map of maize (1-10 chromosomes)



(A. J. Cardinal, M. Lee & K. J. Moore, TAG 2003)



- SHDF
- SHAF
- SHADL
- STNDF
- STADF
- STADL



Conclusion

- Crop plants have a great potential for the production of energy (Biomass, Bioethanol, Biodiesel, etc.)
- Crop and energy yield depends on heritable (genetic) and environmental effects (heritability => gain of selection)
- Heritable variation has long been exploited by breeding
- Plant breeding efficiency can be increased by molecular (genetic) tools today

Thanks ...

Co-workers

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