CROPGEN Utrecht 2005

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

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Crop plants

Vegetable oil

Starch

$$CO_2 + H_2O + \text{light} + \text{chlorophyll} = (CH_2O) + O_2$$

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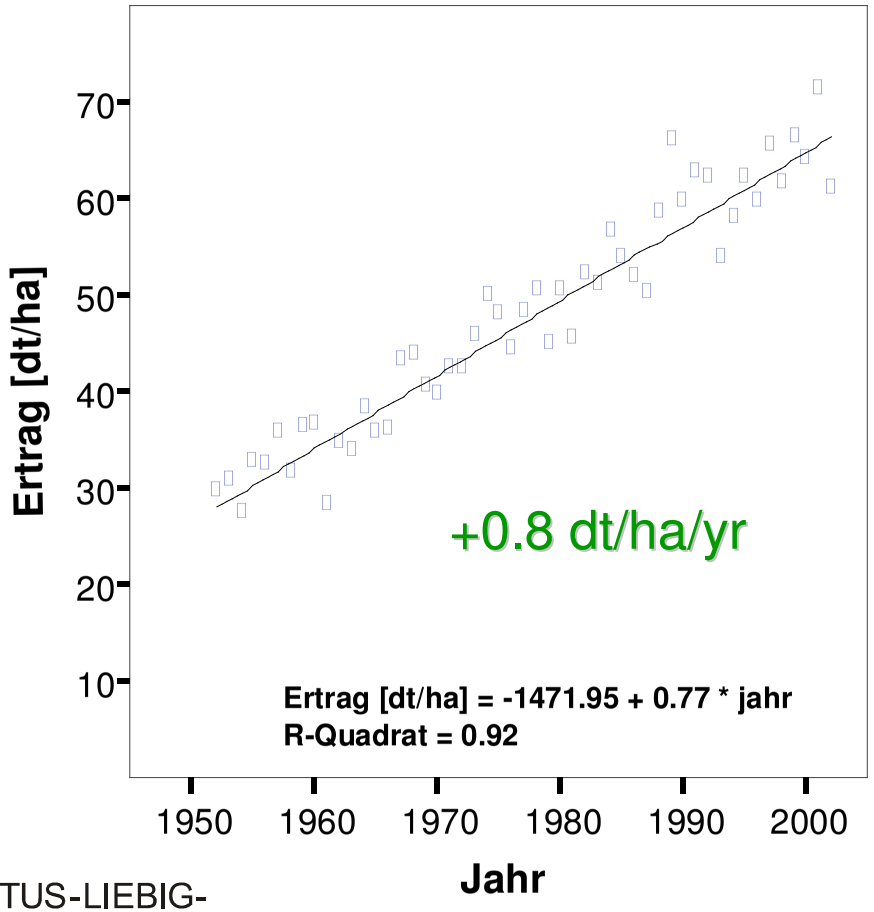
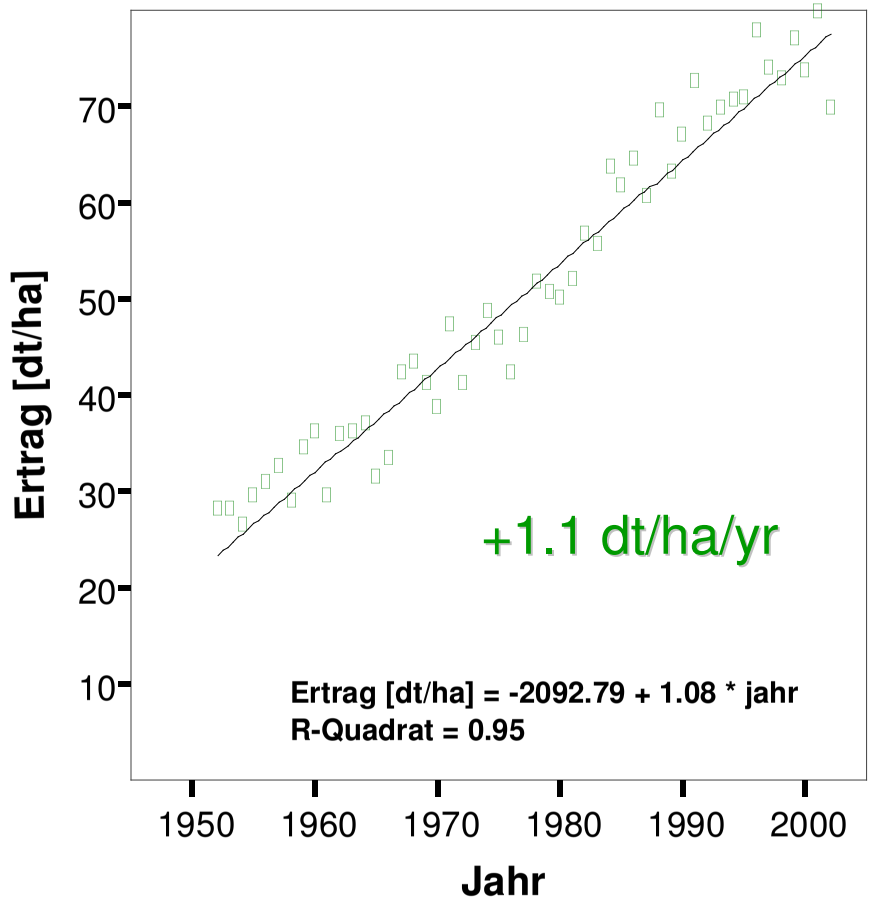
Breeding Progress

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

Winter barley



Winter wheat



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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 Resources[1)]

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
Vegtable 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.

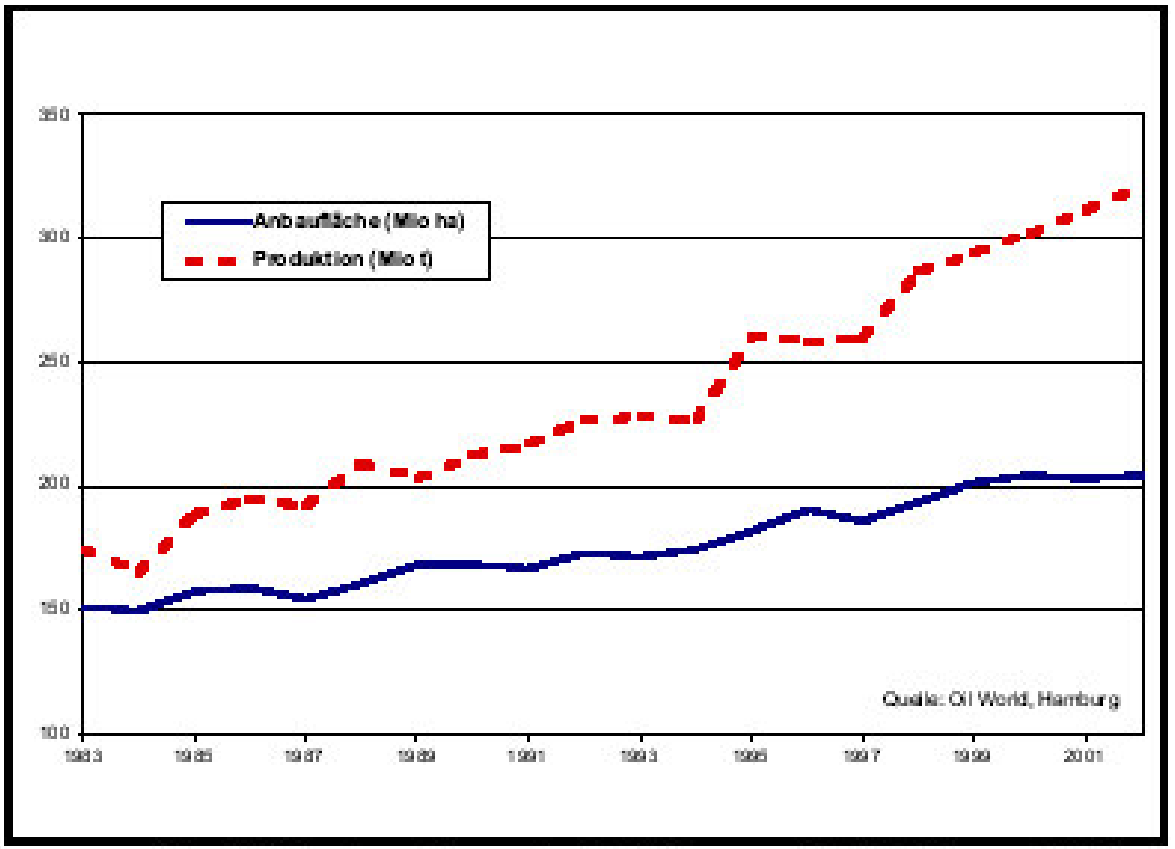

Abb. 11 Ölsaatenanbau weltweit: Flächen- und Produktionsentwicklung

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

Oilcrops for Europe

- Oilseed Rape
- Sunflower

=> Vegetable oil

=> Biodiesel (RME)

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

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Cereals (whole crop), Grasses, etc.:

=> Biomass => Fuel

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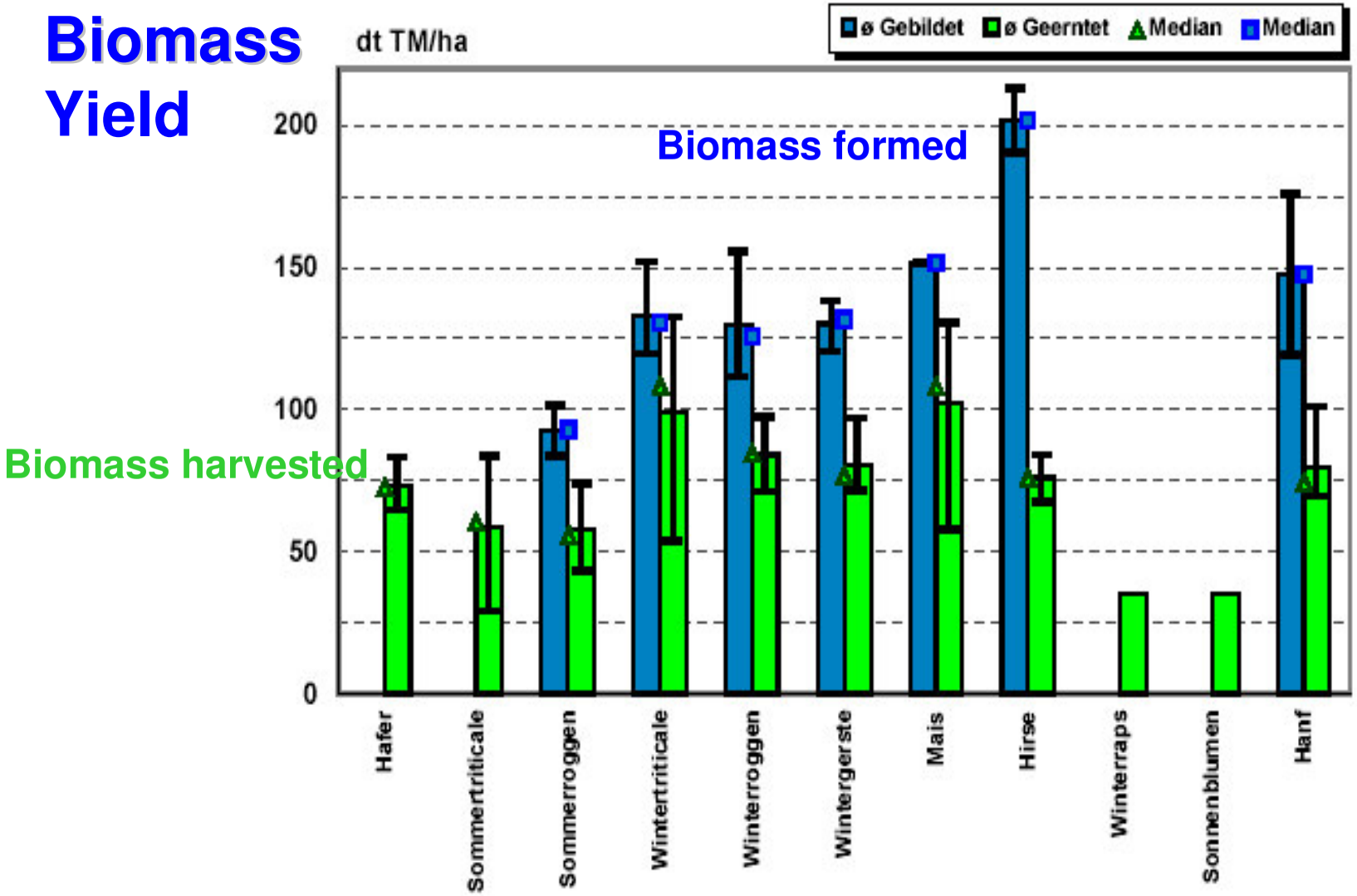
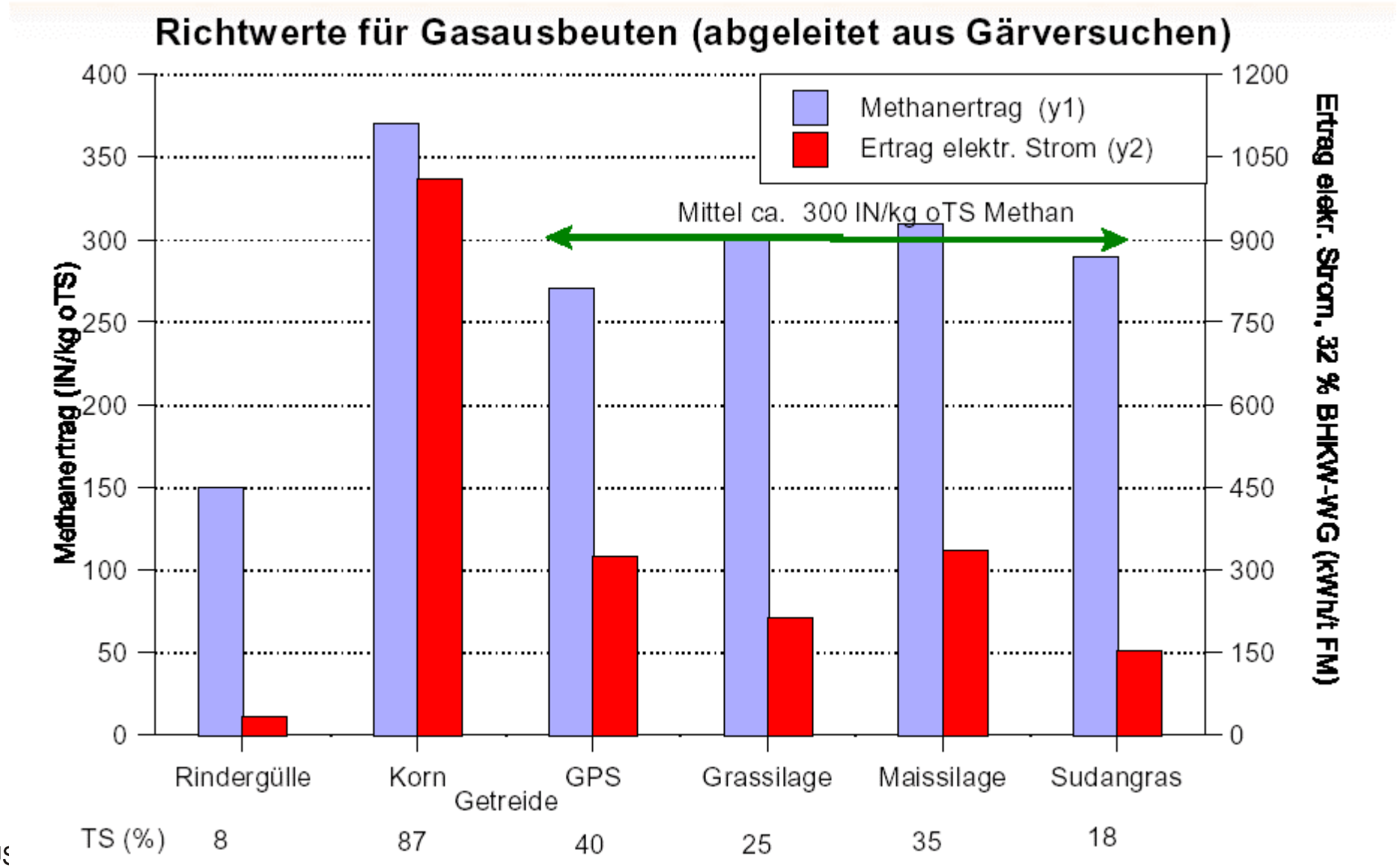
Biomass Yield



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

Quelle: Jürgen Maier[1]; Dr. Reinhold Vetter[1]; Volker Siegle[2]; Dr. Hartmut Spliethoff[2], [1]Institut für umweltgerechte Landbewirtschaftung (IfUL), Müllheim, [2] Institut 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

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Breeding goals

- Yield output
- Yield stability
- Product quality

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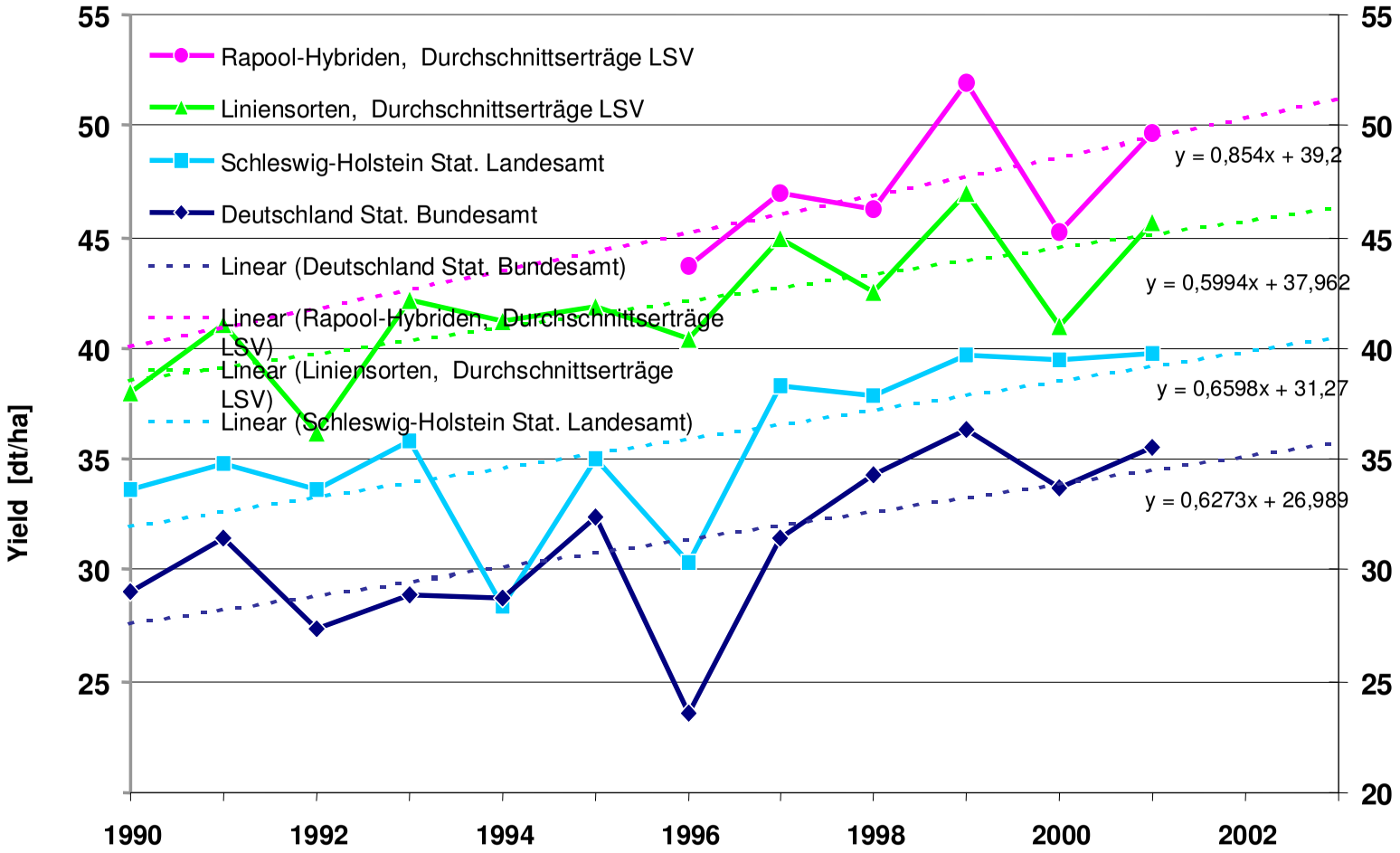
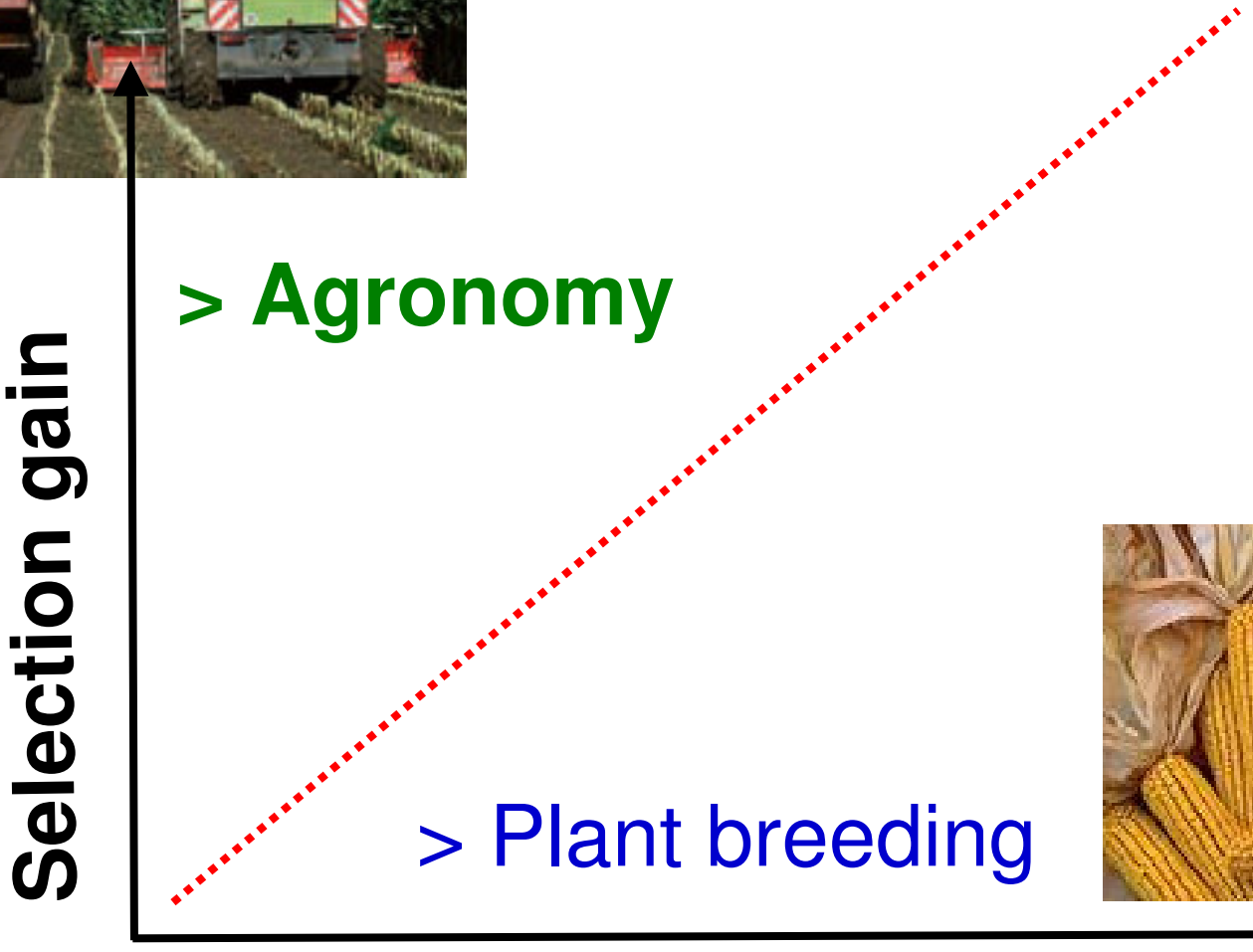
Recent yield progress of winter oilseed rape in Germany



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



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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

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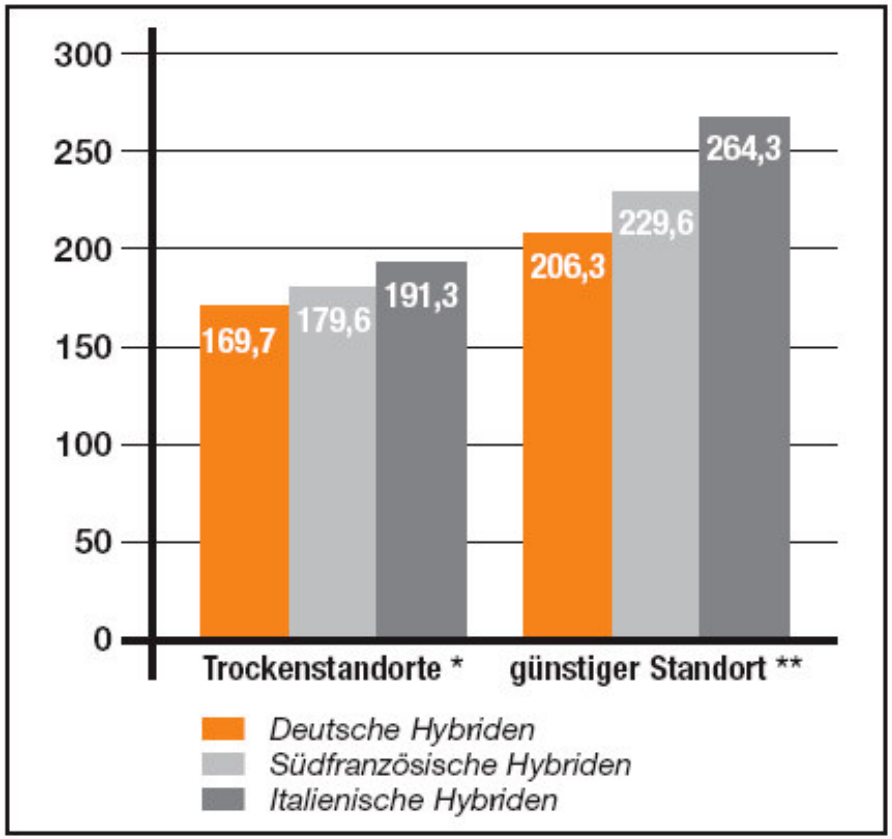
Silage maize (Energy maize)

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



* Trockenstandorte 2003: Einbeck, Bernburg, Bersenbrück
** Günstiger Standort 2003: Altötting

http://www.kws.de/

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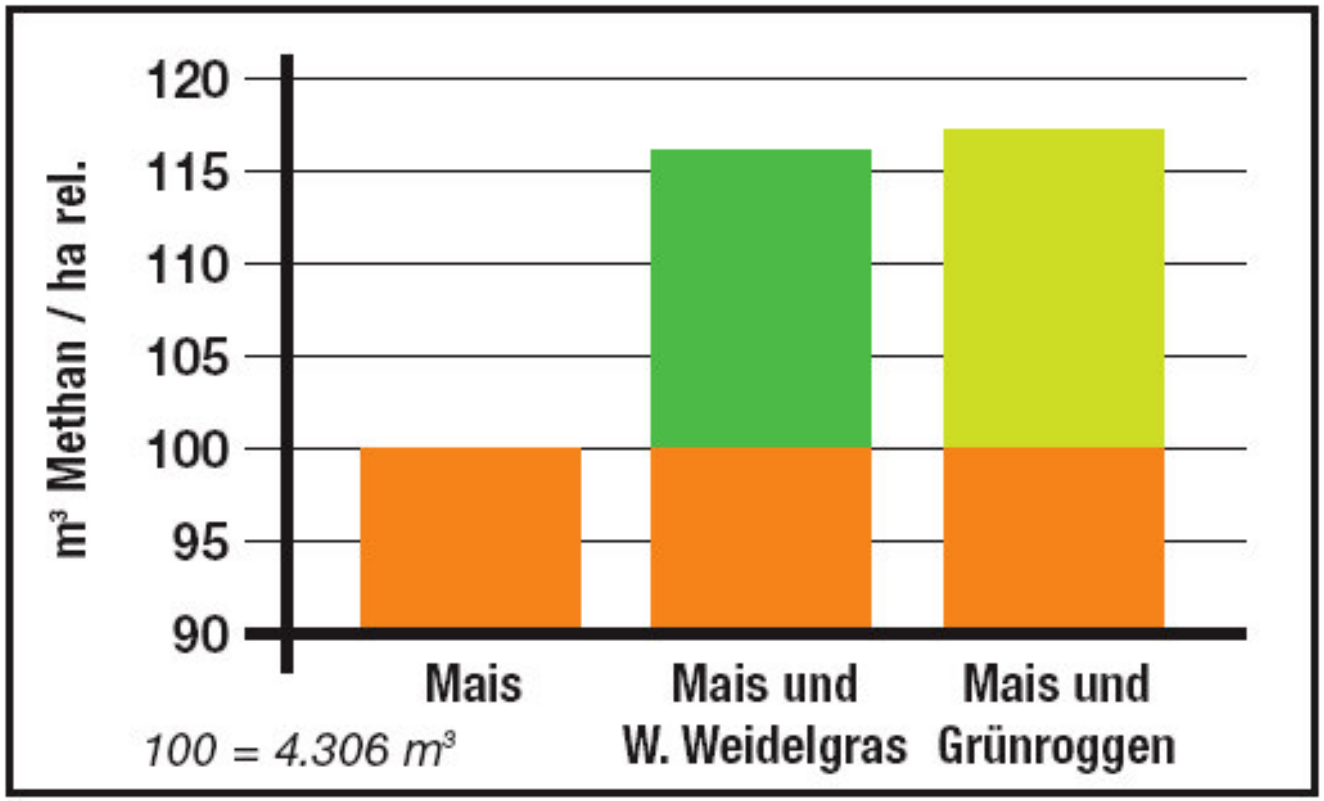
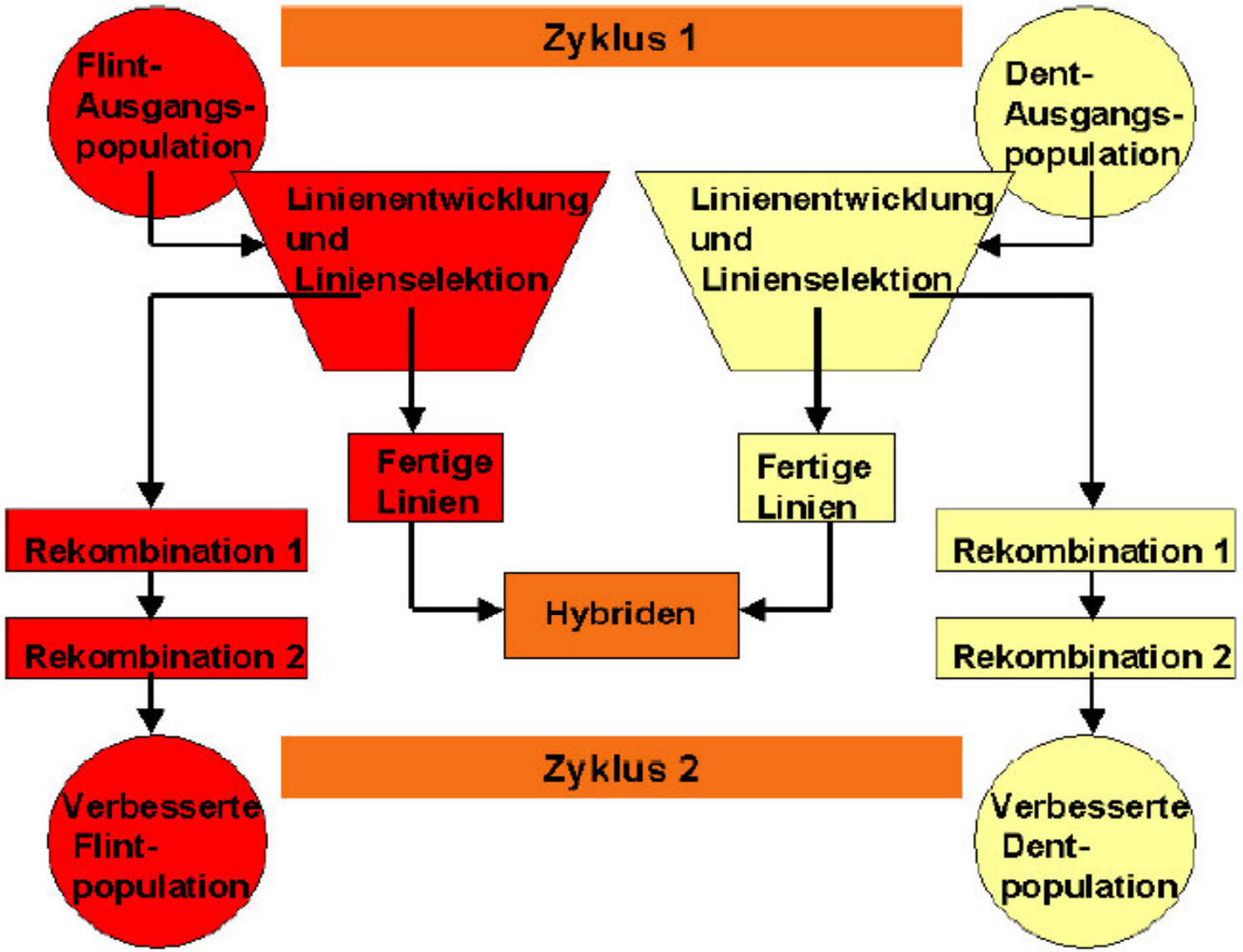
Effect of the previous crop – maize or mixtures of maize with Italian ryegrass and forage rye - on methane yield of maize



nach: GRÖBLINGHOFF und LÜTKE ENTRUP 2004



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

Hybrid breeding

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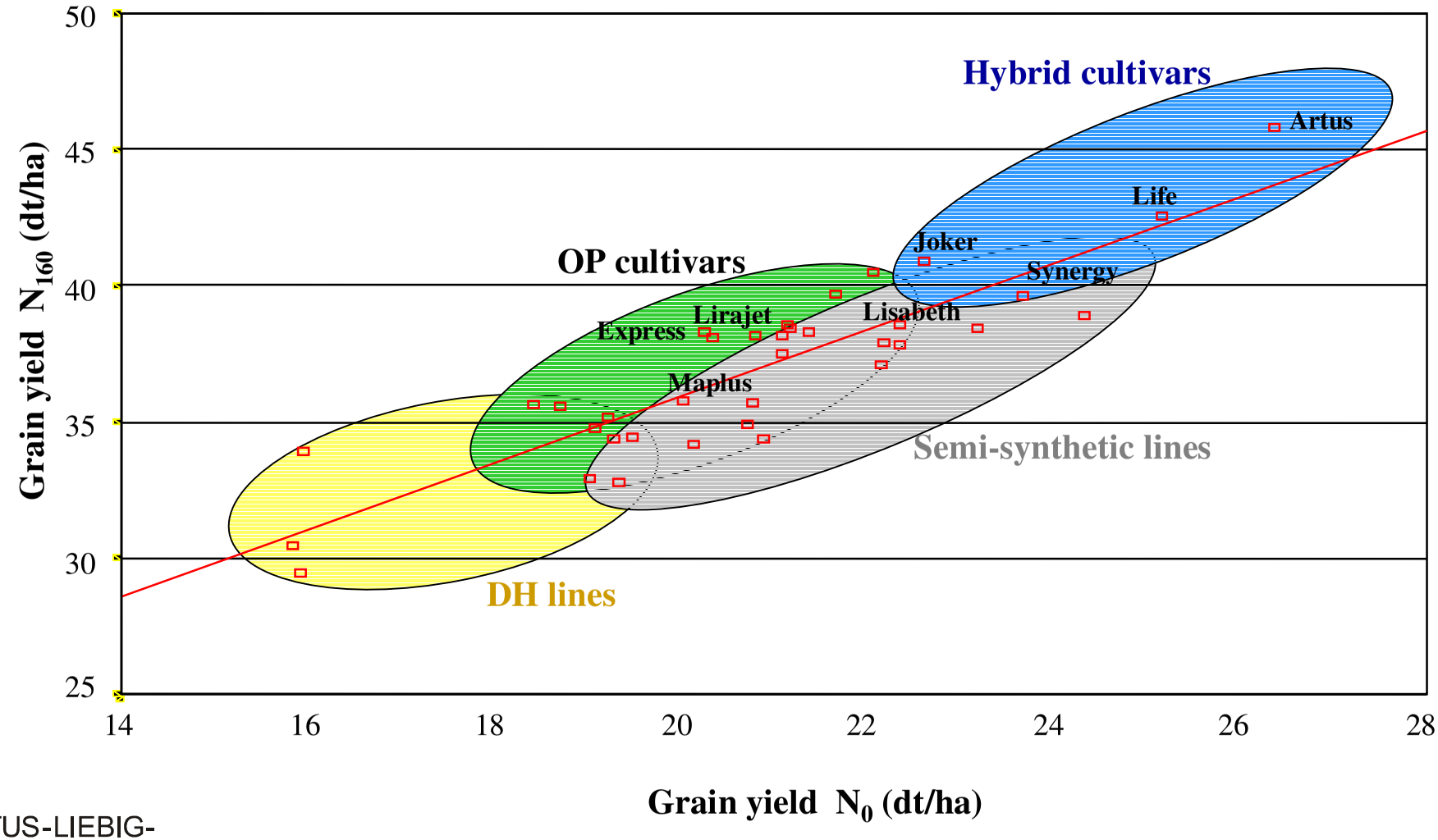
Grain yield of winter oilseed rape variety types

at varying N-supply



Rapeseed

Molecular markers: AFLPs

Mapping population:

F_2-Population:

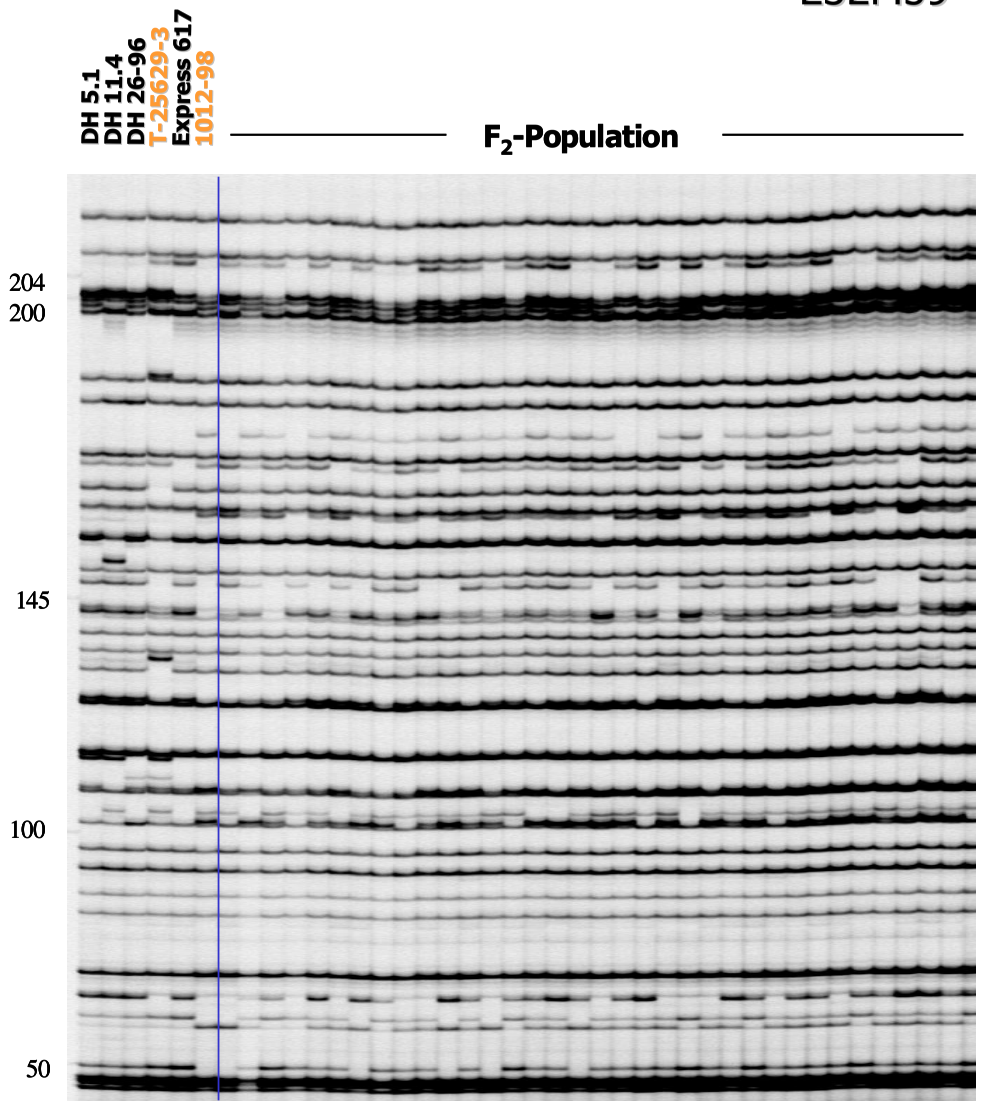
Express 617 x 1012-98

22 Primer combinations

DH-Population:

T-25629-3 x DH26-96

20 Primer combinations



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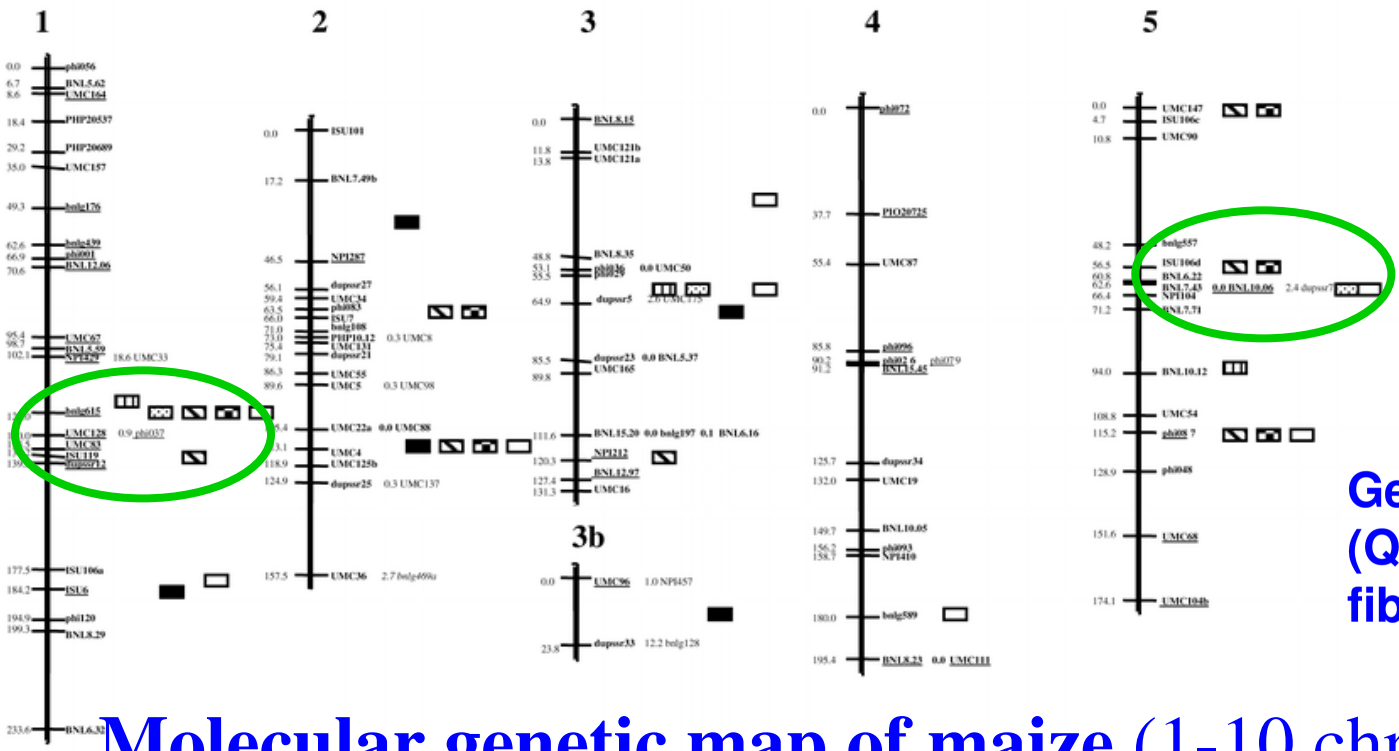
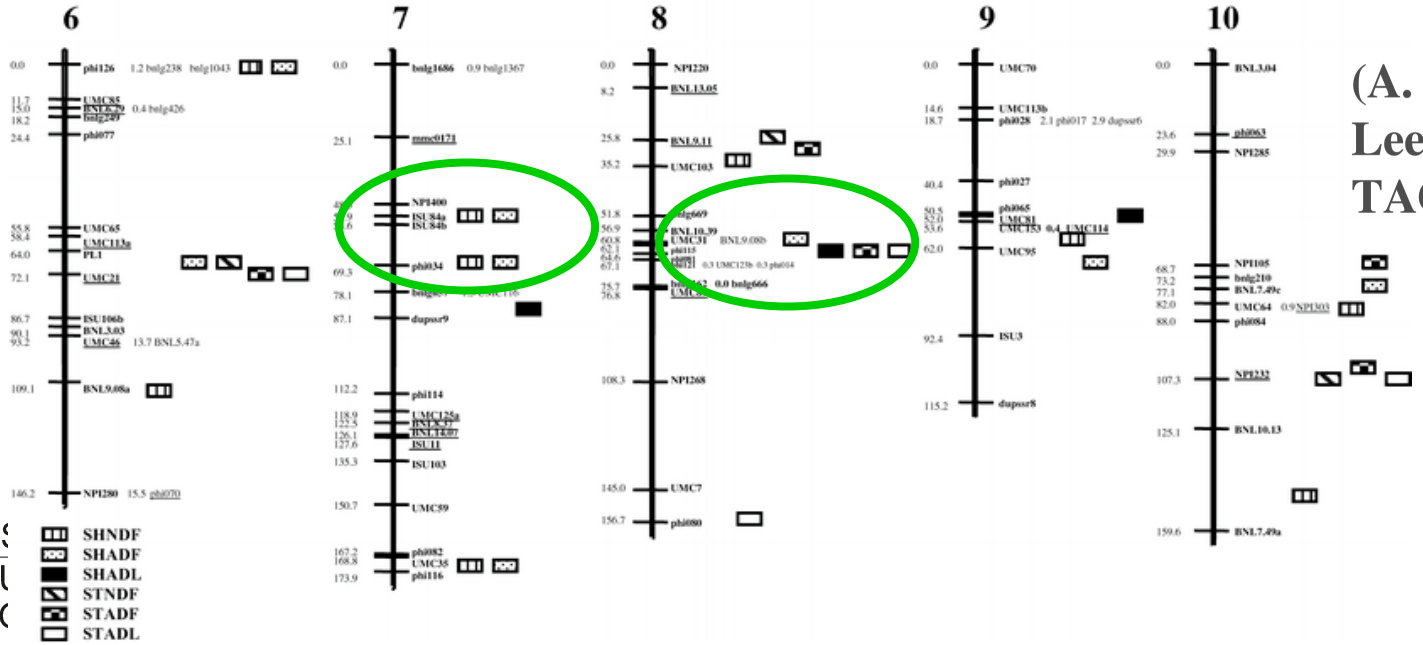


Genomic regions (QTL) relevant for fibre content

Molecular genetic map of maize (1-10 chromosomes)



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

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

Funding

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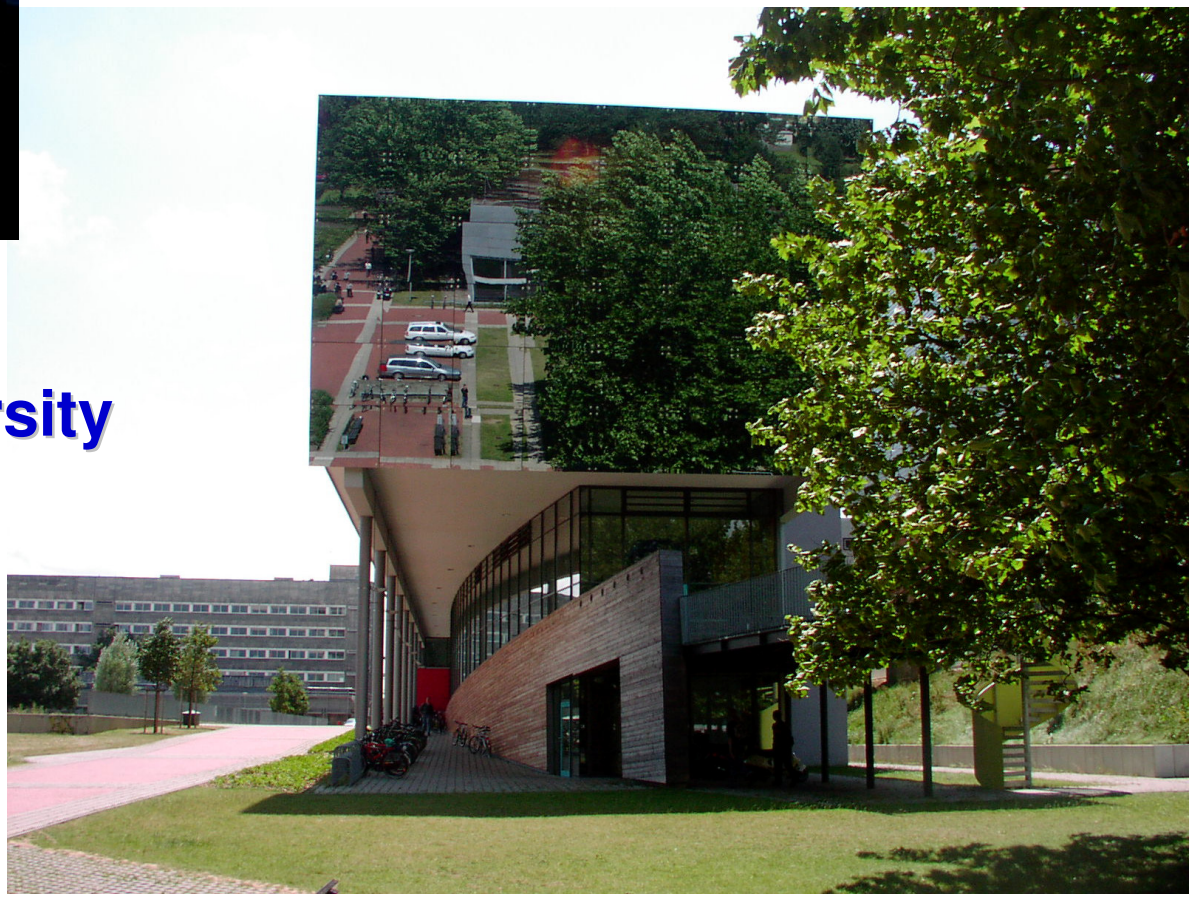

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