Seed Production of Hybrid Rice

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What is hybrid rice?

- Like in other crops, the first generation progeny (F1) obtained by crossing two genetically different varieties (parents) of rice is called ‘Hybrid’.
- Since rice is self-pollinated, cytoplasmic male sterile (CMS) parent is used as female parent, which is normally called ‘A’ line.
- The fertility restoring line which is called ‘pollinator’ to the female parent is known as male parent. It is generally referred to as ‘R’ line, and is used for hybrid seed production.
- The hybrid combines the desirable characters from CMS line and R line. They exhibit vigour for several quantitative characters including yield.

Grain quality of hybrids:

- The rice grain quality is assessed in terms of milling, head rice recovery, size, appearance and cooking characteristics.
- In rice, the cooking quality preferences vary from region to region.
- The adoption of hybrids depends on the profitability which in turn depends on its yield advantage over the inbred (pure line) varieties and market price of the produce as determined by cooking quality and eating characteristics.
- Quality characteristics are of paramount importance in popularization of rice hybrids

Breeding technique for commercial hybrid seed production : Cytoplasmic geneic male sterility system

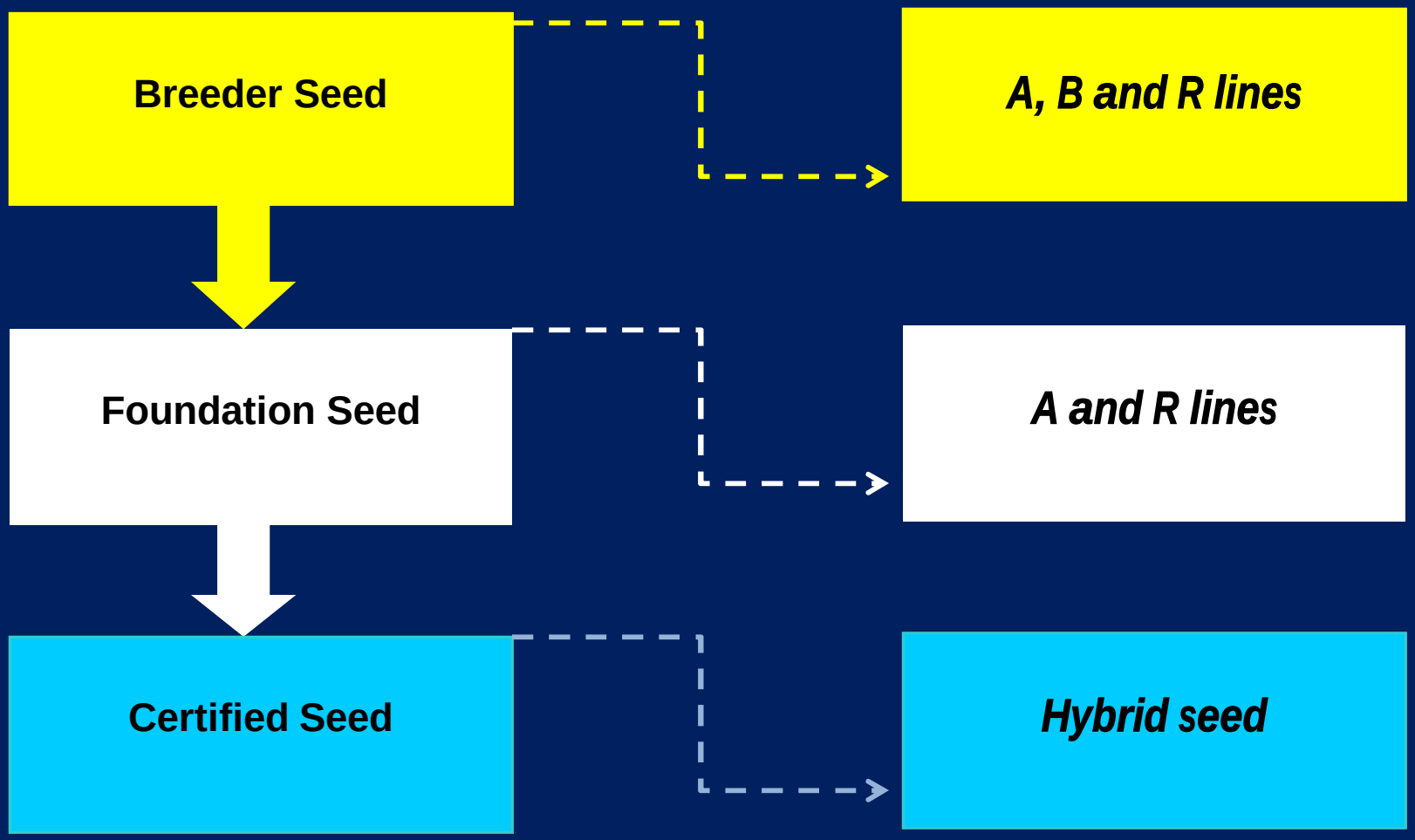
Stages of seed production : Breeder seed – Fundation seed- Certified Seed

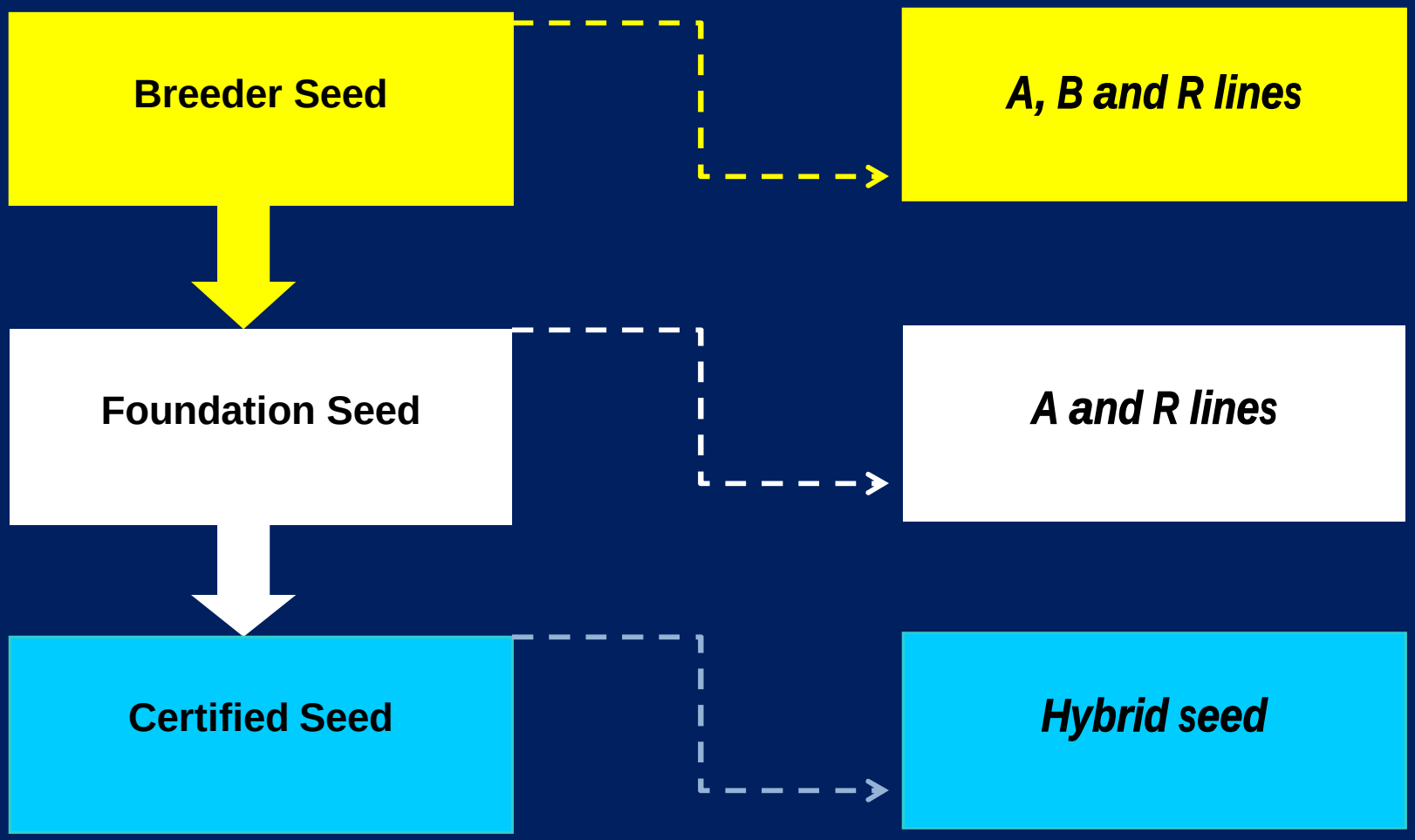
Seed Multiplication work at different Stages

Breeder Seed stage : A (AxB), B, R lines are raised separately under isolation.

Foundation Seed stage: A (AxB) and R lines raised separately under isolation.

Certified seed stage : A and R line are crossed under isolation to get hybrid.


Breeder Seed
A, B and R lines
Foundation Seed
A and R lines
Certified Seed
Hybrid seed


Breeder Seed
A, B and R lines
Foundation Seed
A and R lines
Certified Seed
Hybrid seed

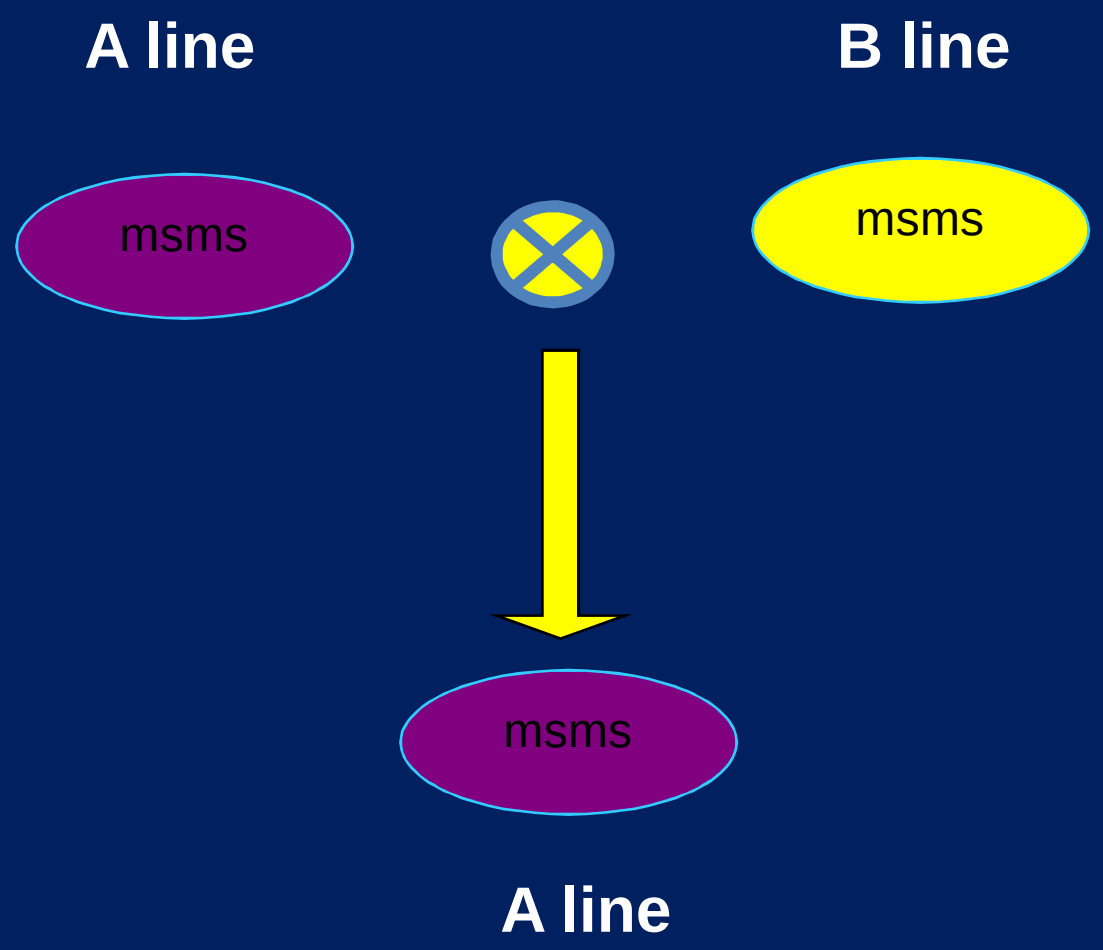
Hybrid Seed Production

- The success of hybrid rice technology primarily depends on genetic purity, timely availability and the affordability of hybrid seed costs to the farmers.
- The production of pure hybrid seed at affordable price in rice- a self-pollinated crop, is a highly skill oriented activity
- There are two systems (2-line and 3- line) hybrid breeding and seed production, but at presently three line method, using cytoplasmic male sterility system, is in vogue.

A line:

- It is cytoplasmic male sterile line which is used as female parent in hybrid seed production.
- It is maintained by crossing with the B line (maintainer line).
- Both these lines are isogenic having homozygous recessive nuclear genes conferring male sterility, differing only in cytoplasm which is sterile (S) in A line and fertile (F) in its maintainer, B line.

Seed of A line is produced by making cross between A X B



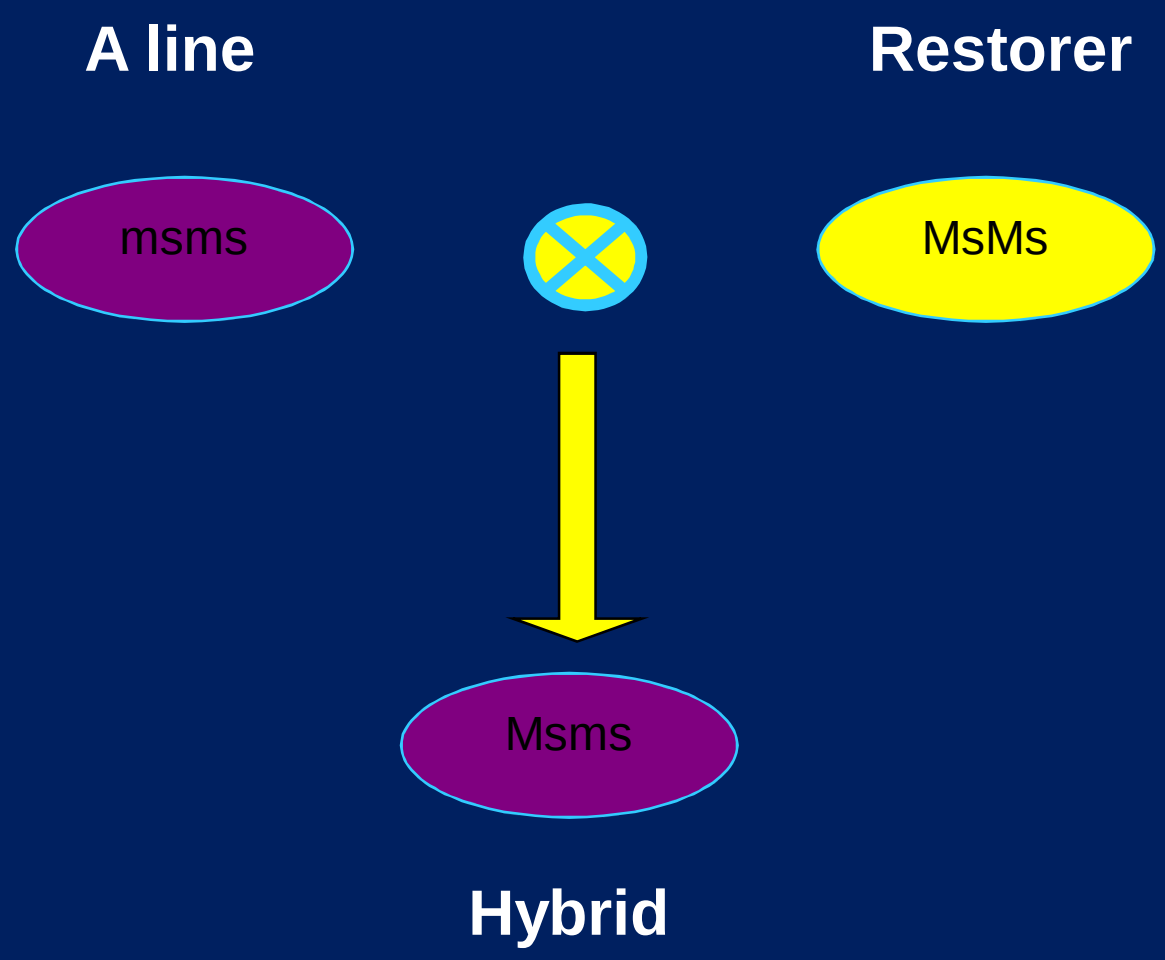
B line: It is iso-genic to A line and is used as pollen parent to maintain male sterility in A line. This line is maintained by growing in isolation, atleast 5 m away from any rice variety.

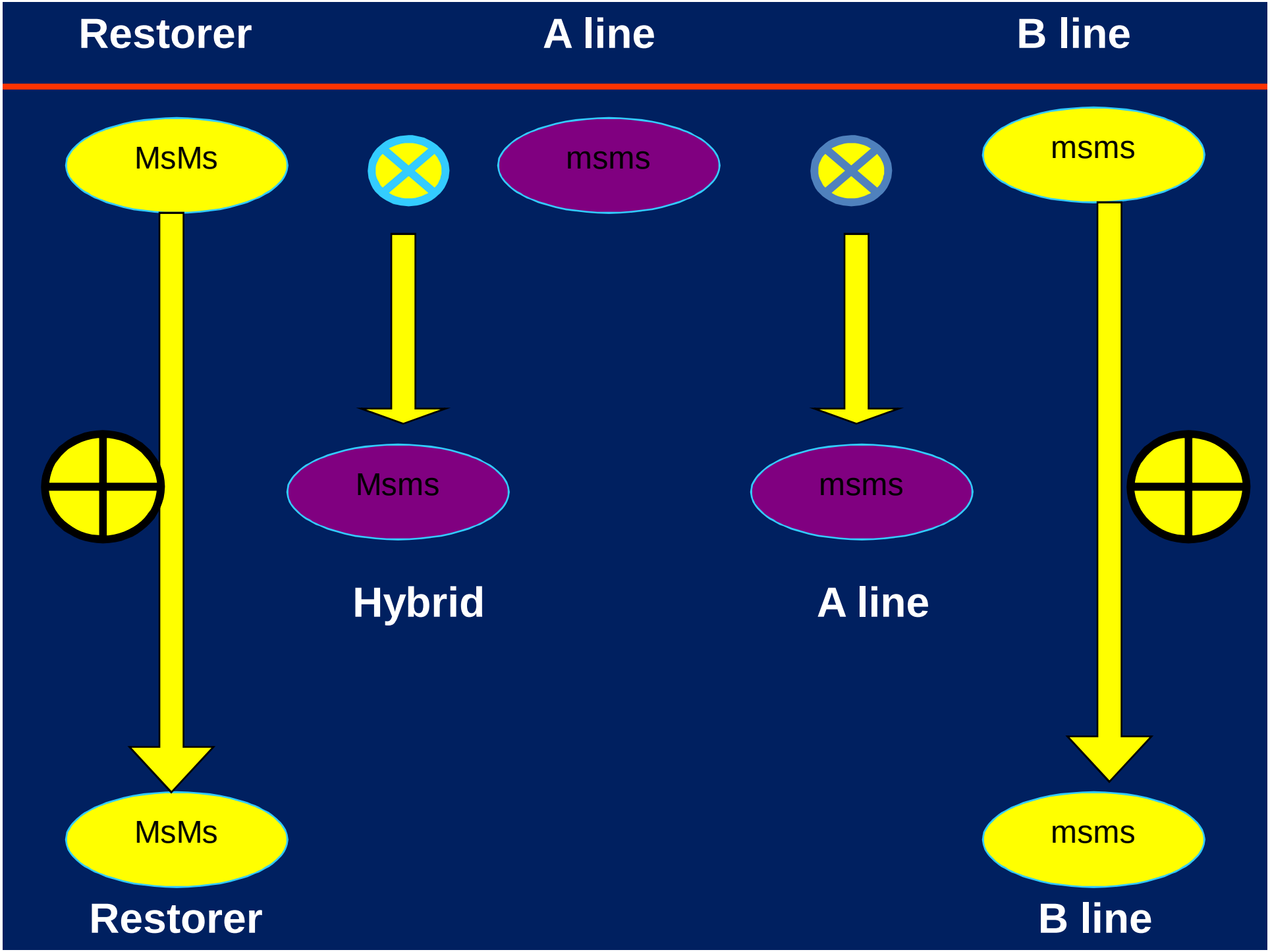
R line: This is also called as fertility restorer or pollinator line. This is used in hybrid seed production by growing along-with A line in a standard row ratio. It is also maintained by growing in isolation, at least 5 m away from any rice variety.

Seed of R line is produced by selfing (male fertile)

Seed of B line is produced by selfing (male fertile)

Hybrid seed is produced by making cross between A X R




Restorer
A line
B line
MsMs
msms
msms
Msms
msms
Hybrid
A line
MsMs
msms
Restorer
B line

Climatic and resource requirement

Seeding time and season:

- The transplanting of seedlings of parental lines should be planned in such a way that flowering doesn't coincide with rains which result in poor seed setting due to pollen wash.

- This is the reason that hybrid seed production is not so successful during *kharif* (rainy season) both in the North and the South, but *rabi* season is most suitable in the Central and the Southern India.

- Other potential states for hybrid seed production of rice in the country are Chhattisgarh and Orissa.

Temperature requirement:

- The transplanting of seedlings of parental lines should be planned in such a way that flowering coincides with most favorable conditions such as daily mean temperature of 24-30^0 C, relative humidity of 72-80 %, difference in day and night temperature in the range of 8-10^0 C, bright sunshine, moderate wind velocity and no continuous rains, particularly at the time of flowering

Soil conditions:

- The field should be fertile with uniform topography, having good drainage and irrigation facilities and free from ‘volunteer plants’.
- The uniform topography and homogeneity of the field in respect of fertility will ensure synchronous flowering and ultimately the highest yield of hybrid seed.

Nursery raising and seed rate:

- To ensure multi-tillered (4-5 tillers) seedlings and convenience in uprooting, sparse seeding in nursery is desirable. For this, 30 g seeds/m^2 would be required.
- 15 kg seed for A line and 5 kg seed for B or R line would be required for planting crop in one hectare of land
- Wet beds of one metre width and of convenient length with good drainage facility should be prepared. 250 kg FYM, 1 kg N and ½ kg each of phosphorus and potash per 100 m^2 should be applied

Isolation:

For ensuring genetic purity of the parental and hybrid seeds, optimum isolation is required. The isolation of the hybrid seed production plot from other rice varieties can be provided by the following means:-

Barrier isolation: This can be achieved through physical barriers:

(i) natural means like mountains, forests and rivers and

(ii) growing taller crops like sorghum (*jowar*), maize, pearl millet (*bajra*), sugarcane, *Sesbania* (*dhaincha*), etc.

These barrier crops are planted covering a distance of 30 m between hybrid seed producing plot/parental seed producing plot and other rice varieties.

Time isolation: It can be provided by planting the parental lines of the hybrid in such a way that they come in full flowering stage 21 days either prior or after the rice varieties grown nearby start flowering.

Space isolation: For providing the space isolation, it is essential that no other rice variety should be grown in a distance of 100 m. For the seed production of A line, this distance should be still larger (500 m).

Row ratio and planting pattern:

Following features of rice plant have profound effect on row ratio.

- Taller the pollinator, larger number of female rows it may cover or pollinate.
- Vigorous pollinator may pollinate larger number of female rows.
- Larger size of the inflorescence or panicle of the pollinator (R line), larger amount of pollen grains will be produced and pollinate larger number of rows of female (A) parent.
- If the duration of opening of floret (flower) in A (female) line is longer, large number of female rows may be alternated with 2 rows of R line.
- If the stigma of A line is fully exerted, the number of rows of this parent could be increased.

The row ratio of female (A line) and R (pollinator or male) parent is kept 10:2, whereas in seed production of A line, the row ratio of A and B line is usually kept 8:2.

The higher out-crossing may be attained if the row direction is adjusted nearly perpendicular to the wind direction prevailing at the time of flowering.

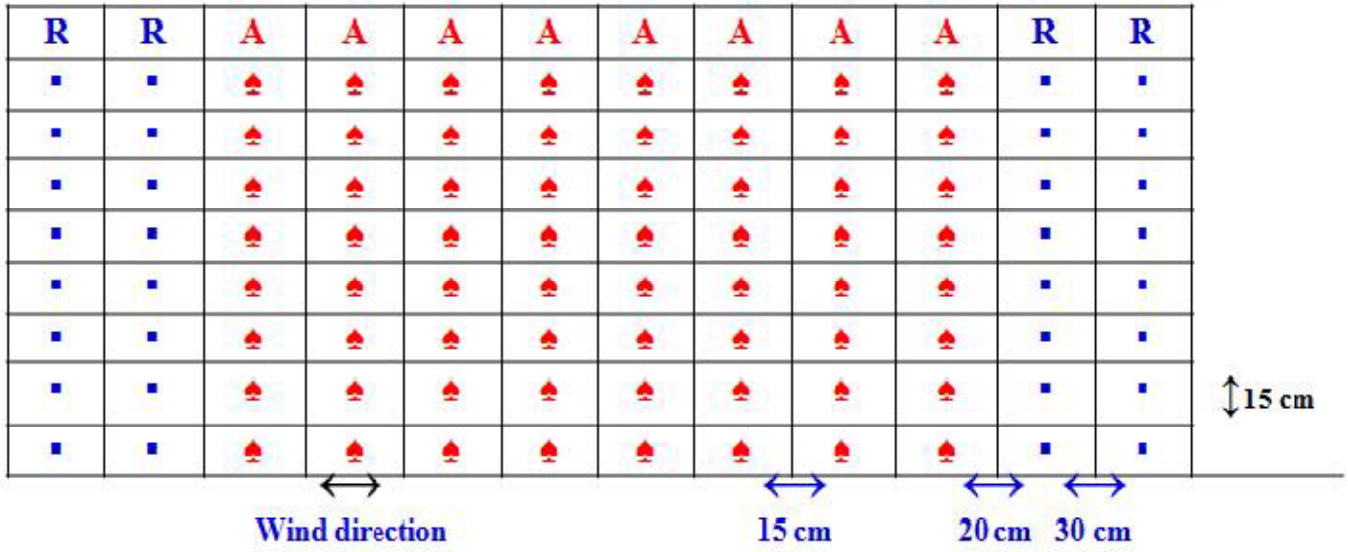
Spacing and method of transplanting:

The spacing between various parents should be as follows.

Male:Male	= 30 cm
Male:Female	= 20 cm
Female:Female	= 15 cm
Plant:Plant	=15 cm or 10 cm

At each hill, 2-3 seedlings should be transplanted at the age of 21-25 days. The transplanting of older seedlings delays flowering, whereas for younger seedlings flowering occurs in advance.

Scheme 1: Row Ratio, Row Direction and Planting Pattern for Hybrid Rice Seed Production (Male : Female ratio = 2 : 8)




Planting Layout: in case flowering duration of R line is more than A line
Two rows of R line with 30 cm row distance
Space (115-145cm) for transplanting of 6-8 rows of CMS line


Planting Layout: In case flowering duration of both parents are same
Six rows of CMS line (15 cm)
Two row of R/B line (30cm)

Spacing and method of transplanting:

The spacing between various parents should be as follows.

Male:Male	= 30 cm
Male:Female	= 20 cm
Female:Female	= 15 cm
Plant:Plant	=15 cm or 10 cm

At each hill, 2-3 seedlings should be transplanted at the age of 21-25 days. The transplanting of older seedlings delays flowering, whereas for younger seedlings flowering occurs in advance.

Application of gibberellic acid (GA3):

This hormone has the following favourable effects:-

- Increases the duration of floret opening, thus ensures pollination.
- Increases the stigma exsertion and its receptivity.
- Promotes plant height.
- Widens the flag leaf angle and thus facilitates easy entry of the pollen grains.
- Influences flowering and thus transplanting in parental lines can be adjusted.
- Promotes panicle exsertion and growth rate of secondary and tertiary tillers.

Synchronization:

Seeding interval: The parental lines differing in their growth duration can be sown on staggered dates in the nursery beds, so that they come to flowering at the same time in the main field where hybrid seed is to be produced. This is called ‘staggered’ or ‘differential’ sowing.

Through fertilization: Depending upon the environmental conditions, synchronization of two parents can be adjusted by foliar spray of nitrogenous/ phosphatic fertilizers.

The spray of 2% urea to early parent delays flowering by 2-3 days and use of phosphatic fertilizer to late parent enhances flowering by 2-3 days.

However, the dose of the fertilizers will depend upon the difference in growth duration and responsiveness of the parental lines.

Roguing:

Roguing is a process of removal of unwanted rice plants from the seed production plots. To ensure high genetic and physical purity of hybrid seed, it is essential to follow roguing in the following stages:-

At vegetative phase: On the basis of morphological characters of leaf and the plant, leaf shape and pigmentation.

At flowering: Early and late types, absence/presence of awns, panicle exsertion, anther colour, panicle characteristics, etc.

At maturity: Per cent seed set on plants in the female parent, grain type, shape, etc

Flag leaf clipping:

- Generally, the flag leaves are longer and erect compared to panicle and therefore, they pose hindrance for easy pollen grain dispersal and could influence the out crossing rate.
- Clipping of flag leaf helps in free movement and wide dispersal of pollen grains to give higher seed yield.
- The flag leaves should be clipped off when the main culms are in booting or pre-emergence of panicle stage.
- About half to two-third portion of flag leaf from the top should be removed.
- Cutting of flag leaf is not advisable in the plots infested with diseases as this operation may spread the disease further.

Supplementary pollination:

- The pollen parent plants are shaken which helps in shedding and dispersal of pollen grains over the A line.
- This can be done either by rope pulling or by shaking the pollen parent with the help of two bamboo sticks.
- The first supplementary pollination should be done at peak anthesis time when 30 to 40 % of the spikelets are open and anthers are fully exserted.
- This process is repeated three to four times during the day at an interval of 30 minutes.
- This process should be done for 7-10 days during flowering period.

Supplementary Pollination through bamboo stick shaking

Supplementary Pollination through rope pulling

Weed management:

2.5-3.0 kg of Butachlor should be mixed in 50-70 kg of sand and apply in one ha area after 5-6 days of transplanting. Need based hand weeding is also recommended to ensure healthy crop.

Nutrient Management:

25% of the recommended dose of N in the form of urea should be applied at 30-35 days of planting and remaining 25% nitrogen and 25% of potash should be applied at 70-75 days after transplanting or at panicle initiation stage.

Water Management:

A thin film of water should be maintained for initial 30 days. The water level is increased later on to 4-5 cm when the crop reaches maximum tillering stage.

Types of contamination

Presence of B line in A line called as pollen shedders

Presence of A line in B line called as off type

Presence of R line in B line called as rogue

Presence of B line in R line called as rogue

Pollen shedders and off type cause physical contamination, whereas, rogue cause physical and genetical contamination.

Field inspection:

Field inspector inspects the foundation and certified seed production programme atleast four times.

Out of these four inspections

- 1st is made before flowering
- 2nd and 3rd during flowering
- 4th at physiological maturity

to verify

- Isolation distance
- Planting ratio
- Planting pattern
- Off-types
- Pollen shedder
- Objectionable weed plants
- Incidence of objectionable seed borne diseases
- True nature of the parents.

Harvesting, threshing and processing:

- First, the male parent (pollen parent or R line) should be harvested, followed by the female parent.
- Threshing should be done separately, if possible on separate threshing floors.
- After drying, the seed should be bagged with labels both inside and outside the bags.
- The seed yields used to be very low (3 to 5 q/ha), but with experience over the years, 15 to 25 q/ha average yields are being obtained now.
- The seed yields are higher in dry season as compared to wet season. Hence large scale seed production is generally taken in dry season only.

Seed testing:

The submitted sample is tested for verification of seed standard

Genetic purity is verified by

ODV
GOT test