

Lecture 2

What is hybrid maize?

When maize is self-pollinated, each generation becomes weaker. Self-pollination is the process of taking the pollen from a single plant and applying this to the silks of the same plant. This is called **inbreeding**, and after successive generations leads to weakened plants called inbred lines. These inbred lines are small in size, have small cobs and reduced yields. However, when two inbred lines are crossed, the vigor is restored in the resulting seed, and the yield of the plants grown from the seed is greatly increased. This is called **hybrid vigor**. It occurs as a result of the interaction between the sets of genes obtained from the two different inbred lines. The effect of some of the harmful genes expressed in one of the inbred lines will be masked by more beneficial ones found in the other parent plant. This is called **heterosis**, and has been exploited to develop hybrid cultivars that are now widely grown by farmers.

The characteristics of hybrid maize

- It is uniform in appearance
- It has vigor (makes them more competitive with weeds)
- It is high yielding.
- It is selected for improved grain quality.
- A particular hybrid can be selected for specific pest and disease resistance or drought tolerance.

Developing new hybrids

Hybrid maize is produced by cross-pollinating two unrelated male and female plants of different inbred lines. By nature of the maize plant having separate male and female flowers, the tassel and cob, it is possible to control the crossing or mating of the plants. A plant may be used as

either a male or female parent. If a plant is used a male, the pollen from the plant is used to cross onto the silks of a different female plant. The pollen from the female plant is eliminated, usually by physically removing the tassel from the female plant before it sheds its pollen. The resulting seed on the female plant gives rise to hybrid plants that are uniform in color, maturity, plant height and other plant characteristics. In order to produce seed of hybrid maize, the male and female inbred lines are grown under strict conditions and evaluated for yield potential and field characteristics.

Crosses between males and females can be made in four different ways to give rise to different kinds of hybrids:

1. **Single-cross hybrids** – This is when two unrelated inbred parents are crossed.
2. **Three-way hybrids** – Three parents are involved in a three-way cross. The female of a three-way hybrid is a single-cross hybrid, while the male is an inbred line.
3. **Double-cross hybrids** – In this cross, both parents are single-cross hybrids.
4. **Top-cross** – In this case, one of the parents is an open-pollinated variety and the other is a single-cross hybrid or an inbred line.

Plant breeders carefully select the parents of hybrids over many years of testing. They are chosen based on performance, disease resistance, drought tolerance, and maturation length. Only the best hybrids are released for commercial production and sale. The production of seed is done in a very controlled manner.

Hybrid seed production

Hybrid seed production is strictly monitored in order to avoid contamination. Male and female parents are inter-planted in alternating rows. There are normally 3 to 6 female rows and 1 or 2 male rows. The female plants are de-tasseled before they shed any pollen, i.e., the tassels are

physically removed. Only the male plants will shed pollen in the field. Inspectors check to see that all emerging female tassels are removed and that neighboring maize plants are at least 360 meters away. This is to ensure that pollen from nearby crops do not fall on to the silks of the female plants. Thus, the female plants are fertilized by pollen that comes only from the male plants. Once the male plants have provided the pollen, they are removed from the field to ensure there is no mixing of seed between the male and female plants. Only the seed from the female plants constitutes the hybrid seed.

It is important that the male and female plants flower at the same time and that the pollen is shed from the male plants when the female silks are receptive, in order to produce a maximum amount of seed. This is called *nicking*.

There are three stages in commercial seed production:

The production of the breeder's seed – this is when the breeder selects and produces the seed for the inbred lines. Only a little seed will be produced as inbred lines are not very vigorous. This seed will then be used for foundation or basic seed production.

The foundation or basic seed is the first multiplication of the breeder's seed (inbred lines). This is also the stage in which the single-cross hybrid will be produced for the three-way or double-cross hybrids. Enough seed of the parents will be produced in order to produce the hybrid seed.

Certified seed is the last stage in seed multiplication. Seed companies contract approved and capable farmers to plant the foundation seed in the ways described above in order to ensure purity and to produce enough seed for the farming sector.

Throughout the production of hybrid seed, the seed company and the seed producer have to adhere to certification standards. The seed fields are checked for isolation, off-types and purity,

while the harvested seed is verified for lack of defects, adequate germination rate and freedom from pests and diseases. Any crop that fails to meet the standards is rejected and may not be sold as seed. Seed that has been certified by the authorizing agency is labeled accordingly and may be sold.

The advantages of growing hybrid maize:

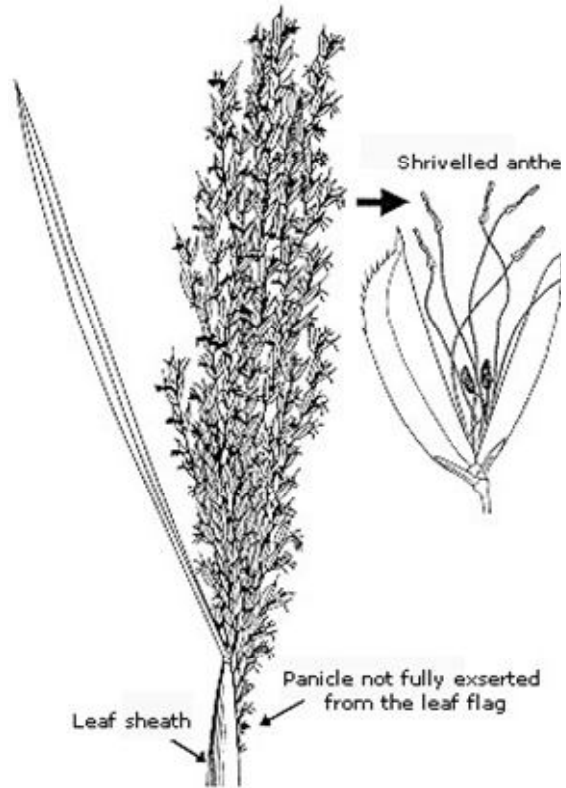
- Hybrids are generally higher yielding than open-pollinated varieties, if grown under suitable conditions.
- Hybrids are uniform in color, maturity, and other plant characteristics, which enables farmer to carry out certain operations, such as harvesting at the same time.
- The uniformity of the grain harvested from hybrids can also have marketing advantages when sold to buyers with strict quality standards.

The disadvantages of growing hybrid maize

- Hybrid seed is more expensive than open-pollinated maize seed.
- The farmer needs to have more than 2 t/ha in order to justify the cost of the seed. Farmers situated in a low potential environment and who cannot afford extra inputs such as fertilizer will not recover the costs of the hybrid seed.
- Fresh hybrid seed needs to be bought every planting season.
- The grain from a crop grown with hybrid seed should not be used for seed. The farmer cannot replant grain as seed without major reductions in yield, which might be a decrease of 30 % or more.
- The farmer might not always be able to source new seed in time for the planting season.

Male sterile line

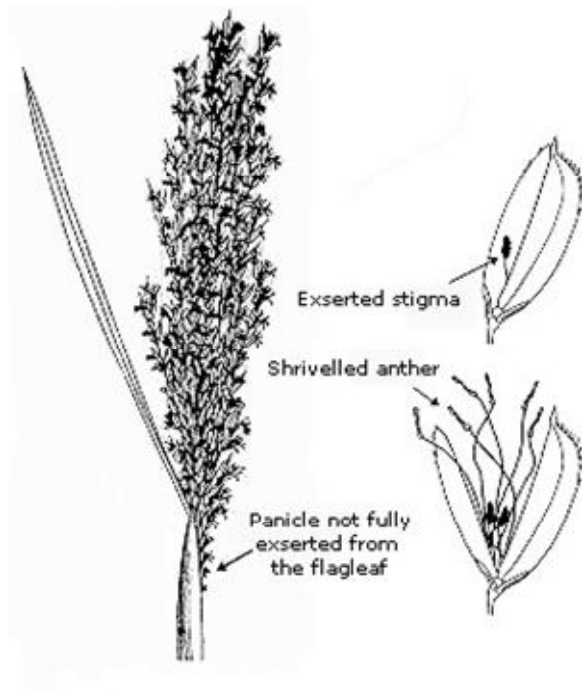
- A rice line that cannot produce viable pollen due to the interaction between cytoplasmic and nuclear genes is described as being cytoplasmic male sterile (CMS).
- It is used as a female parent for hybrid rice seed production.
- The male sterile line is commonly called a CMS line, the seed parent, the female parent, or the A line.
- Panicles may not exert fully. Their basal portion remains inside the flag leaf sheath.
- Anthers are pale or white and shrivelled.
- The flowering period usually lasts for 7 days.



Desirable characteristics of the CMS line

- High seed yields depend on desirable panicle, floret, and stigma characteristics of the CMS line.
- The panicle should be exerted from the flag leaf as far as possible.
- There should be at least 100 spikelets per panicle.

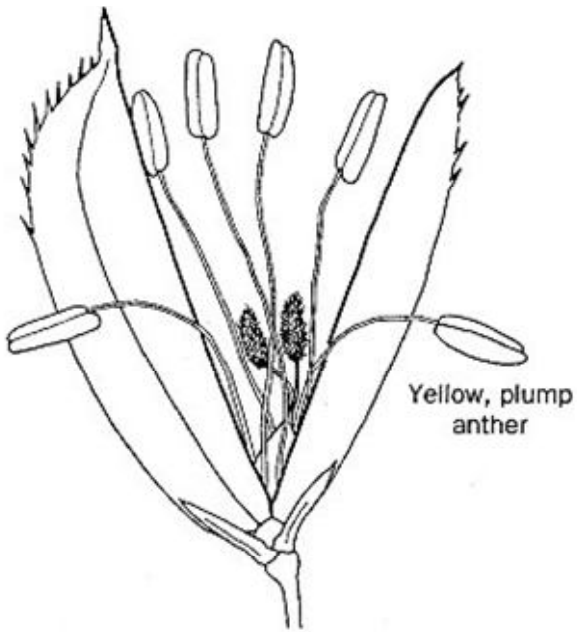
- The floret should open wide and remain open for at least 45 minutes or longer.
- Blooming florets should have exerted stigmas.
- Stigmas should be receptive to pollination for 5 to 7 days.



Maintainer line

- A maintainer line is similar to a CMS line except that it has viable pollen grains and normal seed setting.
- The maintainer line is used as a pollinator for maintaining a CMS line.
- The maintainer is also called the B line.
- The B line cannot restore fertility to the F_1 generation when it is crossed with a CMS line.
- Panicles exert fully out of the flag leaves.
- Anthers are yellow, plump, and shed pollen.

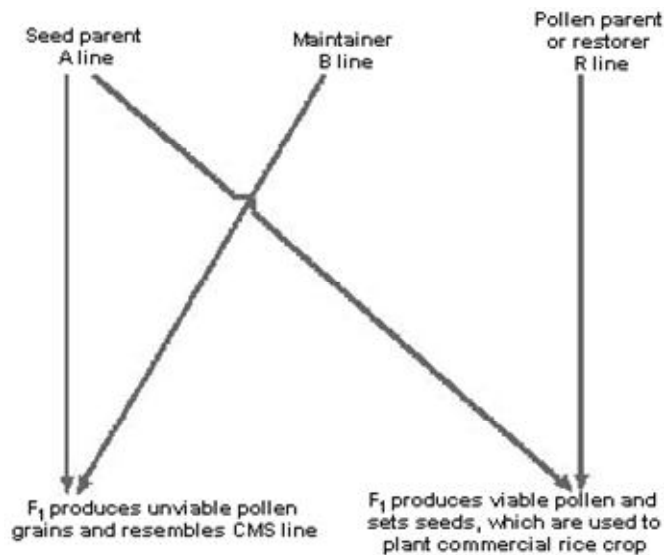
- The B line flowers 2-3 days earlier than the CMS line.
- Flowering lasts for about 5 days



Spikelet of maintainer/restorer line

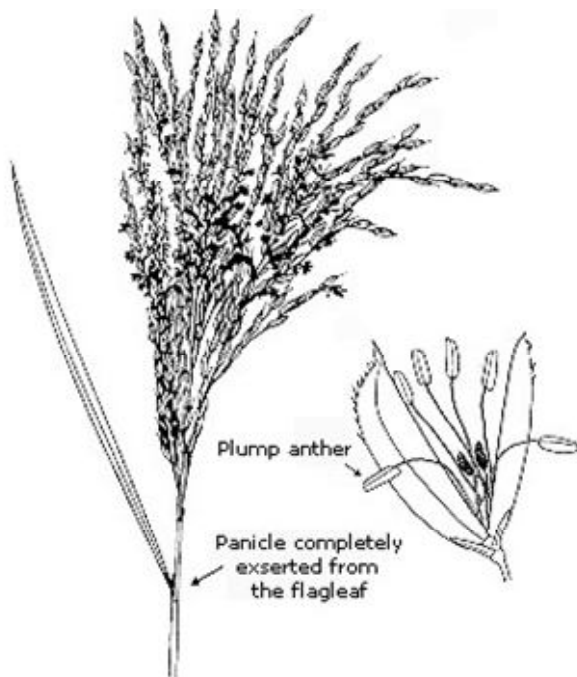
Restorer line

- Any rice cultivar that restores fertility in the F_1 when it is crossed to a CMS line is called a restorer.
- The restorer is also called the pollen parent, the male parent, or the R line.
- The R line is used as the pollinator for the CMS parent for hybrid seed production.
- Growth duration may or may not be similar to that of CMS lines.
- Panicles exert fully out of the flag leaves.
- Anthers are yellow, plump, and shed pollen.
- Flowering lasts for about 5 days.



Desirable characteristics of maintainer and restorer lines

- Panicles should be:
 - long and contain 125 or more spikelets.
 - completely exerted from the flag leaf.
- Filaments should be long for complete anther exertion from the floret.
- Anthers should be large and plump with many pollen grains.
- The anther should shed most of its pollen only after it has exerted from the floret.



Choice of parents for hybrid seed production

- Seed growers normally produce seeds of F_1 hybrids released for commercial cultivation in their country.

- The parental lines should be adapted to the grower's area, even if the hybrid seed may be produced for another geographical area.
- Government agencies or commercial seed companies are the grower's best source of parental seed of hybrids that are popular with farmers.

Seedbed preparation

- Puddle the seedbed field twice at an interval of 7 days to destroy any germinated rice seeds or weed seeds.
- Construct 5-10-cm raised seedbeds of approximately 1 m width of any convenient length.
- Construct drainage channels between seedbeds to drain excess water.
- Apply 5-6 grams of NPK (14:14:14) fertilizer or ammonium phosphate (16:20) fertilizer for each square meter of seedbed area and mix it with the soil.
- Nitrogen increases seedling growth and induces tillering