GENOTYPIC AND ENVIRONMENTAL VARIATION FOR OUTCROSSING RATE IN RAPESEED

H.C. Becker(1), B. Karlsson(1), C. Damgaard(2)

(1) The Swedish University of Agricultural Sciences
S-26800 Svalöv, SWEDEN
(2) University of Aarhus, Ny Munkegade, Building 550
DK-8000 Aarhus C, DENMARK

INTRODUCTION

Rapeseed is a partially allogamous crop with an average amount of outcrossing between 20 and 40%. Nevertheless, rapeseed breeders mainly use breeding methods for self-pollinated crops and in many breeding programs pure line varieties are developed.

It has been proposed by Schuster (1969) and others to produce synthetic varieties by open pollination of mixtures from two or more lines. Due to the partial outcrossing, such synthetic varieties should have higher yields than their parental lines, for the amount of heterosis in rapeseed can be more than 30% (for review see e.g. Becker 1987, Downey and Röbbelen 1989).

There exists a considerable amount of genetic variation for the outcrossing rate (Olsson 1960, Rudloff and Schweiger 1984, Rakow and Woods 1987). If synthetic varieties are achieved, a selection for a high amount of outcrossing should theoretically be very effective (Becker 1989).

One problem when establishing synthetic varieties is a possible environmental influence. Uncontrollable factors like climatic conditions may influence the outcrossing rate and so lead to unpredictable changes of heterozygosity and of yield level under multiplication. The only information found in the literature on the importance of environmental conditions is a report by Mündges-Christmann and Köhler (1990), who observed a difference in the outcrossing rate between two years for one of three varieties investigated.

The aim of the present investigation is to estimate the degree of outcrossing in spring rapeseed under various environmental conditions and to compare the relative importance of genotypic and environmental variation.

MATERIALS AND METHODS

Materials

The material consisted of spring rapeseed varieties of double low quality.

Estimation of Outcrossing

The interplant outcrossing rate was estimated by isozyme electrophoresis using two different approaches:

a) The Swedish variety Topas was found to be polymorphic for 4 isozyme loci. Plants that were homozygous

for 'rare' allels at these loci were identified in the field and the progeny of these plants was analysed in the seedling stage. Outcrossing from plants with the same pattern cannot be detected and so the amount of outcrossing is slightly underestimated, but this does not influence the comparison between different environments. Experimental details are described by Damgaard (1990).

b) Varieties with different electrophoresis patterns were grown in 1:1 mixtures. Single plants were identified in the field and in seedlings of their progeny selfings and outcrossings were distinguished. For calculating outcrossing rates it was assumed, that half of the outcrossings were from the opposite variety and therefore detectable by electrophoresis.

Field Design

The outcrossing rate was estimated in plots grown with normal plant density at different locations in Sweden, Denmark and Northern Germany in 1989 and 1990. The plot size varied between 100 and 400 m² and outcrossing was determined in the centre of the plots. It is assumed, that a possible outcrossing from plants in adjacent plots can be neglected. To verify this assumption, the outcrossing rate between adjacent plots was estimated. It was observed, that outcrossing over a distance of more than 5 m had a very low frequency (Fig.1).

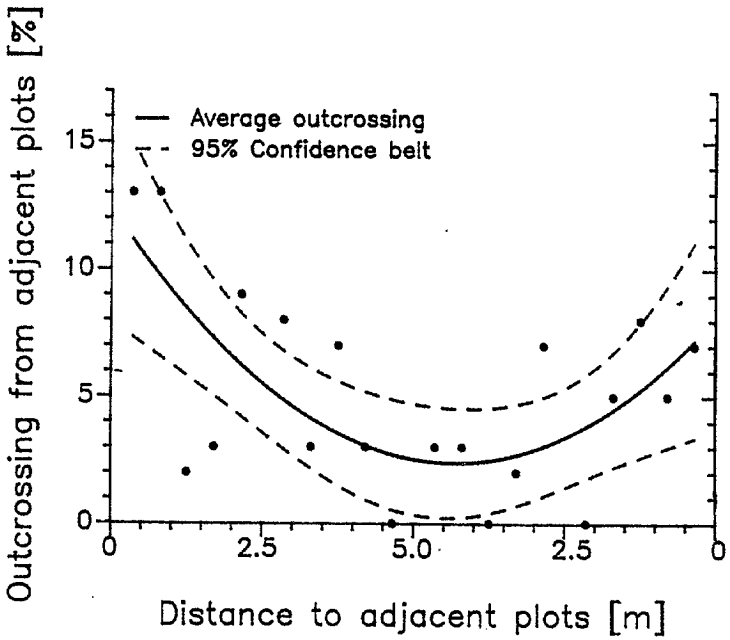

Fig. 1. Outcrossing from adjacent plots in the variety Korall.

RESULTS

Two different types of environmental influences were investigated: the effect of location and the effect of flower position within the plant.

The outcrossing rate in the variety Topas was estimated at 5 locations in 1989 and at 3 locations in 1990. The amount of outrossing differed between 11 and 44%. The effect of the location was highly significant whereas no significant differences between the years was observed.

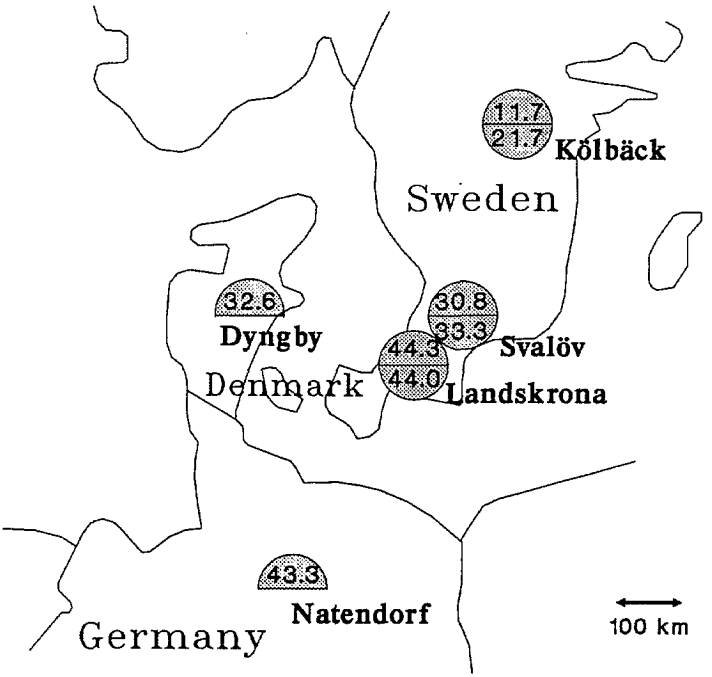

Fig. 2. Outcrossing rate in the variety Topas at various locations in 1989 (upper figure) and 1990 (lower figure).

Five mixtures of two varieties each were grown at 3 locations in 1989. Both the variation between genotypes and the variation between locations were significant, but the influence of locations was much more pronounced (Table 1). Here again, Kölbäck in Middle Sweden hat a much lower outcrossing rate than the two locations in Southern Sweden.

To investigate the influence of the position of flowers within the plant, the outcrossing rate was estimated separately for pods from the top and the middle part of the plants (Table 2). The position of the flowers within the plants significantly influenced the outcrossing rate, but the results differed between locations. The most striking effect was observed in Dyngby, where the outcrossing rate at the top of the plants was much lower than in the middle part.

Table 1. Genotypic and environmental influences on the outcrossing rate in variety mixtures.

Mixture	Location			
	Svalöv	Landskrona	Kölbäck	Average
Korall + Hanna	14.6	50.6	11.3	25.5
Korall + Elin	46.7	60.3	2.3	36.4
Korall + Kajsa	55.7	53.3	9.0	39.3
Korall + Legend	48.7	71.0	8.7	42.8
Korall + Loras	13.3	35.3	13.3	20.6
Average	35.8	54.1	8.9	

Table 2. Degree of outcrossing in the variety Topas in pods from the top and from the middle part of the plant.

Year	Location	N	Outcrossing rate [%]	
			Top	Middle
1989	Dyngby	7	11.6	35.8
1990	Svalöv	5	18.7	33.3
	Landskrona	5	38.7	44.0
	Kölbäck	8	34.2	21.7

DISCUSSION

Some of the results presented are preliminary and require a more detailed statistical analysis. Nevertheless, the most important result is beyond doubt, for the two years and the two experimental approaches (Fig. 2, Table 1) agree well: the outcrossing rate largely differed between the various locations from about 10% to more than 50%. An interesting question is, which environmental factors are responsible for this variation.

We have no convincing explanation for the large influence of the location on the outcrossing rate. To our knowledge, nothing is known on the relative contribution of the three possible mechanisms for the outcrossing in rapeseed: insect pollination, wind pollination, and direct mechanical contact among flowers from different plants. A better understanding of the biological reasons of outcrossing could probably explain the large variation between various environments, and we have started experiments to investigate this question.

CONCLUSIONS

It is concluded, that environmental conditions influence the outcrossing rate to a large extend. The underlying biological reasons for this are not yet known. A better understanding of factors influencing outcrossing is of interest for all categories of rapeseed breeding:

- for breeding pure lines, it is interesting to **reduce** undesirable outcrossing,
- for breeding synthetic varieties, it is important to **increase** the outcrossing rate, and
- for hybrid breeding, a reliably high amount of outcrossing is a **prerequisite** for seed production.

Acknowledgements: Thanks are due to Vibeke Simonsen for showing us the electrophoresis technique, to the seed companies Svalöf AB, W Weibull AB, Pajbjergfonden and Semundo Saatzucht GmbH for help with the field experiments, and to the Swedish Plant Breeding Board and the Swedish Council for Forestry and Agricultural Research for financial support.

REFERENCES

BECKER, H.C. 1987. Quantitative Genetik und Zuchtmethodik bei Raps - Versuch einer Literaturübersicht. Ber.Arb.tagung 1987 A.G. Saatzuchtleiter, Gumpenstein, 67-82.

BECKER, H.C. 1989. Breeding synthetic varieties in partially allogamous crops. Vortr.Pflanzenzüchtg. 16:81-90.

DAMGAARD, C. 1990. Evolutionen af parringssystemer hos hermafroditiske planter - med eksempel i raps. Institut for Genetik og Økologi, Århus Universitet. 82 p.

DOWNEY, R.K. and RÖBBELEN, G. 1989. Brassica species. In: Oil Crops of the World. G. Röbbelen, R.K. Downey and A. Ashri (eds.). McGraw-Hill, New York. pp. 339-362.

MÜNDGES-CHRISTMANN, H. and KÖHLER, W. 1990. Enzymmarker zur Bestimmung der Fremdbefruchtungsrate und der genetischen Struktur bei Winterraps. Mitt.Ges.Pflanzenbauwiss. 3: 163-166.

OLSSON, G. 1960. Self-incompatibility and outcrossing in rape and white mustard. Hereditas 46: 241-252.

RAKOW, G. and WOODS, D.L. 1987. Outcrossing in rape and mustard under Saskatchewan prairie conditions. Can.J.Plant Sci. 67: 147-151.

RUDLOFF, E. and SCHWEIGER, W. 1984. Eine Methode zur Schätzung der Fremdbefruchtungsrate bei Qualtiätsraps (Brassica napus L.). Arch.Züchtungsforsch. 14: 327-334.

SCHUSTER, W. 1969. Vergleich von zwei Zuchtverfahren in der Erhaltungszüchtung bei Winterraps. Z.Pflanzenzüchtg. 62: 47-62.