Effects of Two Cycles of Recurrent Selection for Combining Ability in an Open-Pollinated Variety of Corn

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CERTAIN weaknesses are inherent in any corn breeding method involving continuous self-pollination if the character under selection is quantitatively inherited. The genotype of each selfed \( S_0 \) or \( F_n \) individual establishes a ceiling for the derived lines and, in addition, the rapid rate at which genes are fixed in the homozygous condition under self-pollination imposes severe limitations on the effectiveness of selection. These limitations can be circumvented to some extent by the use of recurrent selection, a breeding method in which inbreeding is held to a minimum. The method as used in modifying combining ability in corn consists of (a) intercrossing \( S_n \) progenies of \( S_0 \) plants selected on the basis of their yields in test crosses and (b) the use of the population of intercrosses as foundation material for the next cycle. The procedure may be continued for successive cycles as long as sufficient genetic variation is present to allow effective selection. The ceiling in this case is the most desirable combination of genes possible from those present in not one, but rather a group of selected individuals. The probability of obtaining the one most desirable genotype is, of course, very low. The chance of obtaining satisfactory individuals should be increased, however, since the greater opportunity for recombination is present and, since the rate of inbreeding is reduced, genetic variability is held at a higher level which will permit more effective selection over an extended period.

The purpose of this investigation was to determine some of the effects of two cycles of recurrent selection for combining ability in an open-pollinated variety of corn. Three second-cycle synthetic varieties developed under the recurrent selection system and the open-pollinated variety from which they were derived were compared as sources of new lines. A group of advanced generation inbred lines developed under a system of continuous self-pollination in which selection at each generation from \( S_1 \) to \( S_2 \) was based on test-cross performance were compared with \( S_n \) lines from the second-cycle synthetics. Finally, a study was made of the extent to which variability for combining ability had been altered under the recurrent selection system.

LITERATURE REVIEW

The general procedure now commonly employed in recurrent selection programs was first outlined by Jenkins (3) as a method for developing high-yielding synthetic varieties of corn. Variations in the general scheme and objectives have since been suggested by Hull (4) and Comstock et al. (11).

Lonnquist (9) developed two synthetic corn varieties by intercrossing \( S_n \) lines from the upper and lower extremes of a distribution as determined by their yield in top crosses with Krug, each the single cross WF9 \( \times \) M14. These were designated KHII and KHIIc, and 30 inbred lines developed from Krug, and KHIc were employed in this study. The three synthetic varieties have been designated KHII, KHIIc, and Kl. The procedures used in the first cycle of their development have been given in detail by Lonnquist (9) and will be only briefly reviewed here.

Thirty-six \( S_1 \) Krug lines were evaluated in top crosses with the parental variety in 1944. The eight \( S_1 \) lines with the highest top-cross yields were selected as basic material for a high-yield synthetic. The seven \( S_1 \) lines with the lowest top-cross yields were used in the production of a low-yield synthetic. Fifty seeds from each of the component \( S_1 \) lines were composited to make up each synthetic. The two composites were planted in isolated increase plots in 1945. Seed (syn-1 generation) was harvested and planted in isolated plots to produce the syn-2 generation of the synthetics in 1946. The synthetics at this stage were referred to as KHII syn-2 and Kl syn-2.

In 1947, plants in KHII syn-2 were self-pollinated and outcrossed to WF9 \( \times \) M14. A yield trial of 152 of the test crosses was grown in 1948 (12). Ten \( S_2 \) lines whose test-cross yields exceeded the mean by two or more standard deviation units were selected as basic material for the second-cycle synthetic referred to as KHIIc. In this designation, \( II \) indicates the second cycle, and (10) the number of \( S_n \) lines used in its production. Thirty-one \( S_1 \) lines, including the 10 mentioned above, whose test-cross yields exceeded the mean by one or more standard deviation units were selected as basic material for another synthetic, KHIIc. These synthetics were advanced to the syn-2 generation in basically the same manner described for the first-cycle synthetics.

Plants in Kl syn-2 were self-pollinated and outcrossed to WF9 \( \times \) M14 in 1948. Seventy-seven of the test crosses were grown in a yield trial in 1949 (12). Eleven \( S_1 \) lines whose test-cross yields were one or more standard deviation units below the mean were used as basic material for a second-cycle synthetic variety, Kl syn-2. This synthetic was advanced to the syn-1 generation in an isolated plot in 1950.

Approximately 100 plants in each of the 3 second-cycle synthetic varieties and in Krug were self-pollinated and outcrossed to WF9 \( \times \) M14 in 1951. On the basis of the amount of test-cross seed available, 76 test crosses from each of the populations were selected to be grown in the 1952 yield trial. Self-pollination had been continued in the eight high- and seven low-combining lines used in making up the two first-cycle synthetics. Selection for combining ability was practiced within each of the lines, the selection at each generation from \( S_0 \) to \( S_2 \) being based on yield of test crosses with WF9 \( \times \) M14 as tester parent combining lines was significantly greater than that of the synthetic from low-combining lines, Lonnquist (11) later compared the test-cross performance of plants from the two synthetics. The mean yield of test crosses from the two populations differed greatly when compared through the yield of the tester parent, WF9 \( \times \) M14, included in the tests as a check. Sprague and Brimhall (13) obtained a shift of about 7 bushels per acre in mean top-cross yield through a single cycle of recurrent selection for combining ability in the Stiff Stalk Synthetic variety.

The recurrent selection method has also been employed in sweet-clover improvement. Johnson (7) found a single cycle of recurrent selection to be very effective in increasing general combining ability. The results indicate that the method may be effective in breeding forage crops.

Selection is for a character other than combining ability, the use of a tester is unnecessary. Recurrent selection has been successfully employed in modifying oil content of the corn kernel (13,14) and in increasing resistance to Helminthosporium turcicae, test blight in corn (6). In the latter case, classification prior to pollination was possible and thus a cycle could be completed in a single season.

MATERIALS AND METHODS

An open-pollinated variety, Krug yellow dent, 3 second-cycle synthetic varieties, and seven lines from Krug, each the single cross WF9 \( \times \) M14 were employed in this study. These three synthetic varieties have been designated KHII, KHIIc, and Kl. The procedures used in the first cycle of their development have been given in detail by Lonnquist (9) and will be only briefly reviewed here.

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