OUTCROSSING IN SUMMER OILSEED RAPE (BRASSICA NAPUS L.) UNDER PEACE RIVER, ALBERTA CONDITIONS

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INTRODUCTION

Rape is predominantly a self-pollinating species (Olsson, 1960) which exhibits outcrossing rates of 20 to 55% under field conditions (Olsson, 1952, 1960; Persson, 1956; Rakow and Woods, 1987; Banks, 1988; Lewis, 1990). Recessive petal colour markers have been used to estimate outcrossing rates of winter and summer rape (Olsson, 1952; Persson, 1956) but later studies suggest these tests were biased since honey bees (Apis mellifera L.), an important pollination vector for rapeseed (Williams, 1978; Holm et al., 1985), have been reported to be sensitive to flower colour in Brassica oleracea (Faulkner, 1976) and in Raphanus raphanistrum (Stanton et al., 1989). More recent attempts to determine rates of outcrossing have exploited erucic acid (cis-13-docosenoic acid) as a marker. Erucic acid is superior to visible character markers such as flower colour since it is unlikely that pollinators can discriminate between flowers derived from seed with different fatty acid compositions. Erucic acid in B. napus is governed by the interaction of two independently inherited genes whose functional alleles predominantly act in an additive manner, although partial dominance for high erucic acid content has been observed (Chen and Heneen, 1989). Since erucic acid deposition is under control of the embryonic genotype rather than the maternal plant (Downey and Harvey, 1963) determination of crossed vs. selfed seeds can be detected directly from F_1 seed.

Five lines summer rape tested over 3 years under Saskatchewan prairie conditions were found to have a mean interplant outcrossing rate of 22% (Rakow and Woods, 1987). Banks (1988) reported that four low erucic acid summer rape cultivars tested over 3 years in Southern Ontario had a mean interplant outcrossing rate of 36% to 41%. Lewis (1990) reported a mean interplant outcrossing rate of 55% for progeny of four low erucic acid summer rape lines grown in the Peace River Region, Alberta in 1988.

This paper presents cumulative outcrossing rates for field tested summer rape grown in the Peace River Region of Alberta in 1988 and 1990 and addresses the question of whether differences among plants in outcrossing rates is attributable to environmental or genetic influence.

MATERIALS AND METHODS

To establish whether the variation in interplant outcrossing rates in summer rape (Brassica napus L.) is genetically or environmentally controlled, outcrossing rates of single plants derived from 4 lines of summer rape were measured at Beaverlodge, Alberta in 1988 and 1990.

Seed harvested from 16 individual low erucic acid plants grown in a block of Reston, a high erucic acid rape cultivar, was obtained courtesy of G. Rakow (Agriculture Canada, Research Station, Saskatchewan). These plants had been part of a study which had been conducted over a three year period, 1982 - 1984. Outcrossing rates for each plant had been calculated by comparing the frequency of low to intermediate erucic acid content of single seeds (Rakow and Woods, 1987). In order to evaluate the progeny of this material in the Peace River Region, it was first necessary to isolate and increase S_1 seed from the mixed low and intermediate erucic acid seeds from each parent. This was accomplished by using a half-seed analysis technique (Downey and Harvey, 1963). Erucic acid contents of single cotyledons were determined by gas chromatography based on the method of Thies (1971). The frequency of low and high determinations was added to the raw data used to determine the outcrossing rates of the 16 parents provided by G. Rakow. Where possible four low erucic acid seedlings from each of the 16 parents were grown and self pollinated giving S_2 seed.

In 1988 a block of the high erucic acid rape line S82-4362 (registered as Hero in 1989) was seeded away from other pollen sources at the Beaverlodge Research Station (55° 13' N, 119° 24' W.) with 40 cm row spacing. Immediately after machine planting the high erucic acid rape, single S_2 seeds from each of the four sibs were hand planted in the inter-row space. Seeds were geometrically planted such that the nearest low erucic plant in the same inter-row space was 8 m away, and in the adjacent inter-row space was 1.6 m further along the row. Low erucic acid plants not flowering at the same time as the Hero block were removed, and individual low erucic acid plants were harvested at maturity. The same procedure was repeated in 1990 at the Beaverlodge Research Station except S_2 seed from a single sib from each of the 16 lines was planted.

Single seeds from each harvested plant were tested for the presence or absence of erucic acid by paper chromatography as described by Thies (1971). In cases where the presence or absence of erucic acid was questionable, the run was repeated. An average of 20 seeds was tested for 243 plants in 1988, and 24 seeds for 35 plants in 1990.

The ratio of outcrossed seeds to total number of seeds analysed from each plant was used untransformed to estimate heritabilities. Broad sense heritability was obtained from an analysis of variance of the two years of progeny data (1988 and 1990) at Beaverlodge, using appropriate expectation of mean squares (Table 1).

Table 1. Expectation of mean squares

Source square	df	Expected mean
Years	y-1	
Lines	l-1	$\sigma_e^2 + y\sigma_g^2 + \sigma_{gy}^2$
Lines x Years	(y-1)*(l-1)	$\sigma_e^2 + y\sigma_g^2$
Error		σ_e^2

Broad sense heritability was calculated as $h^2 = \sigma_g^2/(\sigma_g^2 + \sigma_{gy}^2 + \sigma_e^2)$.

Narrow sense heritability was estimated as the regression coefficient obtained by co-variance analysis (SAS GLM procedure) of the six sets of data (3 years of parental data x 2 years of progeny data).

RESULTS AND DISCUSSION

Outcrossing rates for the 243 individual plants grown in 1988 ranged from 15 to 95% (Lewis 1990), averaging 55%, and for the 33 plants tested in 1990 the range was from 22 to 74% with a mean outcrossing rate of 45%. This wide range of outcrossing rates observed among individual plants within lines and cultivars agrees with earlier reports. Olsson (1952) reported individual outcrossing rates of Lembke (Lenora) winter rape as low as 5 to 10% and as high as 80 to 85%. Rakow and Woods (1987) reported outcrossing rates for individual summer rape plants ranging from 2 to 75%. Using the low erucic acid cultivars Regent, Topas, Hanna, and Westar, Banks (1988) reported inter-plant outcrossing rates, ranging from 0 to 100%.

Heritability in the broad sense was estimated at 0.79, and in the narrow sense was estimated at 0.16. No significant differences were detected in regression coefficients among the six data sets, indicating that a single pooled regression coefficient was appropriate.

This study suggests that selection of lines of summer rape with inherently high rates of outcrossing is possible. These lines could be maintained by inbreeding, and would be expected to be particularly useful in synthetic varieties as envisioned by Schuster (1985).

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