Production potential of grassland and fodder crops in high-output systems in the Low Countries in north western Europe and how to deal with limiting factors

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Limiting factors in the Low Countries

(i) Tightening regulations resulting in reduced inputs and/or restricted freedom to use and crop the land
(ii) Scarcity of land
(iii) Changing climate
(iv) Changing attitudes of consumers

Black: predictable; Blue: ± unpredictable

High-output systems + with limiting factors

≈ **more** (high output) with **less** (limiting factors)

In practice focused on:

Nutrient use **Land use**

≈ nutrient use efficiencies Competition for land

≈ improved eco-efficiency *Horsification*

≈ **sustainable intensification** What

Scope of the presentation

1. Land use

2. Strategies to optimize yields: GAP and
   plant breeding

2.1 Grassland

2.2 Forage maize

3. Conclusion

Land use: horsification

Flanders
140 000 horses, 70 000 ha
Horses/dairy cows: 1/2.9
(Bomans *et al.* 2011)

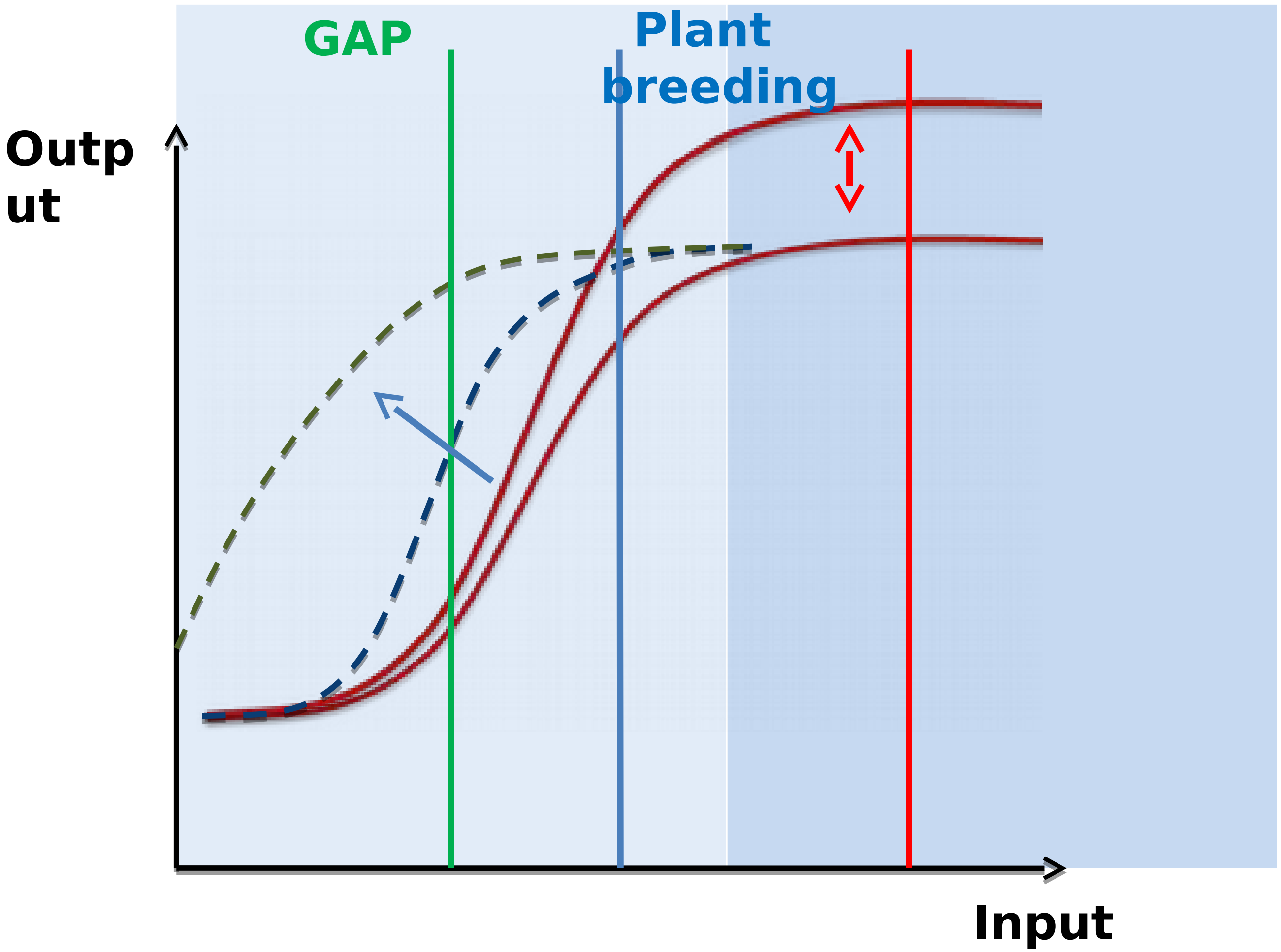
The Netherlands
400 000 horses, 200 000 ha
Horses/dairy cows: 1/2.8
(Van der Windt *et al.*

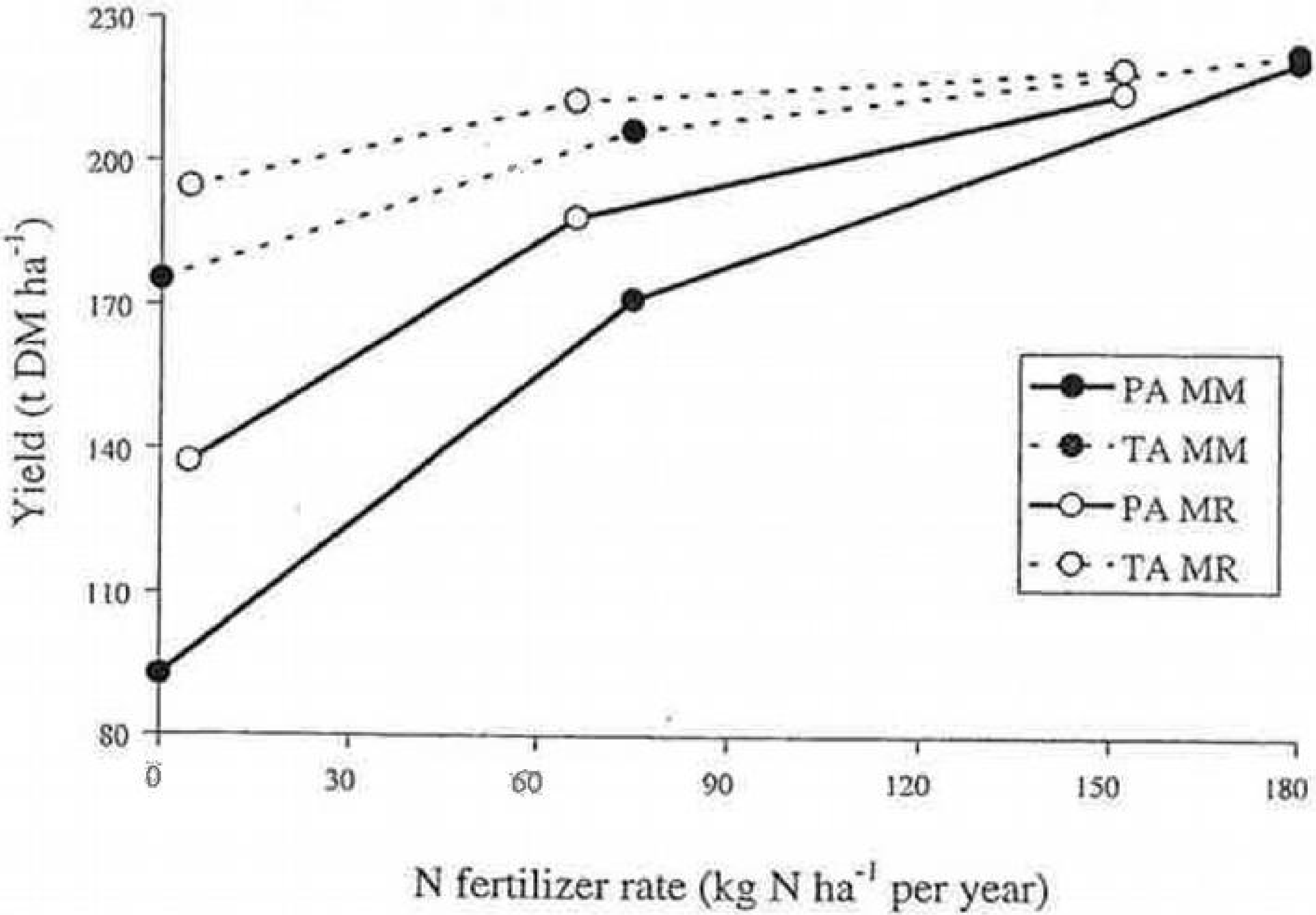
Strategies to produce more with less

(i) Foster what you have = good/ best agricultural practices (GAP/BAP)
(ii) Plant breeding

Success factor is the possibility to modify the production curve in 2 different ways

Modifying the production curve




230
200
170
140
110
80
Yield (t DM ha^{-1})
0
30
60
90
120
150
180
N fertilizer rate (kg N ha^{-1} per year)
PA MM
TA MM
PA MR
TA MR

Grassland

GAP

- Application of N: the less N the less CP in the grass !
- Grassland management
- **Grassland renewal**

GAP: grassland renewal

(i) Management to restrict renewal
(ii) If necessary: "**install grassland in arable land"**

Compared to grassland in grassland:

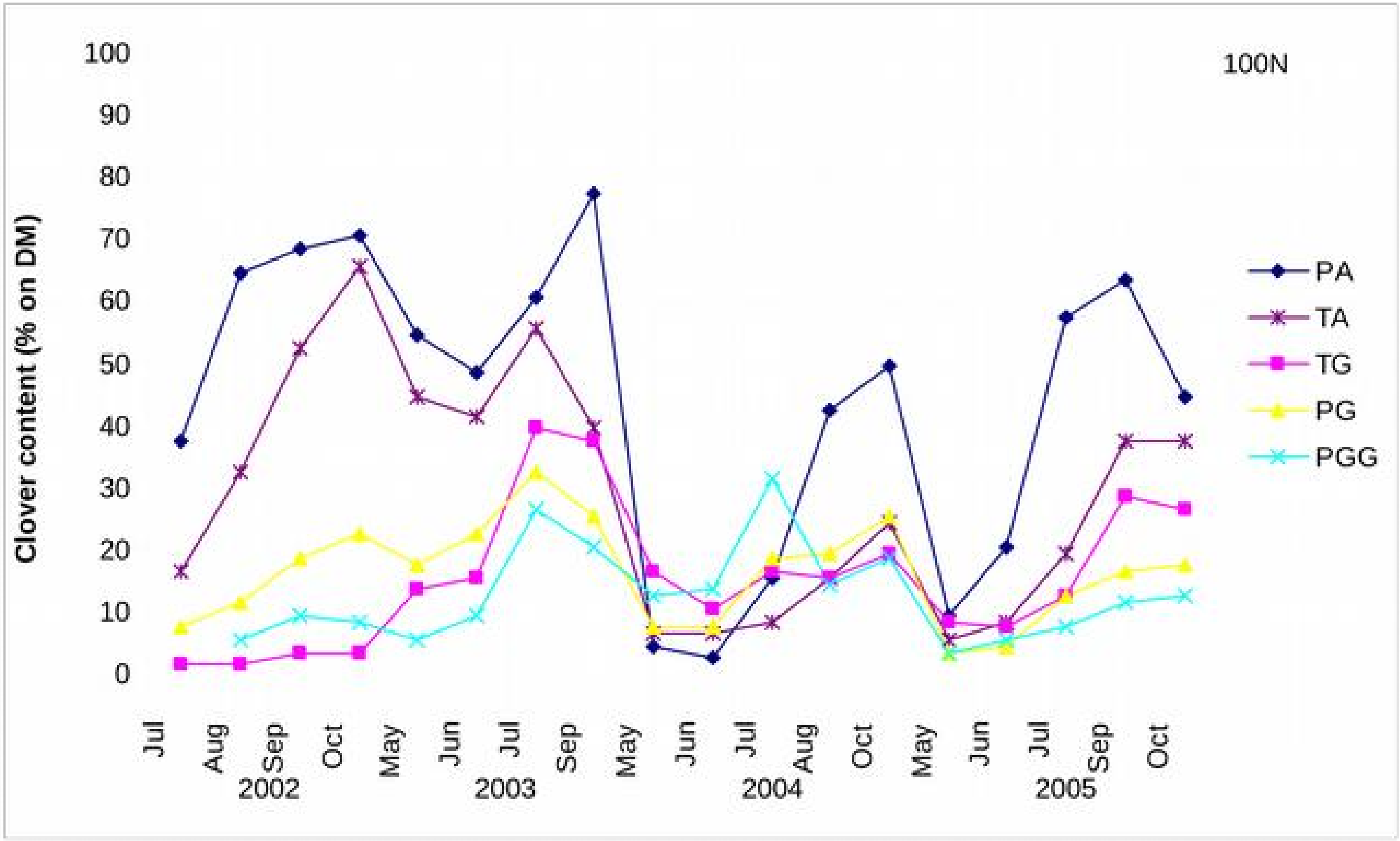
- Better drought tolerance
- Better white clover persistency

GAP: better drought tolerance in arable land

DM yield of resown (spring 2002) grass-white clover related to previous land use. Cutting management. Averages of 0, 100 and 300 kg N/ha (Bommelé, 2007)

Previous land use	2003 very dry	2002-2005	2003-2005
PA	100	100	100
TA	87	94	94
PG	85	93	91
TG	68	84	83
PGG	65	87	81
LSD	*8.2*	*8.0*	*8.8*
100 = .. kg/ha	14280	12610	13490

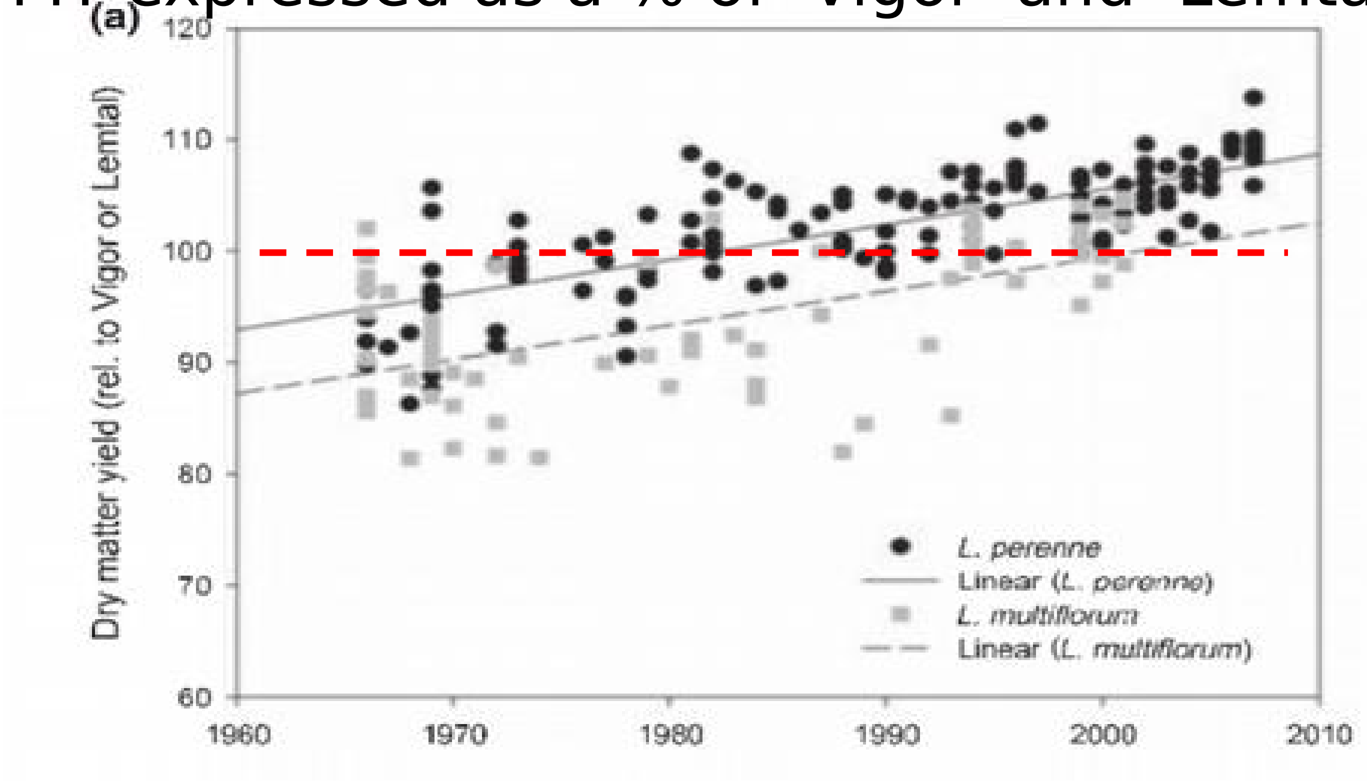
GAP: more clover in arable land



Breeding

Genetic progress in **DM yield** of *Lm* and *Lp*

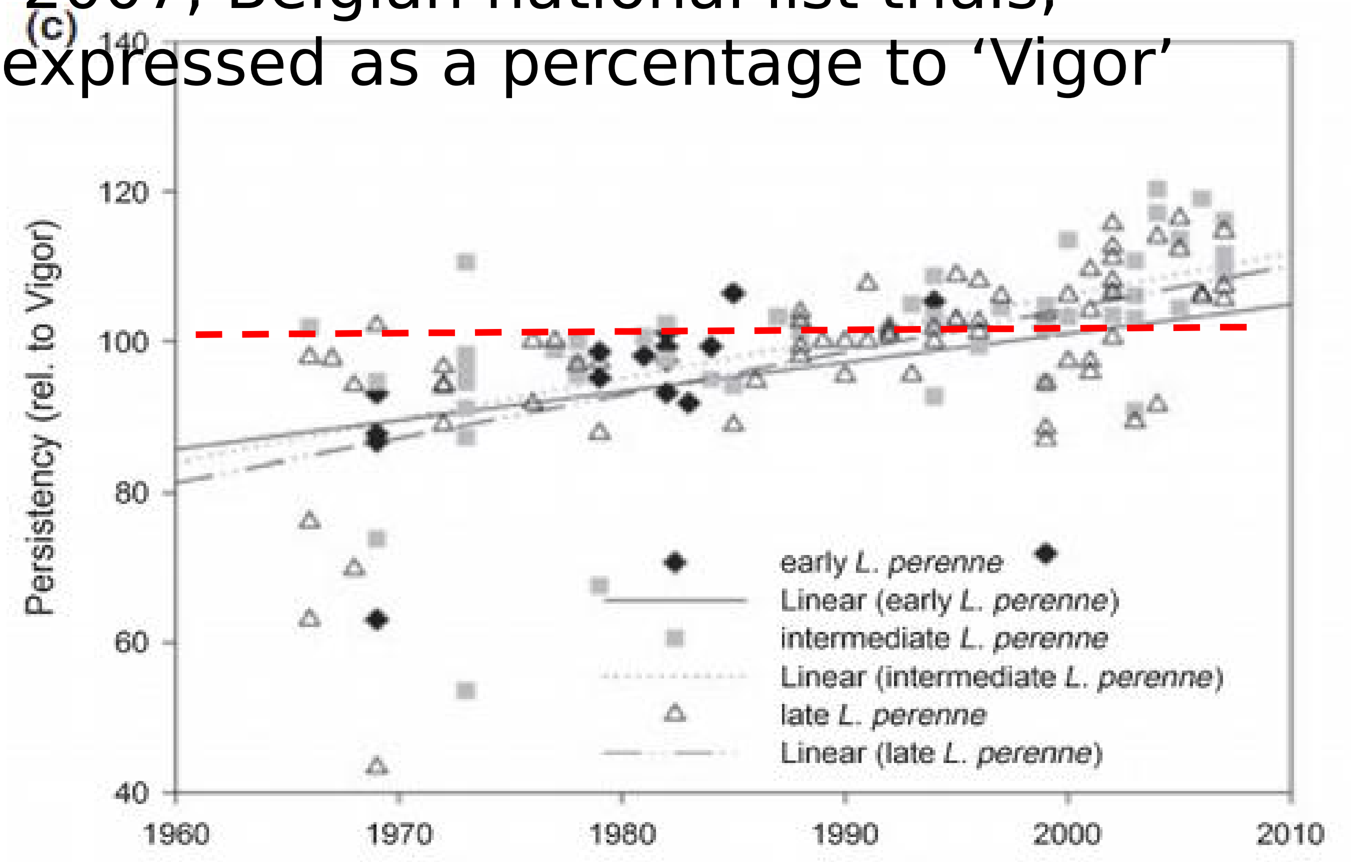
Belgian National List Trials, 1963-2007,
DMY expressed as a % of 'Vigor' and 'Lemtal'



Chaves *et al*. 2009

Genetic progress in **persistency** of ***Lp***

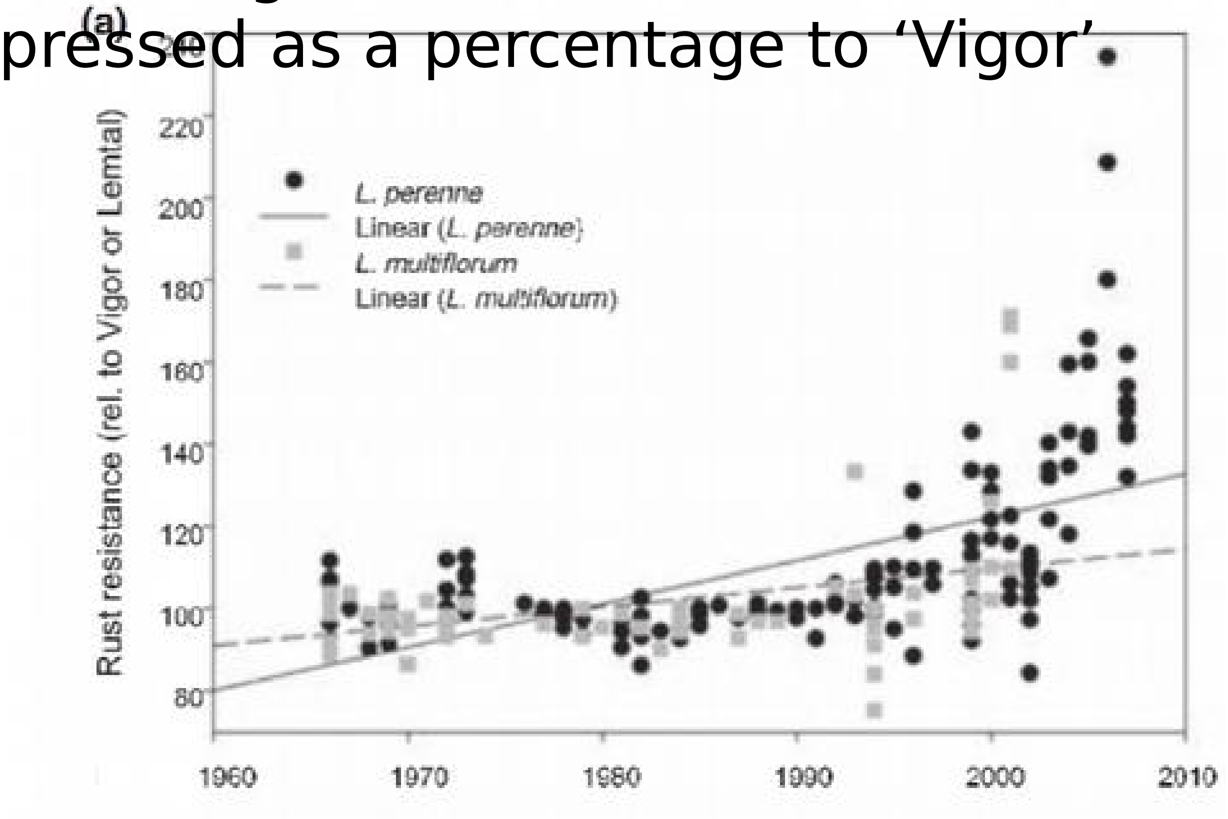
1963-2007, Belgian national list trials,
DMY expressed as a percentage to 'Vigor'



Chaves *et al.* 2009

Genetic progress in **crown rust resistance**

1963-2007, Belgian national list trials,
DMY expressed as a percentage to ‘Vigor’



Chaves *et al*. 2009

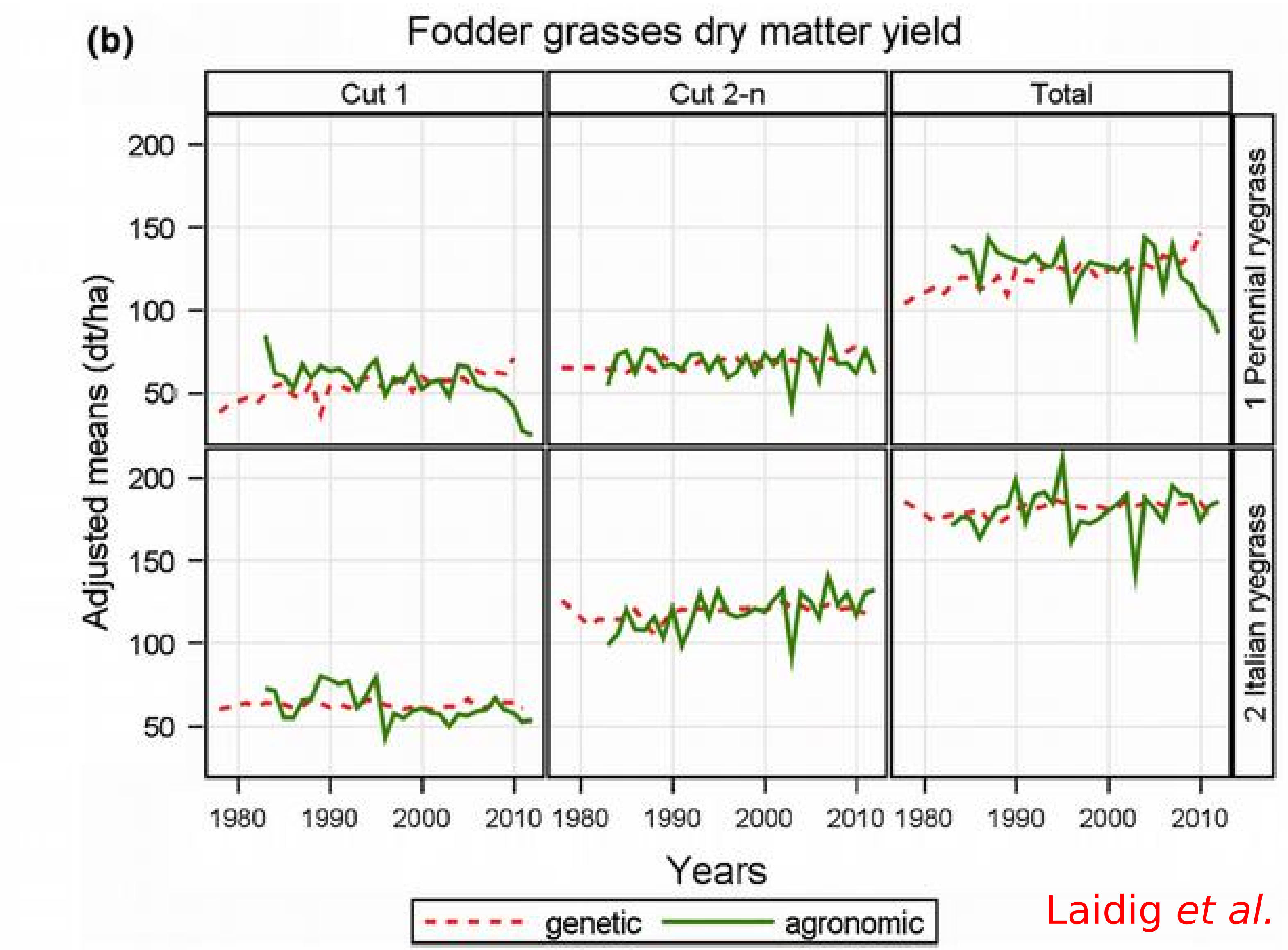
Breeding: summary

Annual **genetic** progress in the period 1963-2007

In % rel to 'Vigor' for *Lolium perenne* (Lp)
rel to 'Lemtal' for *Lolium multiflorum* (Lm)

	DM yield	**Persistency**	**Crown rust**	
	1963-2007	1963-2007	1963-2007	1990-2007
Lp	0.31	0.59	1.1	3.6
Lm	0.23	0.54	0.47	6.2

- Healthier *Lolium*
- Slightly more persistent and more productive



Lp

L
m

Laidig *et al.* 2014

Agronomic ? Non-genetic = management, climate change, political decisions,..

Progress by mechanisation and organisation

Progress by other species

Pros and cons of tall fescue (*Fa*) compared to *Lp*
(Cougnon *et al.*, 2014), **Belgium, 190 and 300 kg N/ha/year**

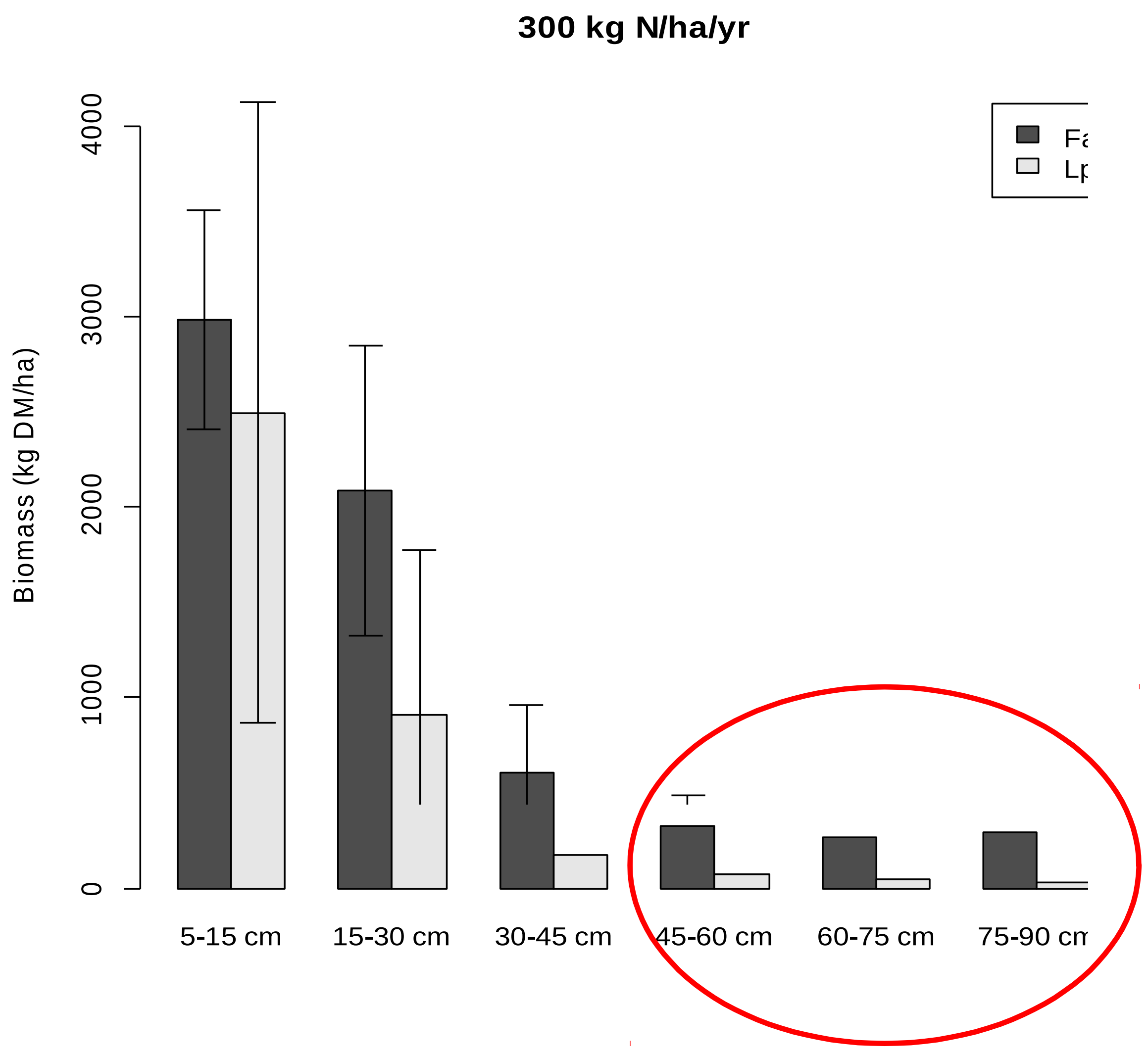
+

- **Averaged over 3 years after year of establishment: + 23% DM yield**
- **In dry spells: 50% more DM**
- **Comparable N-content, hence better N-export and N-productivity**
- **More roots and deeper rooting**

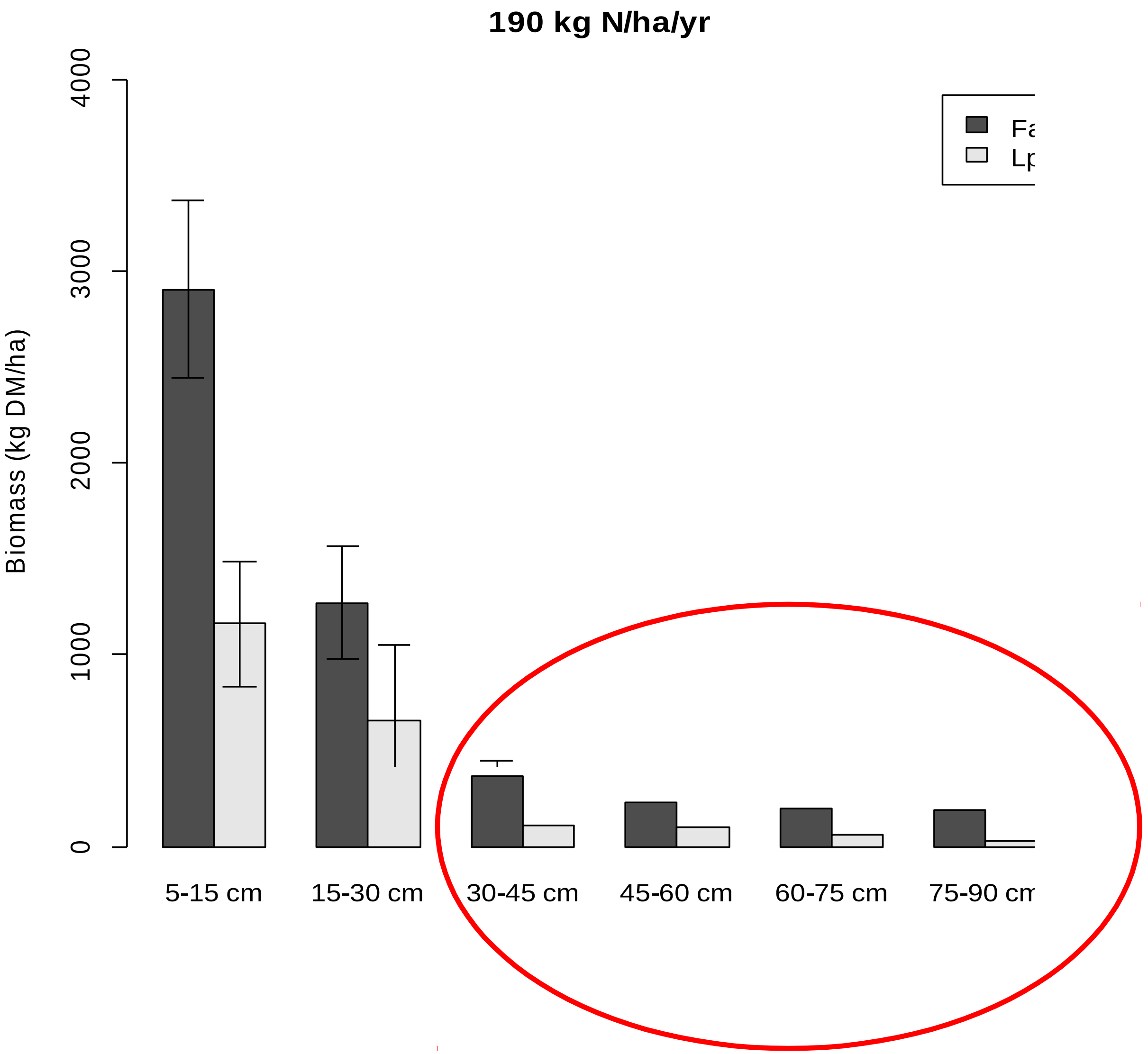
-

- **Low animal preference under grazing (? Wilted and conserved grass)**
- **Lower digestibility (approx. 7%-units less than *Lp*)**
- **Slow establishment**

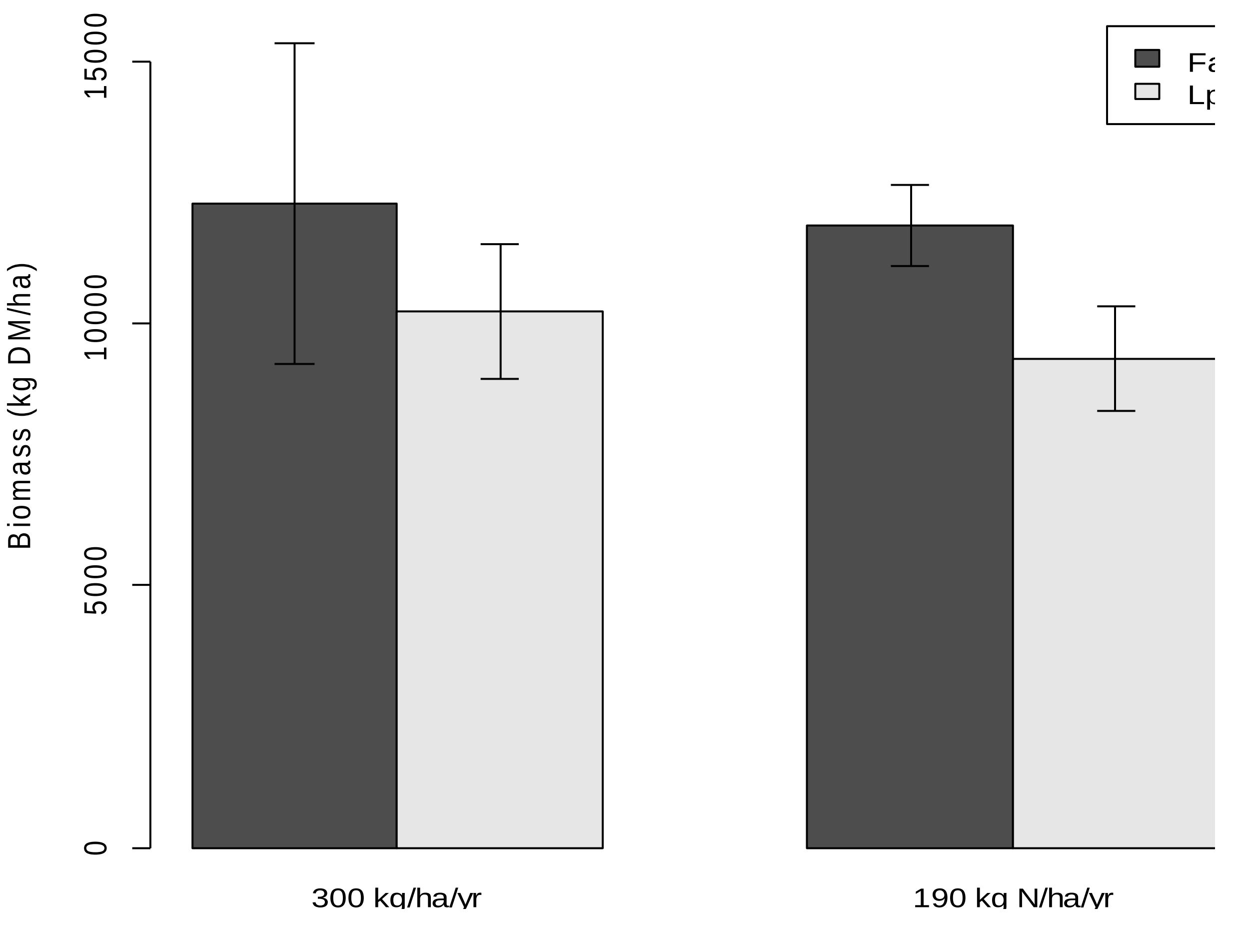
Root biomass (-5 to -90 cm)



Root biomass (-5 to -90 cm)



Stubble biomass (+5 to -5 cm)



Forage maize

Importance of forage maize

Rations maize to grass in Flanders	
October-end of April	60/40 (grass silage)
May-end of September	50/50 (grazed + conserved grass)

More or less equal areas of maize to grass
circa 0,2 ha grass and 0,2 ha maize per cow

Agronomy of silage maize

Very tight crop rotation or in monoculture

Increasing problems with

-weed control (e.g. C_4 grasses)

-pests (*Diabrotica virgifera virgifera*), nematodes

-Fusarium fungi

-soil organic matter

Slowly changing attitude

-Regulation: crop diversification topic within the greening of CAP

-**Practical necessity**: weeds in monocropping up to 20% less sensitive to foliar-applied maize herbicides than in rotation (Claerhout *et al.,* 2015)

GAP: “grow maize in rotation”

Borelli et *al.*, (2014), Po Valley, 26 year trialling, sandy loam soil, different rotations

(i) “crop rotation improved **yield stability**, the longer the rotation, the better the stability”
(ii) “Crop rotation can **compensate for reduced inputs**”
(iii) “An **insurance** against low yielding years”

GAP: maize in rotation

Field trials in Belgium, sandy loam soil, 1987-2000

maize in monoculture (MM) *versus* maize in a 3 year rotation cycle (MR)

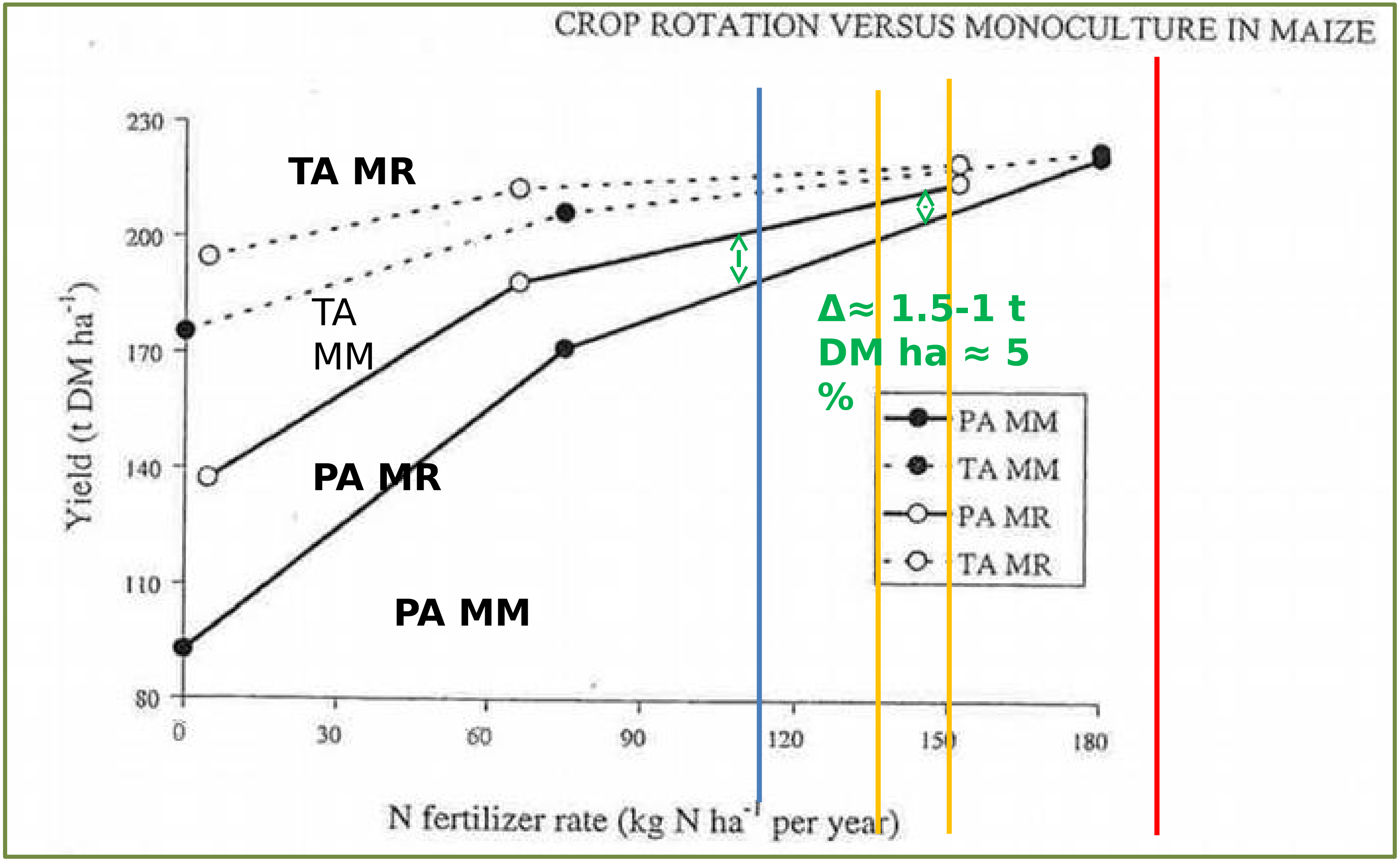
Maize, fodder beet, faba bean

Fodder beet, maize, faba bean

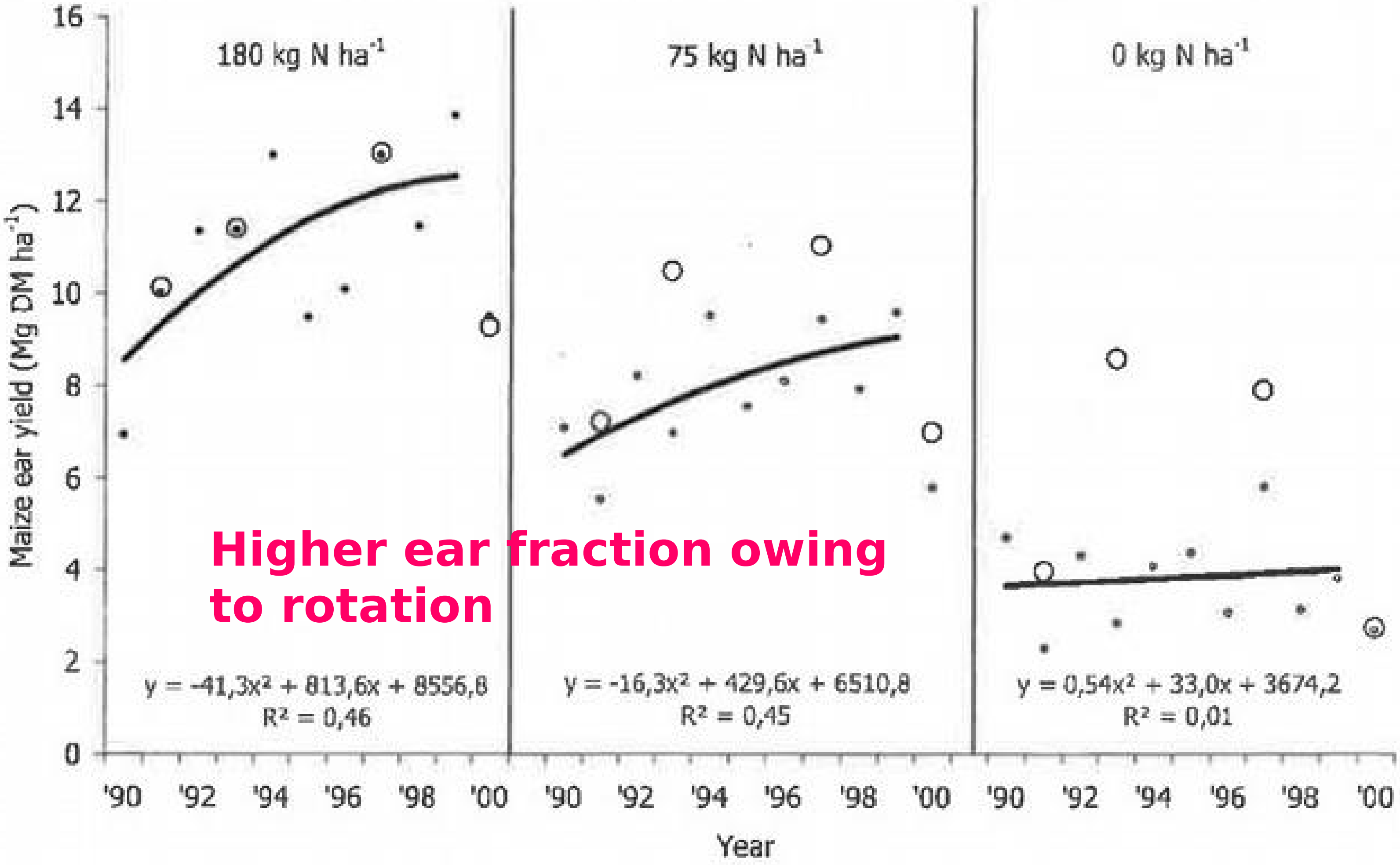
Fodder beet, maize, maize

In 80% of cases: MR > MM

Yield bonus of MR: NS at 180 N; + 25% at 75 N



Nevens and Reheul, EJA (2002



Ear DMY of forage maize in monoculture *versus* rotation
Open circles: maize in rotation; dots: maize in monoculture
Nevens and Reheul, NJAS (2002)

GAP: “apply ley arable rotation”

In theory

-Plenty of opportunities: $\underline{+}$ 1:1 ratio in land use for forage maize and grass
-Allows to save N (not a driver, since many dairy farms have plenty of (organic) N)
-Increases soil organic matter and soil organic carbon
-Allows to take advantage of grass breeding in ley phase

Ley arable rotation

Field trial M.66.1 (Belgium, sandy loam soil)

1990-1998; 3 year grass/3 year arable;
Grassland: first growth cut, later **grazed**; 300 kg N/ha/y; Low white clover abundancy
Forage maize on arable land: 0, 75, 180 Kg N/ha/y

NFRV: 250 kg N/ha/y, divided (%) as approx, 50/30/20 in Y1,2,3 respectively

No need for N during Y1, whatever the crop

	Responsible farming
Maize monoculture, 180 N	Maize in ley/arable system Y1: 0 N Y2: 75 N Y3: 180 N
DM yield: results of 9 years	
177 500 kg DM (100)	173 100 kg DM (98)
N: 1620 kg (100)	N: 765 (47)
109 kg DM/kg N (100)	226 kg DM/kg N (207)
N content (%) in DM in year 2 of arable period	
9,0	9,7

C sequestration in ley/arable system: approx 400 kg C/ha/y (annual mean over 35 years)

±30000 kg C/ha in top soil in arable at the end of the 35 y period,
±60 000 kg C/ha in permanent grassland

Ley arable rotation

Does the management in the ley period matter ?

Hypothesis: less N available for forage maize when ley was grazed compared to cut

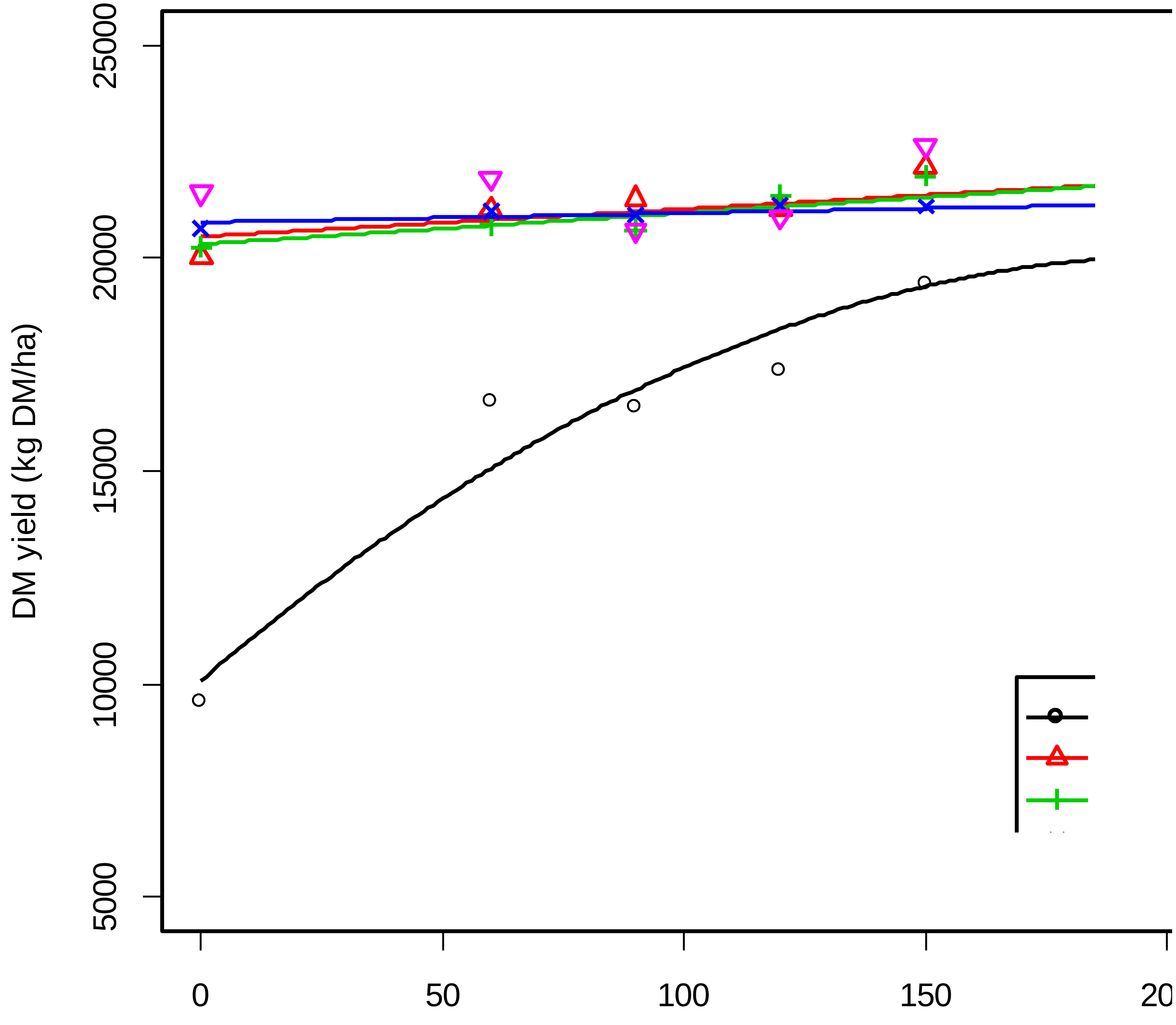
Hypothesis **not** confirmed (no significant differences) in our trials

Ley phase 2005-2007

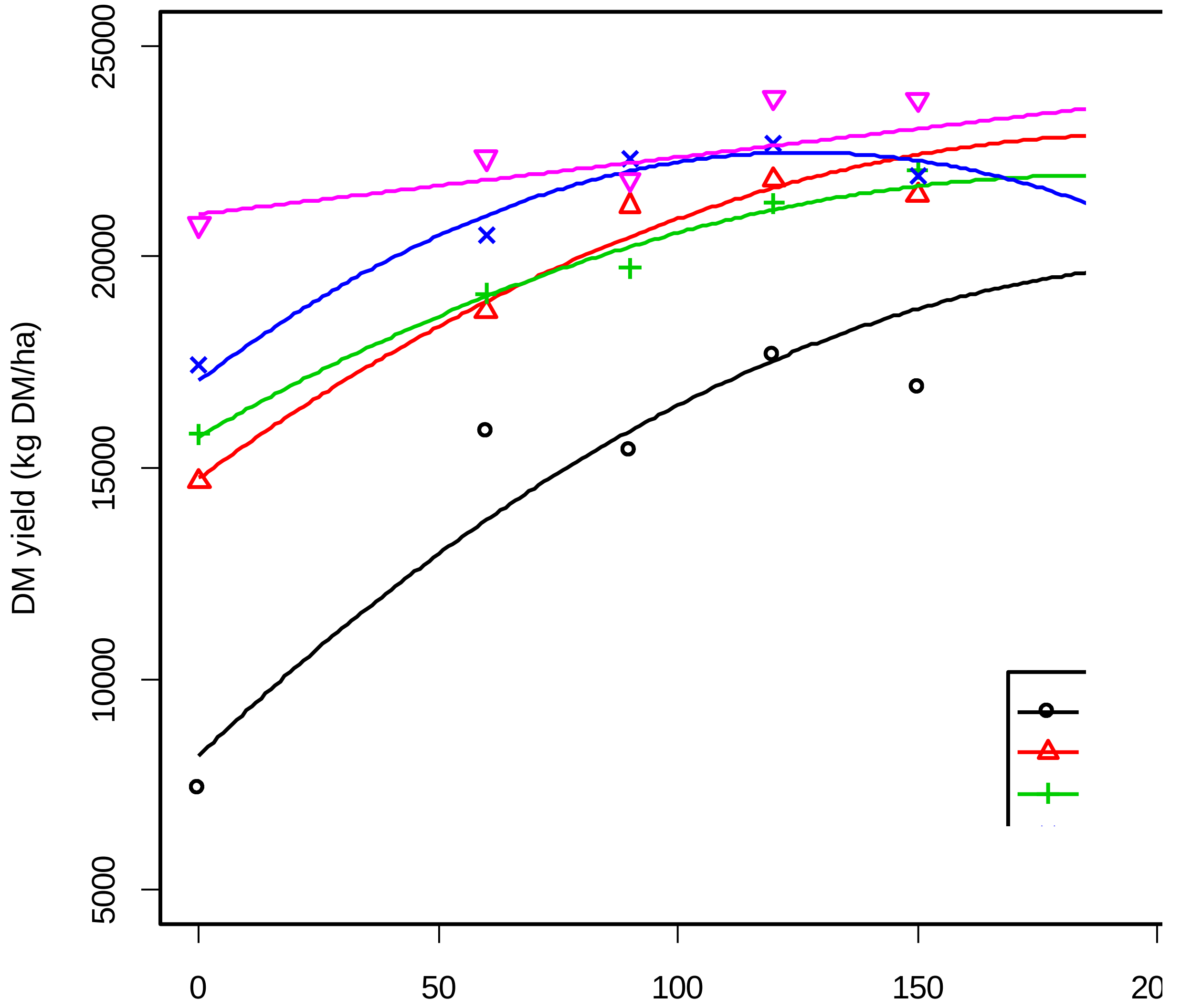
Ley Phase 2005-2007

- PA: Permanent arable land; maize monoculture
- TGg: Grazed temporary grassland
- TGc: Cut temporary grassland
- PGg: grazed 2005-2007
- PGc: grazed 2005-2006, cut in 2007

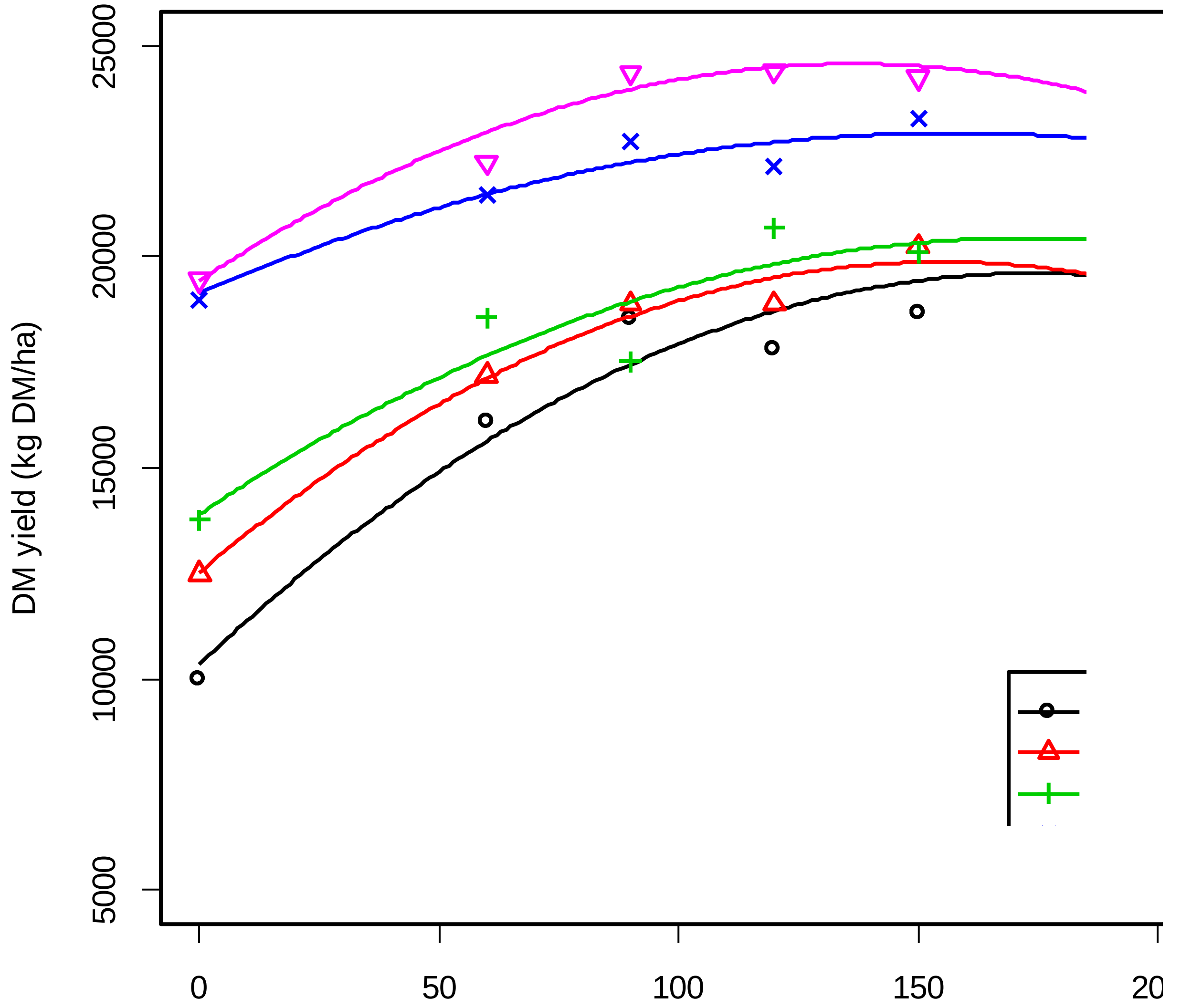
Results Maize yield 2008



Results Maize yield 2009



Results Maize yield 2010



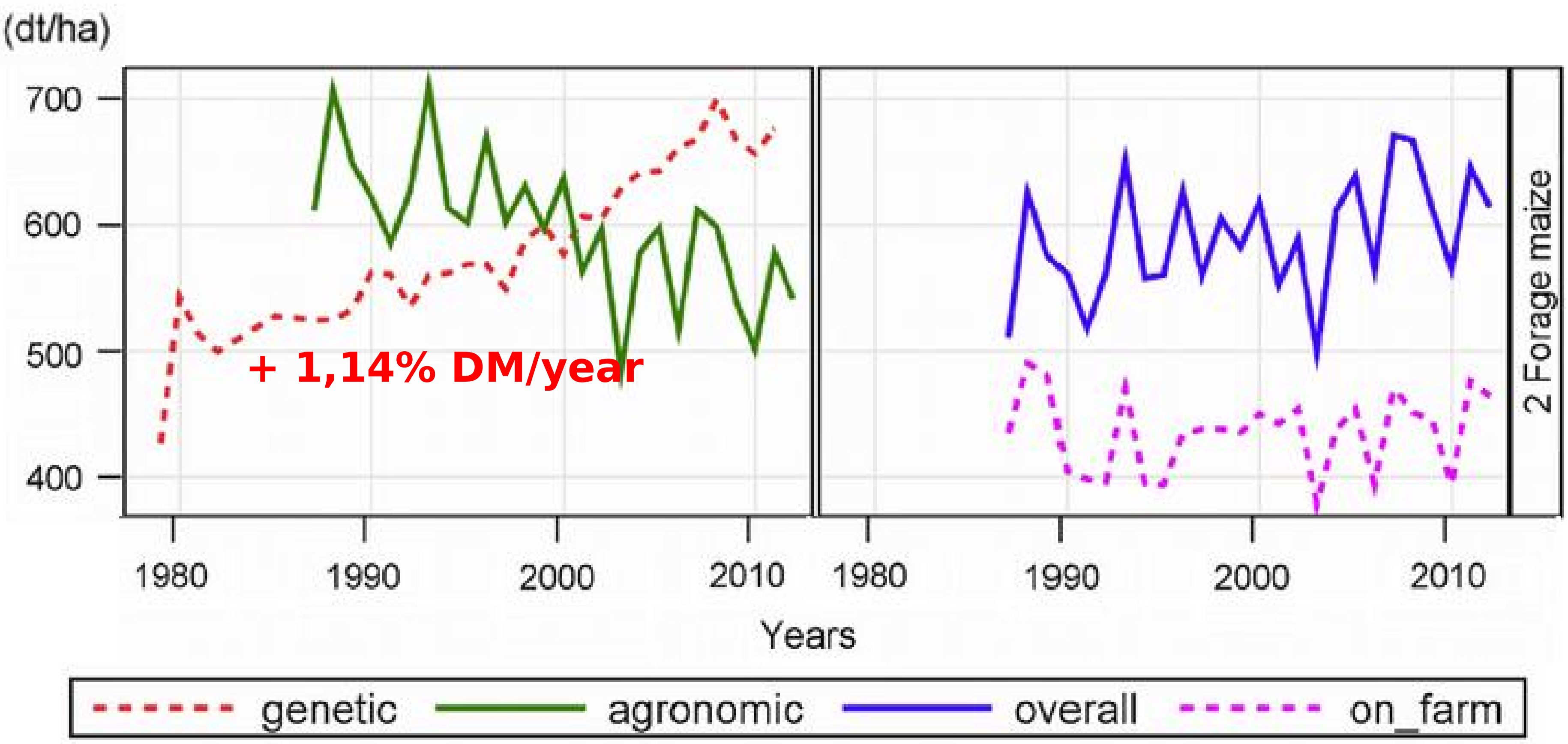
Responsible farming: N fertilization to obtain yield of reference situation (PA 150 N)

Year 1			Year 2			Year 3		
	N	yield		N	yield		N	yield
PA	**150**	**100 (19364 kgDM/ha)**	**Pa**	**150**	**100 (16912 kg DM/ha)**	**Pa**	**150**	**100 (18672 kg DM/ha)**
TGm	0	103	TGm	**60**	111	TGm	**90**	101
TGg	0	105	TGg	**60**	113	TGg	**90**	94
PGm	0	107	PGm	0	103	PGm	0	102
PG	0	111	PGg	0	123	PGg	0	104

Breeding

German NL Trials, 1983-2012
Laidig *et al. 2014*

FY

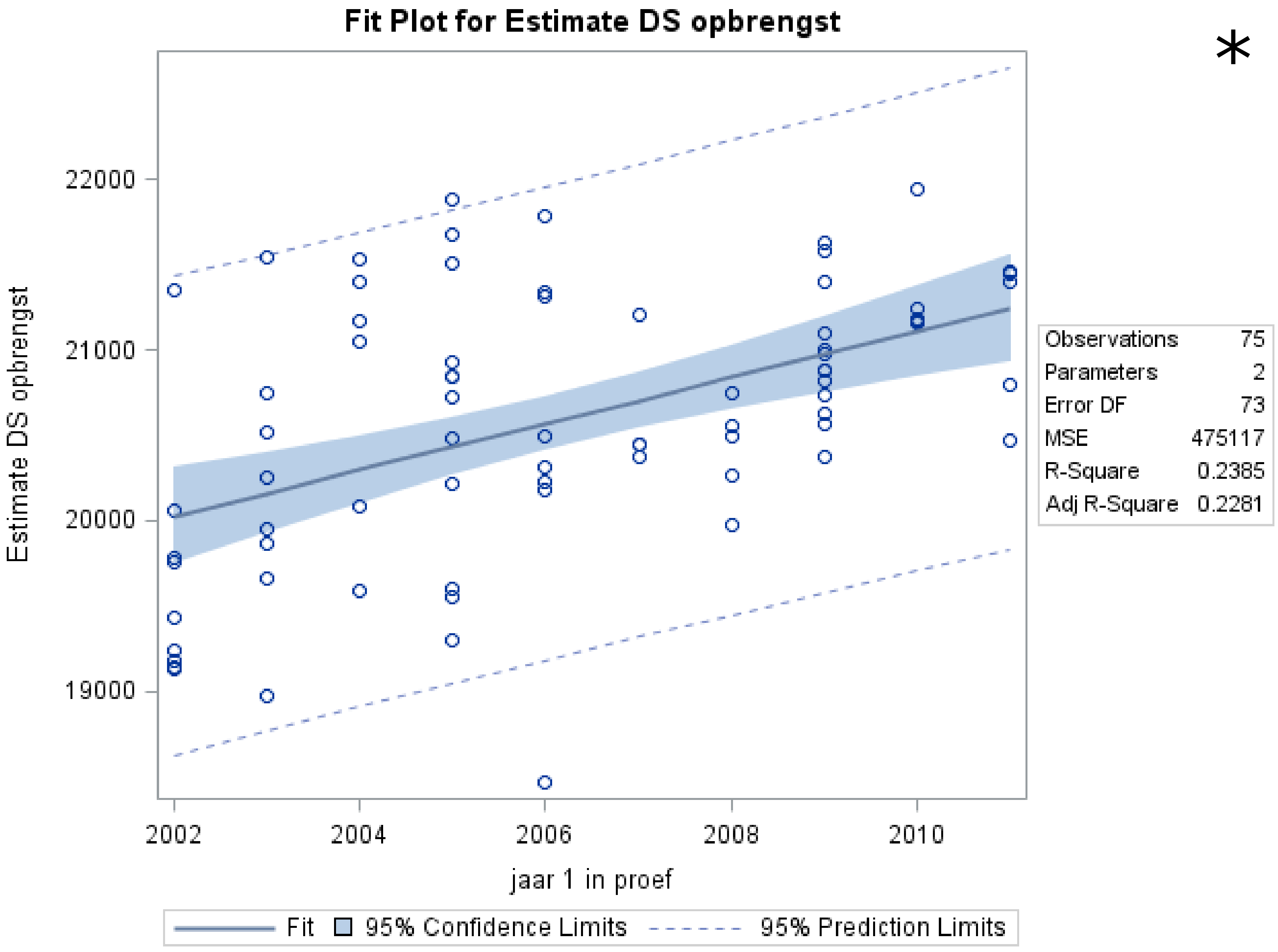



It takes GAP to take advantage of gain

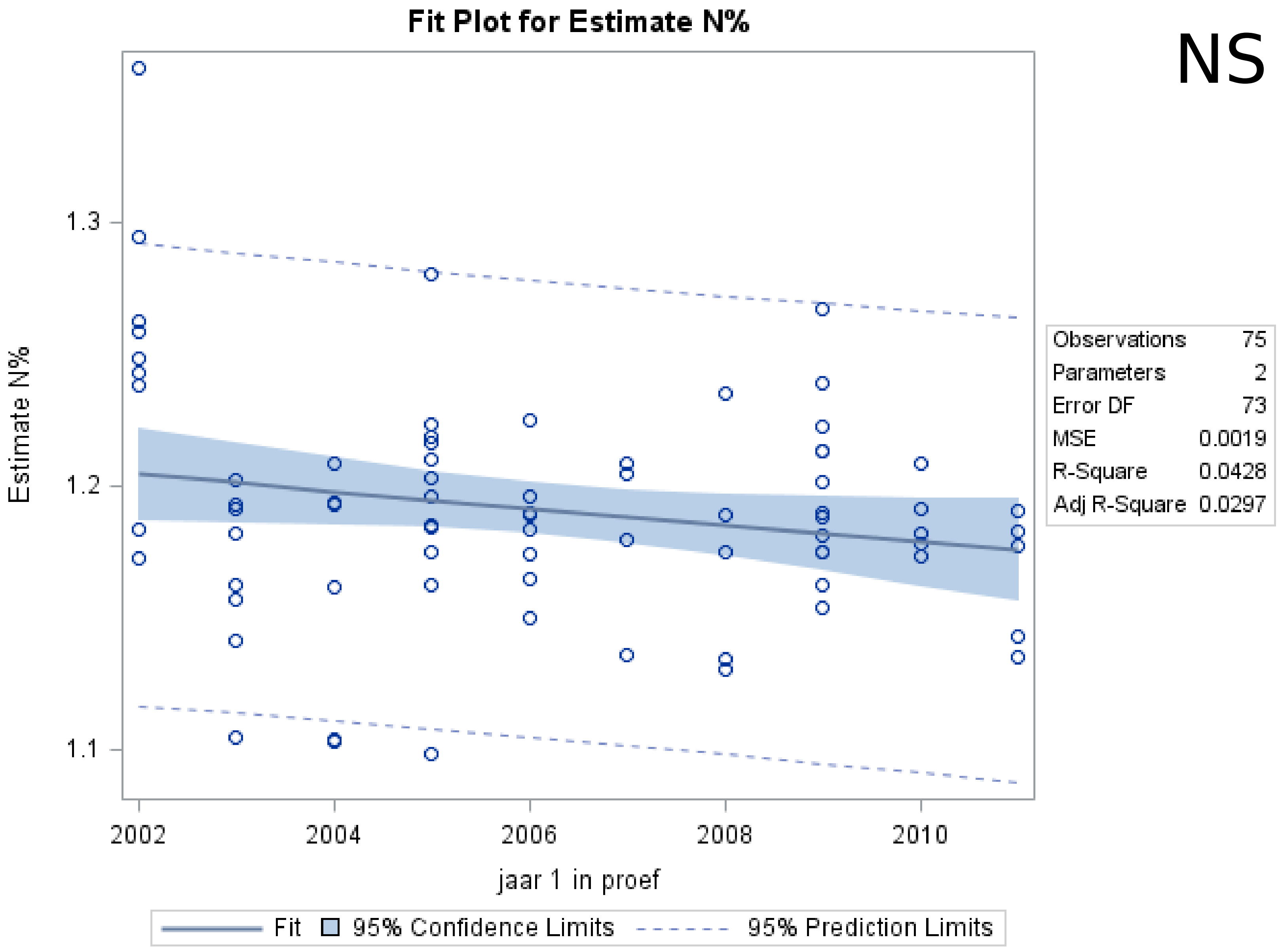
Residual soil nitrate

Q: Do high yielding (35% more in 30 years)
modern varieties export more nitrogen ?

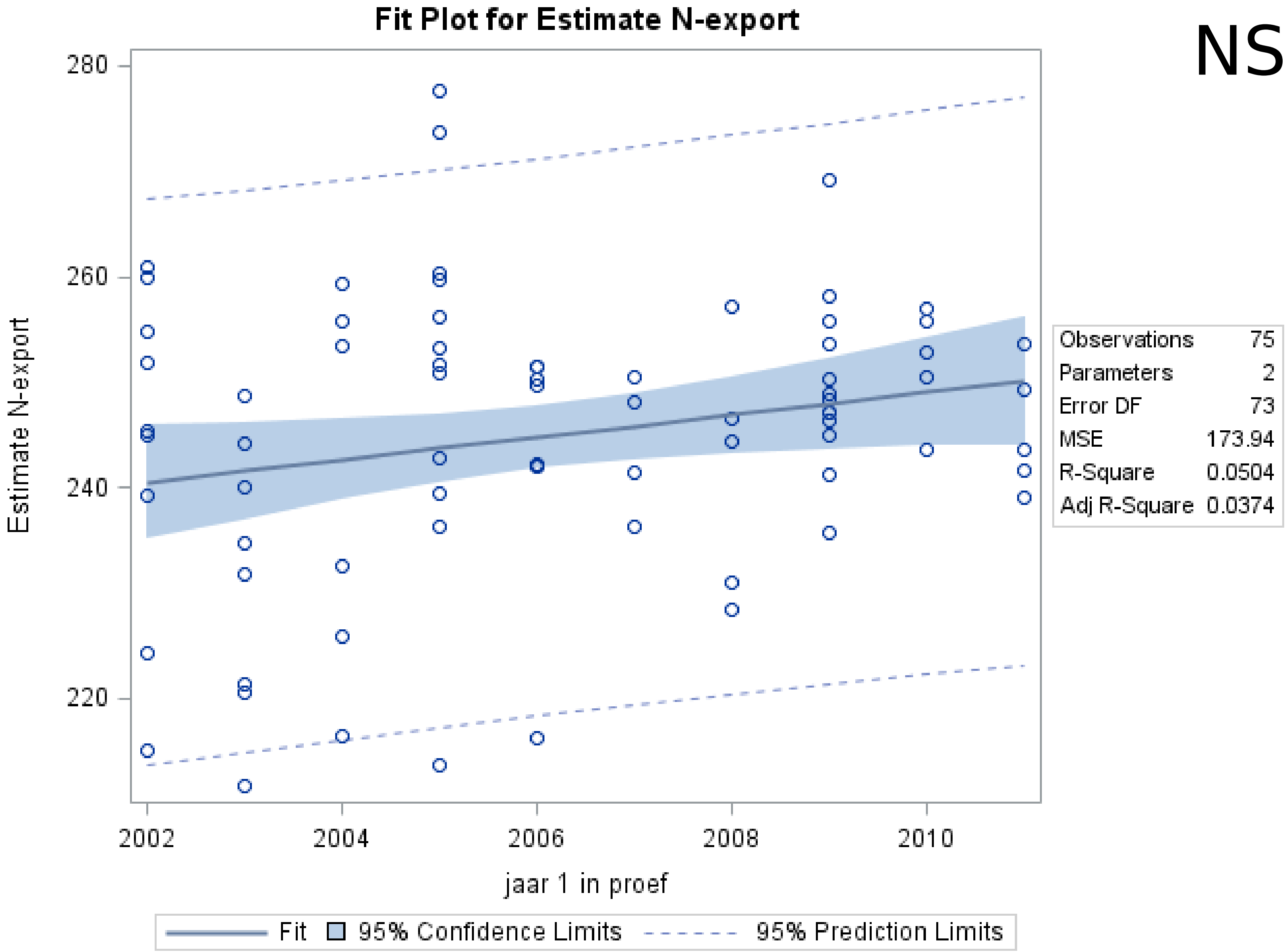
A: Slightly


Fit Plot for Estimate DS opbrengst
Estimate DS opbrengst
22000
21000
20000
19000
2002
2004
2006
2008
2010
jaar 1 in proef
Observations 75
Parameters 2
Error DF 73
MSE 475117
R-Square 0.2385
Adj R-Square 0.2281
Fit
95% Confidence Limits
95% Prediction Limits

*


Fit Plot for Estimate N%
Estimate N%
1.3
1.2
1.1
2002
2004
2006
2008
2010
jaar 1 in proef
Observations 75
Parameters 2
Error DF 73
MSE 0.0019
R-Square 0.0428
Adj R-Square 0.0297
Fit
95% Confidence Limits
95% Prediction Limits

NS


Fit Plot for Estimate N-export
Estimate N-export
280
260
240
220
2002
2004
2006
2008
2010
jaar 1 in proef
Observations 75
Parameters 2
Error DF 73
MSE 173.94
R-Square 0.0504
Adj R-Square 0.0374
Fit
95% Confidence Limits
95% Prediction Limits

NS

Fodder beet
perfect 3th crop in new CAP ?

Co-ensiling fodder beet with forage maize ?

Proportion of beet in maize silage: 25% (DM basis)

No negative effects
(i) on conservation
(ii) on performances of dairy cows

Cover crops to consume residual soil N

***Lp* and *Fa* tolerant to herbicides**

Conclusions

Optimising yields in intensive systems is possible by combining

(i) good agricultural practices
(ii) good mechanisation and organization
(iii) taking advantage of plant breeding