GCIRCBUL17*20

Development of Low-Input Oilseed Rape *(Brassica napus)* for Industrial Uses

Entwicklung von Low-Input Rapssorten (*Brassica napus*) für industrielle Verwendungen

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Introduction

Winter oilseed rape (*Brassica napus*) is the most important oil crop in Germany and the European Union. However, the production of oilseed rape is so far characterised by a comparatively high input, e.g. of nitrogen (N) fertiliser. The high level of production intensity leads to a considerable risk of post-harvest N losses by nitrate leaching (e.g. Aufhammer et al. 1994, Sieling et al. 1998, Sieling & Christen, 1999). A reduction of nitrogen input on the one side and/or an increase in nitrogen efficiency of oilseed rape cultivars on the other side (Riemer et al. 1998, Kessel & Becker 1999) could lead to a lower risk of nitrate leaching. Furthermore, a reduction of chemical inputs can also decrease the costs of production and enhance the economic competitiveness of rapeseed as compared to the production of other grain crops, i.e. cereals. A more cost efficient rapeseed production will be essential in the near future considering the reduction of oilseed allowances according to the Agenda 2000 of the European Union (cf. Müller et al. 1999).

Materials and methods

To determine differences in nitrogen efficiency and low-input suitability of rapeseed, field trials at three different locations were carried out from 1997 to 1999 in the Lahn-Dill-Region, Hesse, in the central part of Germany. The locations are characterised by different soil origin and climatic conditions ranging from high fertility at the research station of the our institute in Rauischholzhausen and Mardorf near Marburg/Lahn (altitude 200–295 m) with loess soils, i.e. 65–80 points (according to the national soil classification with a scale up to 100 for highest fertility in Germany) and two locations with less favourable cropping conditions in

Hohensolms (altitude 300–360 m, 35–50 points, decomposited slate soil) and Niederhörlen (altitude 340–360 m, 30–40 points, decomposited slate soil). Conventional tillage systems (plough, rotary harrow) were used in Rauischholzhausen and Niederhörlen whereas in Hohensolms a reduced tillage system (chisel, rotary harrow) was applied. A set of 36 genotypes including modern hybrid cultivars, open-pollinated varieties and inbred lines (double-low-varieties [00] and high-erucic-acid genotypes [HEAR]), were tested under varying fertilisation levels of 0 kg N/ha (N_0), 80 kg N/ha (N_{80}) and 160 kg N/ha (N_{160}). Amongst the HEAR material semi-synthetic inbred lines derived from resynthesized rapeseed were included (Lühs & Friedt 1995, Friedt & Lühs 1998). The endogenous Nitrogen content of the soil (N_{min}, 0–90 cm depth) at the beginning of vegetation was determined and considered for calculation of the respective fertilisation rates. Above ground biomass and seed yield were determined at harvest. Oil content, nitrogen content in seeds and straw were measured by NIRS. Finally, harvest-indices (HI) and nitrogen-harvest-indices (NHI) were calculated.

Results and Discussion

The average grain yield of winter rapeseed tested here was comparatively high even under less favourable conditions in the Lahn-Dill-Region fairly good (Table 1). A clear relation between fertilisation and yield could be determined, since N fertilisation resulted in yield increases of 0.88 t/ha (N_{80}) and 1.61 t/ha (N_{160}), respectively. The yield increase was more obvious at the location of Niederhörlen, where nitrogen fertilisation showed the most pronounced effects.

Table 1: Average yield of 36 winter rapeseed varieties as affected by nitrogen fertilisation and location (t/ha, 9% moisture)

Location	Year	N_0	N_{80}	N_{160}	average
Rauischholzhausen	1997	2.20	2.73	3.24	2.72
	1998	1.45	2.45	3.41	2.44
	1999	3.03	3.84	4.51	3.79
	average	2.23	3.01	3.72	2.98
Hohensolms	1998	2.49	2.92	3.63	3.01
	1999	1.81	2.67	3.72	2.73
	average	2.15	2.67	3.67	2.87
Niederhörlen	1998	0.85	2.22	2.98	2.02
	1999	1.73	3.39	4.13	3.08
	average	1.29	2.81	3.56	2.55
Mardorf	1998	3.05	3.46	3.88	3.47
Overall average		2.08	2.96	3.69	2.91

The differences in soil fertility are obvious at the N_0 level where the low yield especially in the most unfavourable location, i.e. Niederhörlen, traced back to a low nitrogen mineralisation rate in spring. But even at the highly fertile conditions in Rauischholzhausen and Mardorf a further decrease in yield would have to be expected if no N fertiliser were applied continuously over a whole rotation or longer. The buffer capacity for organic nitrogen of these fertile soils seems to be much better than in other cases. Regarding grain yield, the modern hybrid cultivars showed a considerable yield advantage in all fertilisation levels, years and locations (Fig. 1). This observation is not surprising since the hybrids are supposed to have a wide adaptability to soil and climate conditions besides their high yielding potential in general.

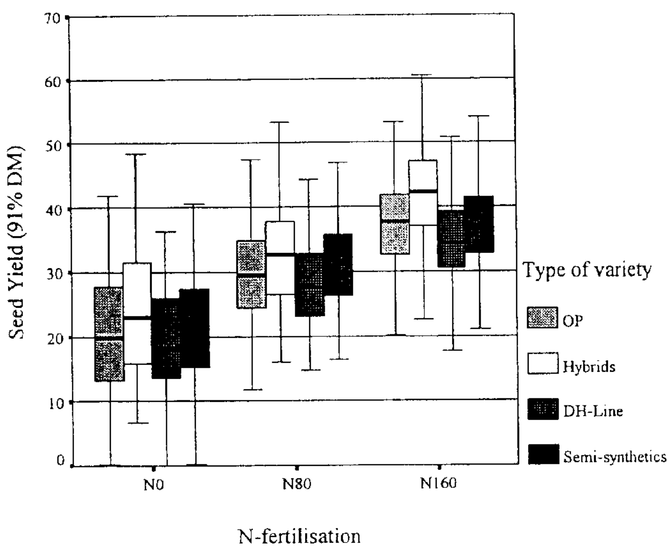

Fig. 1: Seed yield of different variety types due to N-fertilisation level (1997-1999, 3 locations)

The harvest-indices (HI) showed a slight increase with enhanced nitrogen levels (Fig.2,

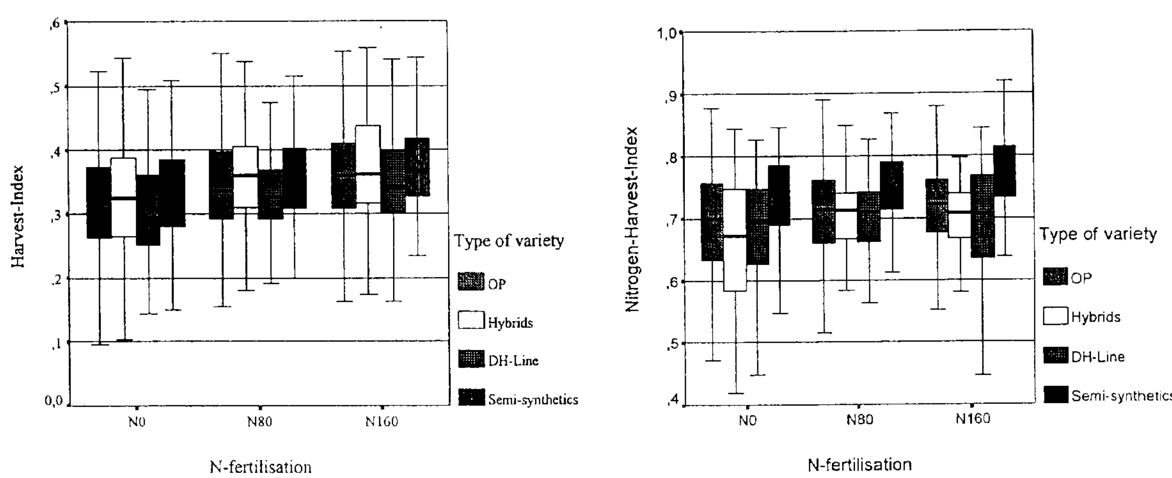

Fig. 2: Harvest-Index and Nitrogen-Harvest-Index of different variety types as affected by N-fertilisation (1997-1999, 3 locations)

Diepenbrock & Grosse 1995). The highest HIs were observed in the hybrids. This might also be an indication for their superior yield potential. The semi-synthetic rapeseed lines showed the highest NHIs at all fertilisation levels whereas the other types showed only minor differences. A slight increase in HI and NHI was observed at higher fertilisation rates. The higher HI in N_{160} might be partly caused by the mineralisation of nitrogen in early spring. The vegetative growth is less influenced by lacking nitrogen than the generative phase in the further development, i.e. seed formation. The tendency for higher NHIs at optimum fertilisation rates can be explained by a longer period with green and functional leaves which leads to a better removal of nitrogen from vegetative organs and further translocation to the developing seeds (Schjoerring et al. 1995).

The seed oil content was affected only at the high fertilisation level, with an absolute decrease of about 2.3% (53.1% in N_0, 53.1% in N_{80} and 50.8% in N_{160} respectively, on a dry matter base). The years and locations differed significantly in oil content with the highest values in 1999 and a tendency for a comparatively higher oil content achieved in Hohensolms and Niederhörlen.

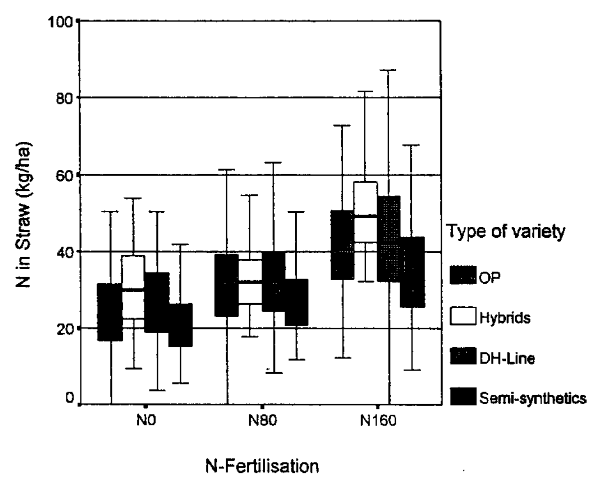

Fig. 3: Nitrogen residual in rapeseed straw at harvest (1997 – 1999, 3 locations)

The environmental impact of a rapeseed crop can approximately be estimated by the ratio of fertiliser-N supplied and the nitrogen uptake of the crop. The residual nitrogen in straw and especially in littered leaves can be rapidly mineralised to nitrate (Fig. 3). Our results show remarkably higher residues of straw-N in the optimum level. This nitrogen is prone to leaching if it is not taken up by a subsequent crop, preferably a catch crop.

The genotypes tested in our trials showed substantial differences in yield potential and suitability for low-input cropping systems. The modern hybrids were superior under all conditions. The breeding material - especially the semi-synthetic lines - showed several interesting properties like elevated harvest- and nitrogen-harvest-indices due a substantially different plant ideotype.

The observed amounts of residual nitrogen rates in straw can be explained mainly by straw yield, but nevertheless differences in nitrogen content could be found. Further improvements in yield and nitrogen efficiency seem to be possible. The development of hybrids based on conventional high yielding lines and resynthesized rapeseed lines as respective parents could be a promising way to enhance nitrogen efficiency and therewith promote the suitability of oilseed rape for low-input production systems.

Table 2: Rapeseed genotypes investigated, their corresponding quality type and origin or pedigree, respectively

Name	Type	Quality	Breeder/Pedigree
Lirajet	OP	00	DSV
Capitol	OP	00	DSV
Life	H	00	DSV
Lisabeth	OP	00	DSV
Wotan	OP	00	NPZ
Express	OP	00	NPZ
Joker	H	00	NPZ
Synergy	H	00	NPZ
Artus	H	00	NPZ
Askari	OP	++	NPZ
Erox	OP	+0	KWS
Maplus	OP	+0	NPZ
Synra	OP	++	BMKG
Sollux	OP	++	DSG
Kr90a	DH	++	'Resyn 125' x 'Excel'
Kr90b	DH	++	'Resyn 125' x 'Excel'
Kr90c	DH	++	'Resyn 125' x 'Excel'
Kr89 (K26/19)	DH	++	'Synra' x 'Bridger'
Kr89 (K26/313)	DH	++	'Synra' x 'Bridger'
K50/49	DH	(+0)	'Marcus' x 'Bridger'
K50/42	DH	++	'Marcus' x 'Bridger'
K50/62	DH	++	'Marcus' x 'Bridger'
K84/215	DH	++	'Marcus' x 'Bridger'
2424/96	OP	+0	Selection (++-Breeding lines)
2462/96	OP	+0	Selection (++-Breeding lines)
2481/96	OP	+0	Selection (++-Breeding lines)
2489/96	OP	+0	Selection (++-Breeding lines)
2491/96	OP	+0	Selection (++-Breeding lines)
2498/96	OP	+0	Selection (++-Breeding lines)
2297/96	R	++	'M8181/89E' x 'Resyn 125a12'*
2302/96	R	++	'M8181/89E' x 'Resyn 125a12'
2304/96	R	++	'M8181/89E' x 'Resyn 125a12'
2312/96	R	++	'M9214/89E' x 'Resyn 91a8'
2318/96	R	++	'M9214/89E' x 'Resyn 91a8'
2350/96	R	++	'Mol9091/89E' x 'Resyn 91a8'
2363/96	R	++	'Mol9091/90' x 'Resyn 91a8'

*) Resyn 91 and 125 derive from the interspecific cross *Brassica oleracea* 'Cauliflower 2287' x *Brassica rapa* 'Yellow Sarson

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