

THE COMPARATIVE EFFICIENCY OF HIGH AND
LOW YIELDING TESTERS IN EVALUATING THE
COMBINING ABILITY OF INBRED LINES OF
MAIZE

By

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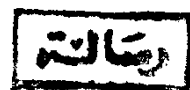
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1. INTRODUCTION

Combining ability and its correct estimation for inbred lines used to make hybrid of maize whether double cross or otherwise, hold a position of cardinal importance in any hybrid maize breeding program. The testing of specific combining ability of inbreds poses no problem, since the tester to be used for that purpose is almost always self evident. But opinions of maize breeders differ with regard to the type of a tester best suited for testing general combining ability. For a long time most breeders recommended a high yielding open pollinated variety but accumulated evidence seemed to point in a different direction. For example El-Ghawas 1963 among others recommended a local highly heterozygous single cross (S.C. 14). Others seemed to recommend other types of testers.

In this study a number of top cross testers covering the yield range high to low among which is S.C. 14 were used and compared with regard to their efficiency in the process of evaluating the general combining ability of a group of 29 inbred lines.

It is hoped that the results obtained herein would be of value in maize breeding in the U.A.R.

II. REVIEW OF LITERATURE

Successful development of improved maize hybrids is dependent upon accurate genetic evaluation of inbred lines. Early work in development of hybrids was based upon visual selection of lines during inbreeding followed by production of and selection among single-cross and double cross combinations. The number of hybrid combinations taking 2 or 4 lines at a time increases rapidly with increasing numbers of lines. It was soon realized that an evaluation procedure was needed which would permit discarding a number of lines not likely to be of value in cross combinations. The studies led to the adoption by most corn breeders of the top cross test for initial evaluation of lines, followed by single cross combination tests of the better lines selected in the top cross test. The preliminary top cross test involved some rather broad gene base stock as the tester parent and was therefore a test for general combining ability.

General combining ability is defined as the average performance of a line in hybrid combinations (Sprague and Tatum, 1942). The first method used to evaluate it was to cross the isolated inbreds among themselves or to a series

or inbred testers (Jenkins and Brunson 1932, Johnson and Hayes 1932 and Sprague 1955). The average performance of any one line in single crosses with the series of inbred testers was taken as the estimate of its general combining ability (Sprague 1955). According to Green (1948), Davis in 1929 made the first suggestion of the use of inbred-variety crosses as a means of testing for general combining ability. There has been, however, much controversy over the choice of the appropriate tester. Jenkins and Brunson (1932) gave the clue to the solution of the problem of testing inbreds for general combining ability. They compared the value of varieties and inbreds used as testers to determine the general combining ability of inbreds of similar maturity and origin. Since their data revealed close agreement between the estimates of combining ability using the one method and those estimates using the other, they recommended the top cross method as it is infinitely less laborious. In their "Suggested procedure" given in the same paper, the authors recommended the top cross method as only a rapid and preliminary test of combining ability of inbred lines, on the basis of which the breeder can discard about 50 % of the lines without the risk of losing "any really superior material" and that the remaining 50 % should be

given a more rigorous test in combination with individual inbred lines. Johnson and Hayes (1936) crossed eleven inbred lines of sweet maize to each of three testers and to one another in all possible combinations. The three testers used were the parental variety from which all eleven lines were derived, an unrelated variety and an unrelated inbred line. While the average yield performance of the line in the three top crosses was positively and significantly correlated with their yield performance in single crosses, the correlations between the yield performance of the same lines in their top crosses to one tester and their performance with each of the other testers were low. This indicated that the testers used did not agree in their estimates of the combining ability of the inbred lines. The authors attributed this lack of agreement, however, to insufficient replicates in the yield trial (2 or 3 replicates of one row each).

Davis (1934) (c.f. Sharma, 1967) suggested that a low yielding variety carrying recessive factors for characters of greatest interest should be used as a tester parent. According to Green (1948), however, Beard in 1940 proposed the use of high yielding single crosses heterozygous for all

yield genes. Sprague and Batum (1942) stated that in top crosses the tester chosen should provide a sufficiently broad base of genetic diversity to insure that differences in yield are due primarily to differences in general combining ability. Hull (1947) observed that per se high yielding testers were worthless for the testing general combining ability. He argued that the masking effects of the dominant desirable alleles in such testers render them ineffective. The observations of Green (1948) with regard to the combining ability for lodging resistance agreed with this hypothesis. A lodging resistant double cross and a lodging susceptible open pollinated variety were used as testers for the F_2 progenies of three single crosses. When considerable lodging occurred, there was little difference between testers, with little lodging, however, the lodging susceptible tester gave a much greater range for standability within all the F_2 progenies than the lodging resistant tester. But Keller (1949) reported that if Hull's hypothesis was correct, the component of variance due to the interaction of lines with testers would be less for high combining testers than for low combining testers. Separate estimates of the line x tester component of variance were obtained for the high and low yielding groups in 22 single crosses. The averages of these estimates

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were essentially the same for the two groups. This indicates that the performance level of the tester had no effect on the ranking of the lines for their combining ability.

Federer and Sprague (1947) carried out studies to compare the relative efficiency, with fixed number of plots, of increasing the number of replicates or the number of testers. They found that in determining general combining ability, increasing the number of testers is more important than increasing the number of replicates.

Mc Gill (1949) (c.f. Lennquist and Rumbaugh, 1958) using 59 early and 69 late, more or less unselected inbred lines obtained highly significant correlation coefficients ($r = 0.80$ and 0.70) for yield when compared in crosses to 2 unrelated single cross testers. A more restricted group of lines was studied in test cross combinations with inbred line, single cross, double cross and variety testers. The results were such as to suggest that no one type of tester could be characterized as being entirely satisfactory in evaluating the relative yield potential of a group of lines.

Matzinger (1953) used 2 double crosses, their 4 parental single crosses and their 8 constituent inbred

that the choice of a suitable tester is dependent upon the ultimate use to be made on the material and supported the use of a tester providing a broad gene base for determining general combining ability.

Grogan and Zuber (1957) compared 2 double crosses and their 4 component single crosses (designated as DC_1 and its components SC_1 and SC_2 ; DC_2 and its components SC_3 and SC_4) as top cross tester parents of 3 segregating groups of S_1 lines for general combining ability. These group of lines were : one group of 57 S_1 segregates of a 3-way crosses which contained one of the parental lines of the SC_1 tester and which were previously tested for general combining ability using 2 open pollinated varieties, two groups of 44 S_1 segregates each of the first segregating generation of two unrelated different single crosses. The first group of segregates were crossed to all 6 testers, the second group was crossed to DC_1 , SC_1 and SC_2 , while the third group was crossed to DC_2 , SC_3 and SC_4 as testers. They found that the agreement between testers for measuring yield varied with the segregating population to which the testers were crossed. Also they showed that some single crosses as top cross testers

appeared to be as efficient as double crosses in estimating general combining ability.

Sprague (1959) pointed out that a desirable tester is one that is heterogenous and unrelated to lines tested as such material would be more widely adaptable to different locations and environments. Thompson and Rawlings (1960) compared 4 single crosses as testers (two low yielding and two high yielding of different ear heights) in an attempt to determine which was the best tester for measuring ear height and yield by crossing, 6 dwarf and 26 low eared normal inbreds with these 4 testers. They found that all four testers were about equally effective for measuring ear height but slight advantage was indicated for the lower yielding testers for yield evaluation. They tended to support the hypothesis that a low-performing tester is better than a high performing tester for yield. In 1962 Rawlings and Thompson confirmed these results and concluded that a low yielding tester would discriminate more effectively among combining abilities of the lines crossed with it than would a high yielding tester. Genter and Alexander (1962) compared the performance of S_1 lines per se and in test crosses with 2 single cross hybrid testers. The variability of the S_1 means was found to be larger than that for

test cross means. Contrary to expectancy, the line x environment interaction was less than the test cross x environment interaction. The authors concluded that S_1 performance was more reliable as a measure of general combining ability than test cross performance. However, the degree to which S_1 line performance is indicative of general combining ability remains to be determined.

Hayes (1963) stated that a tester should be genetically diverse from the lines tested, adapted to the region where the inbreds are to be used in crosses and should consist of material that previously have not been selected for high combining ability. Among ten top crosses testers used by El-Ghawas in 1963 (3 open pollinated varieties, a synthetic variety, 3 double cross hybrids and 3 single crosses) to evaluate the general combining ability of 8 inbred lines derived from 7 diverse sources local and introduced, one single cross (S.C. 14) gave the best estimates. The standard of comparison was the average performance of the lines in single cross combinations among themselves. He concluded that S.C. 14 was a highly heterozygous single cross producing a vast gametic array of genotypes. Lonnquist and Lindsey (1964) made a

study to evaluate 169 S_1 lines using three types of test procedures; (a) lines per se; (b) test crosses to an unrelated synthetic tester; and (c) test crosses to the parental population. The results suggested that selection for yield based upon (a) S_1 per se, and (b) an unrelated tester, were dependent upon different genetic effects. This conclusion was based on results from all possible single cross combinations among the three highest and three lowest yielding lines selected in (a) and in (b). The mean yields of the H x H, L x L, and H x L crosses from lines selected in (a) behaved as if selection had been based on additive effects, that is, the mean yield of the H x L combinations was essentially intermediate between the means of H x H and L x L crosses. The intercrosses among lines selected in (b) behaved as if overdominant genes had been selected for i.e., $H \times L > H \times H > L \times L$ combinations. The performance of the next cycle populations resulting from two types of selection did not differ significantly although both were superior to the parental synthetic.

Genčev et al. (1965) pointed out that in combining ability tests the tester gives a more reliable result when used as the pollen parent. Nada (1966) carried out a study

important, a good tester may be produced by selecting a low yield within the parent variety. Finally Sharma *et al.* (1967) used two groups of 4 high performing and 4 low performing complexes and varieties to test the suitability of the complexes and varieties in each group as testers for evaluating the same two groups in synthetic combinations. Previous combining ability tests of the two groups showed that the high performing group possessed the high general combining ability values while the low performing group had low general combining ability values. Diallel crosses between the eight complexes and varieties were made (excluding reciprocals) and their performance on per se basis was determined. The results indicated that on the basis of top crosses where low yielding varieties were used as testers the high performing varieties and complexes had the highest ranks ranging from 1 to 4 and the low combiners were ranked lowest. But when high yielding complexes and varieties were used as testers the low combining varieties were ranked from the lowest to the highest combiners. Similar disparity in ranking was also observed for the high combiners. They pointed out that the ranking for most of the tested stocks was disturbed a great deal by the high performing and high general combining ability testers, and conversely the ranking