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UGE 223, COMMERCIAL PLANT BREEDING

Development of Hybrids

Hybrids: Hybrids are the first generation (F1) from a cross between two pure lines, open pollinated varieties or clones that are genetically dissimilar. Most of the commercial hybrids are F1s from two or more pure lines (tomato, rice, Jowar) or inbred lines (maize, sunflower, caster etc.)

Pure line: It is the progeny of single self-fertilized homozygous plant.

Inbred line: It is a near homozygous line obtained by continues inbreeding in a cross pollinated crop followed by selection.

Single cross: when two inbred lines or pure lines are crossed to produce the Fl hybrid it is known as single cross.

Double cross: when two single crosses are crossed the resulting hybrid population is known as double cross.

Three-way cross: It is a cross between a single cross and an inbred to give hybrid population.

Top cross: when an inbred is crossed with an open pollinated variety it is known as an inbred variety cross or a top cross. The purpose of top cross is to estimate the GCA of the inbred line crossed with OPV. When the cross is made to assess the combining ability it is known as test cross. A test cross may be made with an inbred (for SCA), hybrid, synthetic or OPV (for GCA). The common parent used in the test cross is known as tester and the progeny derived from these crosses are known as test cross progeny.

Polycross: It is the progeny of a line produced through random pollination by a number of selected lines.

Varietal cross: when two open pollinated varieties are mated it is known as varietal cross or population cross.

History of hybrids: Hybrids were first commercially exploited in maize because the yielding ability Of OPV could not be improved by mass selection or progeny selection.

In 1878 Beal had shown that certain varietal crosses showed substantial heterosis and he suggested that such varietal hybrids might be used as varieties.

In 1908 Shull suggested a method for producing single cross hybrids in maize. He suggested that inbreds should be developed from OPV by continues self-fertilization. The inbreds that combined to produce superior hybrids should then be crossed to produce single cross hybrids. Shull's scheme could not be exploited commercially because of the following reasons:

1. Outstanding inbred lines were not available to produce hybrids with higher yields than that of OPV.
2. Since the female parent was an inbred,the amount of hybrid seed produced per acre was low (30-40 % of OPV), consequently the hybrid seed was expensive.
3. The male parent was also an inbred, hence pollen production was poor. So more area was to be planted under the male parent. This made the hybrid seed more expensive.
4. The hybrid seed was poorly developed as it was produced on the inbred line. The seeds were irregular, undersized with poor germination, thus requiring higher seed rate.
5. Cost of hybrid seed was very high.

The last four drawbacks were overcome by the double cross scheme proposed by Jones in 1918. Since in a double cross the female and male parent are single crosses, the seed and pollen production are abundant, seed quality and germination were high as a result the cost of hybrid seedwas low.

The first double cross maize hybrid was produced at the Connecticut Agricultural Experimental station and grown in Connecticut in 1921 and was named as Burr Learning Hybrid.

Development of Hybrid: Breeding for hybrids involves three steps:

1. Development of Inbred lines
2. Evaluation of inbred lines
3. Commercial utilization of the crosses for seed production.

1. Development of inbred lines: Inbred lines are developed by continues self fertilization of a cross-pollinated species. Inbreeding of an OPV leads to many deficiencies like loss of vigour, reduction plant height, plants become susceptible to lodging, insects and pests and many other undesirable characters appear. After each selfing desirable plants are selected and self pollinated or sib pollinated.

Usually it takes 6-7 generations to attain near homozygosity. An inbred line can be maintained by selfing or sibbing. The purpose of inbreeding is to fix the desirable characters in homozygous condition in order to maintain them without any genetic change.

The original selfed plants is generally referred as S0 plant and the first selfed progeny as S1 second selfed progeny as S2 as so on. The technique of inbreeding requires careful attention to prevent natural crossing. The inbred lines are identified by numbers, letters or combination of both. In India inbred lines are developed and released through co-ordinate maize improvement scheme and are designated as CM (Co-ordinate maize), CS (Co-ordinate sorghum) etc.

CM-100-199 - Yellow flint

CM-200-299 - Yellow Dent

CM-300-399 - White Flint43

CM-400-499 - White Dent

CM-500-599 - Yellow

CM-600-699 - White

2. Evaluation of inbred lines: After an inbred line is developed, it is crossed with other inbreds and its productiveness in single and double cross combination is evaluated. The ability of an inbred to transmit desirable performance to its hybrid progenies is referred as its combining ability.

GCA: The average performance of an inbred line in a series of crosses with other inbred lines is known as GCA.

SCA: the excessive performance of a cross over and above the expected performance based on GCA of the parents is known as specific combining ability. Thus GCA is the characteristic of parents and SCA is characteristic of crosses or hybrids. The inbreds are evaluated in following way.

a. Phenotypic evaluation; It is based on phenotypic performance of inbreds themselves. It is effective for characters, which are highly heritable i.e. high GCA. Poorly performing inbreds are rejected. The performance of inbreds is tested in replicated yield trials and the inbreds showing poor performance are discarded.

b. Top Cross test: the inbreds, which are selected on phenotypic evaluation, are crossed to a tester with wide genetic base eg. An OPV, a synthetic variety or a double cross. A simple way of producing top cross seed in maize is to plant alternate rows of the tester and the inbred line and the inbred line has to be detasselled. The seed from the inbreds is harvested and it represents the top cross seed. The performance of top cross progeny is evaluated in replicated yield trials preferably over locations and years. Based on the top cross test about 50% of the inbreds are eliminated. This reduces the number of inbreds to manageable size for next step. Top cross performance provides the reliable estimate of GCA.

c. Single cross evaluation: Outstanding single cross combinations can be identified only by testing the performance of single cross. The remaining inbred lines after top cross test are generally crossed in diallel or line x tester mating design to test for SCA. A single cross plants are completely heterozygous and homogenous and they are uniform. A superior single cross regains the vigour and productivity that was lost during inbreeding and can be more vigorous and productive than the original open pollinated variety. The performance of a single cross is evaluated in replicated yield trial over years and location and the outstanding single cross identified and may be released as a hybrid where production of single cross seed is commercially feasible.

In case of maize the performance of single cross is used to predict the double cross performance.

Number of Single crosses with reciprocals = n(n-l)

Number of single crosses without reciprocals = n(n-l)/2

Prediction of the Perfo rmance of Double Cross Hybrids

In a double cross hybrid, four inbred parents are involved. Theoretically, the potential of the double cross will be the function of the breeding value of these four parental inbreds. Therefore, based on the procedure of testing of the breeding value of inbreds, the performance of a double cross hybrid can be predicted through any of the four methods indicated by Jenkins (1934). Starting with the simplest procedure these methods are:

a) Top-cross testing (one cross per inbred) to know the breeding value of each of the four inbreds (total 4 top-crosses per double cross).

b) Mean of the four non-parental single crosses involved in (AXB) X (CXD) double cross, viz., (AXC), (AXD), (BXC) and (BXD) (total 4 non-parental single crosses per double cross).

c) Average yield performance of all possible six crosses [n(n-1)/2], namely AXB, AXC, AXD, BXC, BXD and CXD (total six crosses per double cross).

d) Average progeny-performance of each inbred can be determined by the mean performance of each inbred in all possible single crosses where it occurs (n-1 crosses per inbred). For instance, the mean performance of AXB, AXC and AXD will determine the average breeding value of the inbred A. Similarly, the mean of AXB, BXC and BXD will indicate the pote ntial of the inbred B and so on (total 12 crosses per double cross).

These procedures of predicting the performance of double cross hybrids have been extensively investigated long ago. The available evidence shows that the method (b), i.e. mean performance of non-parental single crosses, is the most adequate and effective, since there is a close correspondence between predicted and realized yields of double crosses in maize. Fortunately, the total number of crosses required to be sampled per double cross is also the minimum, thus greatly facilitating the testing programme.