# Development of winter oilseed rape hybrids suited for sustainable oilcrop production

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## ABSTRACT

Selected oilseed rape genotypes, including modern open-pollinated varieties, hybrids cultivars, advanced breeding lines, and basic materials (semi-synthetic lines), were tested in factorial (varieties, N levels), multi-location field trials in Germany during three years (1997-1999). Grain and oil yields under varying N regimes were recorded. The accessions tested showed substantial differences in yield potential and suitability for low-input cropping systems. Modern double-low rapeseed hybrid cultivars were superior under all conditions, reaching average grain yields of more than 4 t $ha^{-1}$ at higher N fertilization levels. The more basic breeding materials, particularly the semi-synthetic lines derived from interspecific hybrids (*B. rapa* x *B. oleracea*), showed some interesting agronomic features like comparatively high yield at low-input conditions and elevated harvest- and nitrogen-harvest-indices. Based on these results, the development of hybrid cultivars by exploiting the existing distinct genetic pools of conventional high yielding lines and the semi-synthetic rapeseed lines as respective cross parents is considered a promising route to enhance nitrogen efficiency and utility for low-input farming systems.

**Key words:** *Brassica napus* - winter oilseed rape - nitrogen - low-input cropping - hybrid varieties

## INTRODUCTION

Winter oilseed rape (*Brassica napus* L.) is the most important oil crop in the European Union. The production of winter oilseed rape in Central and Western Europe has been characterised by a comparatively high input of nitrogen (N). The high intensity of production leads to a considerable risk of post-harvest N losses by nitrate leaching in the range of 50-100 kg N $ha^{-1}$ $a^{-1}$ (Aufhammer et al. 1994, Colnenne et al. 1998, Gabrielle et al. 1998, Sieling and Christen 1999, Sieling et al. 1997, Müller et al. 1999, Trinsoutrot et al. 2000). A reduction of nitrogen input and/or an increase in N efficiency of oilseed rape cultivars is expected to reduce the risk of nitrate leaching (Riemer et al. 1998, Kessel and Becker 1999, Kessel 2000, Möllers et al. 2000, Müller 2002). Recently a clear shift has occurred in Europe towards the breeding of hybrid cultivars of rapeseed due to the availability of effective hybridisation systems and the outstanding economic importance of this oil crop. Since the present breeding material is very closely related, the development of divergent gene pools is seen as an indispensable prerequisite for the successful exploitation of yield increase due to heterosis (cf. Buzza 1995). In the present study a diverse set of 36 *B. napus* genotypes has been tested under field conditions to determine differences in nitrogen efficiency and low-input suitability of oilseed rape.

## MATERIALS and METHODS

A set of 36 *B. napus* genotypes (double-low [00] and high-erucic acid rapeseed) were used including hybrid and open-pollinated (OP) cultivars as well as semi-synthetic inbred lines descending from resynthesised *B. napus*. Field trials were carried out at three diverse locations from 1997 to 1999 in the Lahn-Dill Region in Hessen, central Germany. The sites are characterised by different soil types and climatic conditions (Müller 2002, Friedt et al. 2003). Three rates of nitrogen fertiliser treatments were applied: 0 kg N $ha^{-1}$ ($N_0$), 80 kg N $ha^{-1}$ ($N_{80}$) and 160 kg N $ha^{-1}$ with splitting application ($N_{160}$) (plus soil $NO_3^-N$ in 90 cm of soil). Mineral N fertiliser was applied as calcium ammonium nitrate with 27% N. The endogenous nitrogen content of the soil ($N_{min}$, 0–90 cm depth) at the beginning of vegetation was determined. Field trials were carried out with 10 $m^2$ plots. Major phenological data (date of emergence, density, early development, winter survival, date of flowering, and maturity) were recorded in the course of the vegetation period. Above ground biomass and seed yield were determined at harvest; both seed and straw weights were recorded and samples collected for laboratory tests. Crude composition of intact seeds, including oil, protein, glucosinolate and moisture content, were determined by near-infrared reflectance spectroscopy (NIRS) as described by Daun (1995).

## RESULTS and DISCUSSION

The seed yield of the winter rapeseed genotypes tested was comparatively high (overall average 2.91 t $ha^{-1}$), even under less favourable conditions (Tab. 1). A clear relationship was seen between fertiliser rate and yield performance, since N fertilisation resulted in average yield increases of 0.88 t $ha^{-1}$ ($N_{80}$ vs $N_0$) and 1.61 t $ha^{-1}$ ($N_{160}$ vs $N_0$), respectively. As expected, the yield increase was more obvious at the inferior location Niederhoerlen, where nitrogen fertilisation had the most pronounced effects. Differences in soil fertility were particularly obvious at the $N_0$ level, where the low yield - especially at the most unfavourable location Niederhoerlen - derived from a low nitrogen mineralisation rate in spring. However, even under the highly fertile conditions at the locations Rauischholzhausen and Mardorf a further decrease in yield ought to be expected if no nitrogen fertiliser were applied continuously over a whole rotation or even longer. As far as genotypes are concerned, the modern hybrid cultivars showed a considerable yield advantage at all fertiliser rates, years and locations (Fig. 1).

Table 1. Average seed yield of 36 winter rapeseed varieties as affected by nitrogen fertilisation level, location and year

| **Environments** | | **Seed yield (t·$ha^{-1}$, 91% DM)** | | | |
|---|---|---|---|---|---|
| Years | Locations | $N_0$ | $N_{80}$ | $N_{160}$ | Average |
| 1997 | Rauischholzhausen (RH) | 2.203 | 2.729 | 3.236 | 2.723 |
| 1998 | Rauischholzhausen (RH) | 1.452 | 2.453 | 3.406 | 2.437 |
| | Hohensolms (HO) | 2.495 | 2.920 | 3.628 | 3.014 |
| | Niederhoerlen (NH) | 0.847 | 2.225 | 2.982 | 2.017 |
| | Mardorf (MA) | 3.050 | 3.461 | 3.884 | 3.465 |
| 1999 | Rauischholzhausen (RH) | 3.026 | 3.841 | 4.514 | 3.794 |
| | Hohensolms (HO) | 1.806 | 2.666 | 3.719 | 2.730 |
| | Niederhoerlen (NH) | 1.733 | 3.391 | 4.130 | 3.085 |
| Average | | 2.078 | 2.962 | 3.688 | 2.910 |

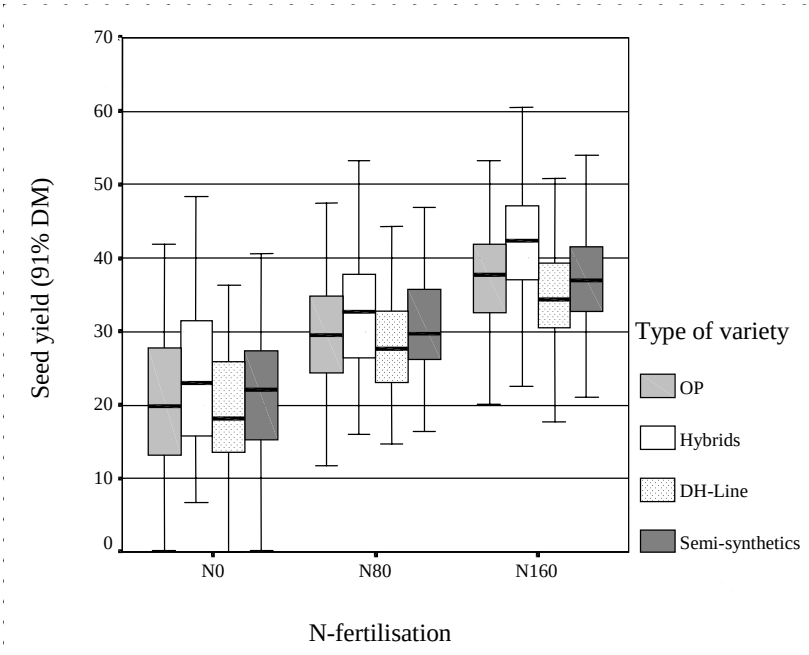


Figure 1. Box-and-whisker plot showing seed yield

of different rapeseed variety types under varying N-fertilisation regimes (1997-1999, 4 locations). Boxes represent 50% of the variation, vertical lines represent the whole range, and horizontal bars indicate median values.

This observation is not surprising, since the hybrids are supposed to have a comparatively wider adaptability to soil and climate conditions, besides their high yielding potential in general.
The seed oil content was affected only at the high fertilisation level, with an absolute decrease of 2.3% oil on an absolute dry matter (DM) base, i.e. 50.8 % oil in $N_{160}$ vs. 53.1 % in $N_0$ and $N_{80}$, respectively.

## CONCLUSIONS

The development of novel hybrids based on the distinct genetic pools of conventional high yielding lines and resynthesised rapeseed lines as respective cross parents should be a promising route to substantially enhance the nitrogen efficiency of rapeseed and therewith to further promote the suitability of oilseed rape not only for high-input, but also for low-input agricultural production systems.

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