INVESTIGATION OF F_1 HYBRID PERFORMANCE IN FALL- AND SPRING-PLANTED CANOLA

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ABSTRACT

Several crop species show heterotic yield increases when hybrids are compared to inbred cultivars, but it remains to be proven that hybrid canola offers any economic yield advantage. The purpose of this study was to investigate heterosis for yield in spring and winter canola, examine its genetic basis and observe morphological characters, which may influence yield. Field trials were conducted with F_1 and F_2 families in 1993 and 1994. Average heterosis in the spring F_1 trial was negative (-1%) and in the F_2 trial, it was +9%. In winter canola, average heterosis was +10% in the F_1 trial and -6% in the F_2 trial. Dominant genetic variance was the major cause of heterosis observed. Increased yield in hybrids was attributed to earlier maturity in spring types and hybrids had more pods per plant than inbred lines in both fall and spring types.

INTRODUCTION

The possibility of utilizing hybrid cultivars has been examined for a variety of crop species, due to the fact that hybrids often show increased yield performance and vigor over their inbred counterparts. In order for hybrid production to be economically feasible, however, the amount of heterosis exhibited must be sufficient to justify the increased cost of hybrid seed.

Canola is a crop which has shown a potential hybrid advantage. Previous research reported yield increases in spring canola of up to 72% (Grant and Beversdorf, 1985) and in winter canola of up to 50% (Lefort-Buson and Dattee, 1982).

The Pacific Northwest has been a center of winter rapeseed production for over a century and recently, growers have expressed an interest in producing spring canola. Additionally, in 1985, the United States Food and Drug Administration (USFDA) granted GRAS (Generally Recognized As Safe) status to canola (USFDA, 1985) and, as such, canola acreage in the USA are rapidly expanding. If canola yields could be increased by growing hybrid cultivars as previous research has suggested, growers would realize increased profits. Consequently, the purposes of this study were to determine the levels of heterosis for yield in spring and winter canola grown in the Pacific Northwest region of the USA, as well as to examine the genetic basis of this heterosis and observe various morphological characters, which may influence yield in canola.

MATERIALS AND METHODS

This research was conducted as separate spring and winter studies. The F_2 generation was investigated in addition to the F_1 generation because any heterosis that exists in the first generation will still be present at 50% in the second generation. For each study, four genotypically diverse parents were selected which differed for average height, time of maturity and yield when grown in the Pacific Northwest region. The spring parents used were 'Westar', 'Helios', 'SN.91.33.1' (a University of Idaho breeding line) and 'Star'; the winter parents used were 'Ceres', 'Tapidor', 'Rebel' and 'Glacier'. In each study, the parents were crossed in a half-diallel design, producing 6 hybrids. Remaining flowers were allowed to self-pollinate in order to maintain a common origin of seed. A minimum of 10 g of seed were obtained from each F_1 hybrid combination. A portion of this seed was increased to F_2 seed, via self-pollination, under greenhouse conditions.

The spring trials were grown in 1993 and the winter trials were planted in 1993 and harvested in 1994. All trials were arranged in a randomized complete block design. The F_1 trials were grown in Genesee, Idaho, USA, in two replicates, and the F_2 trials were grown in Genesee and Moscow, Idaho, USA, with four replicates apiece. The results of the two F_2 sites were averaged. Heterosis was calculated as "high-parent heterosis," in which the yield of the hybrid is expressed as a percentage of the yield of the most productive parent in the cross.

Hayman and Jinks' analyses of variance were used to determine the genetic basis of heterosis for yield. These analyses allow for the partitioning of genetic variance into additivity, directional dominance, non-directional dominance and other genetic effects, such as epistasis or linkage.

Several morphological characters were evaluated during the growing season. These included the following pre-harvest characters: vigor, cover, date of flower start and flower finish, height at maturity, date of maturity and amount of lodging prior to harvest. Yield components investigated included number of plants per meter, number of pods on the main raceme and side racemes, number of branches per plant and 1000-seed weights.

RESULTS AND DISCUSSION

All yields are reported in grams per plot (g/plot). The average yield of the spring F_1 parental lines was 1445 g/plot and of the hybrid lines was 1629 g/plot. However, even though the hybrids out-yielded the parents on the average, the average heterosis in the spring F_1 trial was negative at -1%. There were only three crosses in which heterosis was evident. The parents in the spring F_2 trial averaged 1426 g/plot and the hybrids averaged 1627 g/plot; average heterosis was +9%. In this generation, every cross showed a heterotic advantage.

In the winter F_1 trial, parents averaged 2315 g/plot and hybrids averaged 3156 g/plot. Average heterosis in this trial was +10%, with heterosis evident in five of the six hybrids. Parents in the winter F_2 trial averaged 2085 g/plot and the average hybrid yield was 2131 g/plot. Average heterosis was -6%, with heterosis present in three of the crosses.

Hayman and Jinks analyses revealed that additivity significantly influenced yield in both the spring and the winter F_1 trials. Directional dominance was also highly significant in the winter F_1 trial, explaining the high occurrence of heterosis in this trial. In the F_2 generation, segregation began to occur, and this was reflected in the genetic analysis. Additivity, directional dominance and other genetic effects were significant in the spring F_2 trial. Directional dominance was the most highly significant, indicating a propensity for heterosis, and every cross in this trial did indeed exhibit heterosis. In the winter F_2 trial, additivity, non-directional dominance and other genetic effects significantly influenced yield.

There were no differences between the parental lines and the hybrids for most of the pre-harvest characters measured. The exception was maturity, where hybrids matured significantly earlier than the parental lines. In addition, yield component analyses revealed that both spring and winter hybrids had more pods on the main raceme and side racemes on the average than the parental plants, which could explain the instances of hybrid yield advantage seen in some trials.

CONCLUSIONS

The results of this study revealed some instances of heterosis in both spring and winter canola. However, the degree of hybrid advantage found in this study was not consistent over locations and was smaller than has been observed by other researchers. Furthermore, it was shown that additivity and dominant genetic effects influenced yield in both canola types, suggesting that both inbred lines and hybrid cultivars could be developed for increased yields. Directional dominance was found to be the major cause of heterotic advantage in the crosses examined. Finally, examination of pre-harvest characters on hybrids and parents revealed that hybrids tended to be earlier maturing compared to their inbred parents and inspection of yield component data revealed that yield increase of hybrids was probably due to an increase in pod number.

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