GENETIC STRUCTURES OF RAPESEED VARIETIES (Br. napus) - THEIR YIELD AND YIELD STABILITY

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Rapeseed shows self-pollination as well as cross-pollination. Due to this partial allogamie the expected type of variety is the population variety (for definition compare SCHNELL 1982). Compared to cross-pollinating species population varieties of rapeseed possess a lower degree of heterozygosity depending on the proportion of self-pollination. As population varieties of rapeseed show a certain degree of heterozygosity, they partly use heterosis.

However, while establishing breeding goals quality has mainly been stressed. E.g. the inheritance of glucosinolates (maternal predetermination) leads to a high number of selfings during development of varieties, because it is worth while to use selfings for regular pollination of the desired genotypes. Furthermore selfings are easily conducted and show a considerably high coefficient of multiplication. With regard of breeding methods double-low rapeseed may be compared to self-pollinating species according to the high number of selfing during breeding. Therefore lineal varieties can be widely found for double-low rapeseed.

Like other crops hybrids of rapeseed significantly outyield their parents (RÖBBELEN 1985). Testing 19 hybrids and their male parent RÖBBELEN (1985) found an increase of 13 % due to heterosis. These results showed that it is worth using the difference between hybrids and lines. Consequently heterozygous and homogeneous hybrid varieties should be produced. However, as a prerequisite, a male-sterility inducing system is needed. RÖBBELEN (1985) stated that these systems should be available in a few years.

Until hybrids are available heterosis may partly be utilized with synthetic varieties (SCHUSTER 1982). A synthetic variety is established and maintained by mixing suitable components (e.g. lines) and following propagating of the blend. Due to the partial allogamie synthetic varieties possess a certain amount of heterozygosity and they are more heterogeneous than lines or hybrids.

Heterosis may partly be utilized by F_2's, too. Due to the high coefficient of multiplication F_2-hybrids could be produced at reasonable costs. Like synthetics F_2's are more heterogeneous than lines or hybrids. Beside these categories of varieties mixtures of lines or single-cross hybrids can be grown by farmers. These particular mixtures are homozygous or heterozygous and of course heterogeneous. All characterized categories of varieties are different with respect to heterogeneity and heterozygosity as shown in Fig. 1. Investigations on several crops indicate an influence

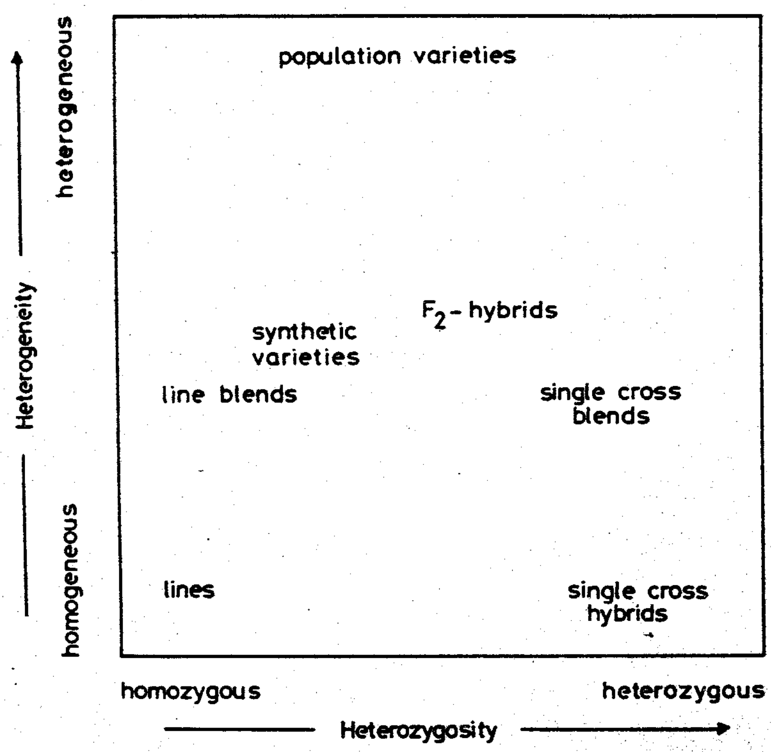

Fig. 1: Alternative types of population structures of rapeseed

of heterogeneity and heterozygosity on yield and yield stability (compare REICH and ATKINS 1970, SCHNELL and BECKER 1986).

The goal of this study was to quantify yield and yield stability of categories of varieties differing in heterozygosity and heterogeneity.

Material and Methods

The parental material used for this experiment consisted of four randomly chosen winter rapeseed varieties with each different origin (JET NEUF, JUPITER, PLANET, SKRZESZOWICKI). These four varieties (in this context termed lines) were crossed onto each other in the diallel design to produce seed of F_1. For each combination the F_2 were established by selfing F_1-plants. Analogous to the parentage of the F_1-hybrids all possible equal proportion biblends were produced representing heterogeneous and homozygous structures. Mixing of suitable lines followed by propagation of the blend would result in a synthetic variety. In order to ensure a defined amount of heterozygosity all six possible two-component synthetics were established by mixing lines (each 42,5 %) and their handcrossed F_1 (15 %). This three component mixture represented a Syn_1 derived from two equally yielding lines possessing an average outcrossing-rate of 30 %, which is true to practial terms (compare SCHUSTER 1982). Furthermore mixtures of F_1's were produced to test heterozygous and heterogeneous structures. The tested F_1-blends were selected from all possible F_1-blends that gene frequencies among F_1-mixtures as well as among means of all tested structures were equal. Fig. 1 shows the design of the types of population structures assuming that lines were nearly homozygous. Categories of varieties showed different levels of heterogeneity. For statistical analysis steps within factor heterogeneity were defined as follows: step 1 contained lines and F_1's, step 2 mixtures of lines and of F_1's, step 3 F_2's and step 4 Syn_1's.

Entries were grown in a complete, randomised block design with four replications at four environments in the years 1982/83 and 1983/84 (for details compare LEON 1987). Plot sizes amounted 10 m^2 for each entry (included handcrossed F_1's and their mixtures). Yields per plot were adjusted to 9 % moisture content and converted to dt/ha. The 'ecovalence', which measures the contribution of a given entry (genotype) to the total genotype*environment interaction (WRICKE 1962), was computed to quantify yield stability of entries.

Tab. 1: Development of the tested categories of varieties

Category of variety (number)	Development	Heterogeneity	Heterozygosity (1-F)
Lines (4)	random selection	homogeneous	0.00
F_1 (6)	crosses of lines (diallel design)	homogeneous	1.00
F_2 (6)	selfing of F_1	heterogeneous	0.50
Biblends of lines (6)	mixture of lines (diallel design)	heterogeneous	0.00
Syn_I (6)	mixed from lines (each 42.5%) and F_1 (15%)	heterogeneous	0.15
Biblends of F_1 (3)	mixture of F_1's	heterogeneous	1.00

F = coefficient of inbreeding

Tab. 2: Mean seed yield (dt/ha) and ecovalence-values

Structures	Seed yield	Ecovalence
Lines	28.95	18.44
Biblends of lines	30.63	6.59
Syn_1	30.81	9.58
F_1	33.35	10.71
F_2	30.09	10.61
Biblends of F_1's	35.35	5.38
$LSD_{0.05}$	1.04	

Results and Discussion

For each group the mean yields and ecovalence-values are listed in Tab. 2. Lines yielded less than all other structures. Biblends of lines showed significant higher seed yield than the corresponding lines. Syn_1 are three component mixtures, but regarding the proportion of components they are near to biblends of lines. Consequently, yields of Syn_1's differed only slightly from mixtures of lines. F_1-hybrids outyielded significantly lines, mixtures of lines and Syn_1's. As to F_1's the increase due to heterosis amounted to 15 %. F_2's surpassed lines by 4 % and yielded less than expected from parental and F_1's results. Biblends of F_1's outyielded the F_1's significantly by 6 %. None of the F_1's was better than any of the biblends of F_1's. All these structures possessed equal gene-frequencies. Differences occured from varied levels of heterozygosity and heterogeneity, e.g., an increase of heterozygosity resulted in higher yields. The difference between lines and F_1 is worth while to be used. The heterogeneous biblends were superior to their components independently of the level of heterozygosity. HÜHN and SCHUSTER (1975) and LEON and DIEPENBROCK (1987) found remarkable mixing effects for rapeseed. As compared to other crops these results indicate specific reaction of rapeseed to heterogeneity.

A low value of the ecovalence, as listed in Tab. 2, implies that the difference between the yield of a given genotype and the corresponding average yield of all genotypes under test varies little over environments, and hence, may be interpreted as an indication of high phenotypic stability (SCHNELL and BECKER 1986). Lines showed highest ecovalence-values and heterozygous F_1's displayed lower values. The effect of heterogeneity on phenotypic stability was eminent as can be seen from the low ecovalence values of biblends of lines as compared to the values of the corresponding lines. The heterozygous biblends of F_1's showed the lowest values. However, the decrease of values from the homogeneous biblends of lines to heterozygous biblends of F_1's was very small. F_2's and Syn_1's revealed medium ecovalence values.

Regarding both yield and yield stability, the heterogeneous and heterozygous biblends of F_1's showed the desired combination of highest productivity combined with highest phenotypic stability. Further investigations are necessary to find out whether heterogeneous types of rapeseed hybrids (three-way or double crosses) or mixtures of single-cross hybrids are generally superior to homogeneous hybrids.

However, until hybrids can be produced with reasonable costs synthetic varieties may provide an alternative category of varieties. Synthetics would partly use heterosis and would afford the advantages of heterogeneity. LEON and DIEPENBROCK (1987) showed that naturally produced Syn_1 of rapeseed with double low-quality revealed a significant surplus as compared to biblends of lines. Consequently, breeding lines is useful to ensure the high quality. However, these lines cannot be expected as the final result of breeding rather than to produce synthetics or hybrids.

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