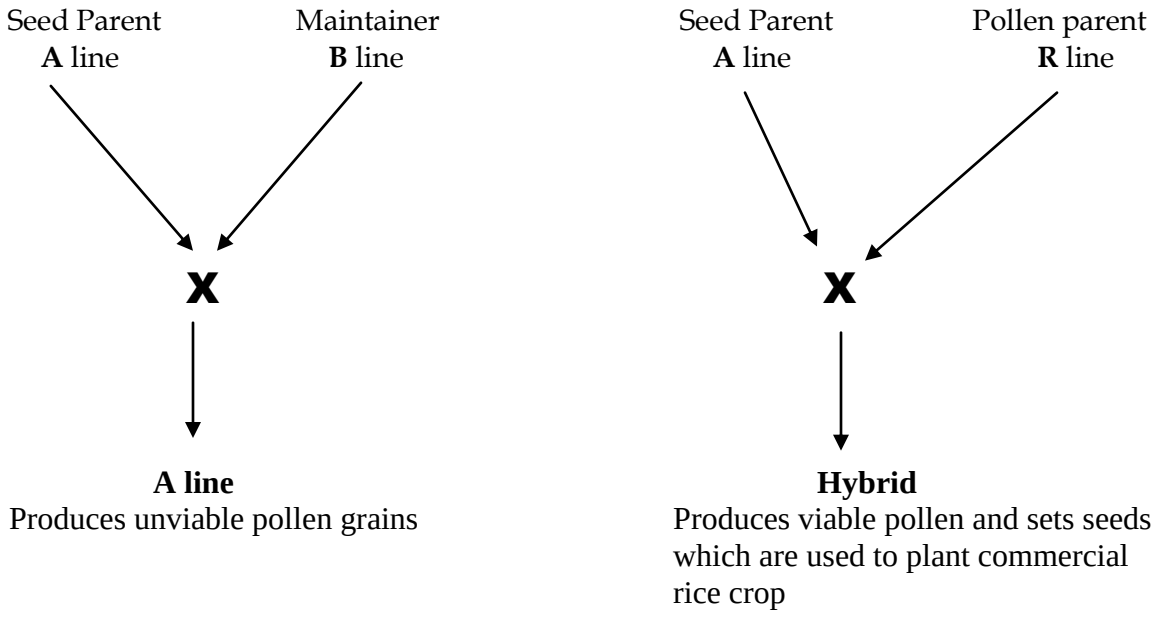
Hybrid Rice Seed Production Seed Production Techniques

Success of Hybrid Rice Technology depends on efficient and economic seed production on large scale. It determines whether the heterosis of hybrid rice can be fully exploited or not. It is reported that the yield of F_1 hybrids will decrease by 0.8% when the seed purity decreases by 1%, so it is very important to establish a sustainable system of seed production to ensure the purity of hybrid seeds in hybrid rice development.

The existing rice hybrids used in commercial production in India are developed by using cytoplasmic genetic male sterility and fertility restoration system (CMS system). This system involves three lines viz., cytoplasmic genetic male sterile line (CMS or `A' line), maintainer (`B' line) and restorer (`R' line) lines for developing rice hybrids. Hybrid Seed Production using the CMS system involves the following two steps.

- Production of `A' line (A x B)
- Production of Hybrid Seed (A x R)

The `B' and `R' lines are multiplied in the same way as inbred varieties.



Thus the procedure of hybrid rice seed production, in which two different lines including male sterile lines (seed parent) and restorer lines (pollen parent) are planted alternatively in a certain row ratio in the same field and the outcrossed seeds are harvested from the male sterile plants, differs from that of inbred varieties, in which only one line is grown and the selfed seeds are harvested. Therefore, in the whole process of hybrid seed production, it requires a set of complicated techniques centering on raising the out crossing rate to obtain a high seed yield.

Rice is self-pollinated crop, where the extent of natural out crossing is only 0.3 to 3.0%. Therefore hybrid rice seed production requires specialized techniques, which need to be thoroughly understood before embarking upon this venture. The success of hybrid seed production depends on various factors such as choice of field, isolation, seeding time, planting pattern and weather conditions during the period of flowering, roguing synchronization in flowering of parental lines, supplementary pollination techniques, proper harvesting, processing, packing and effective seed distribution etc.

1. Choice of location:

Choosing a desirable location for hybrid seed production is very important. In the well isolated area, the paddy field with fertile soil, a desired irrigation and drainage system, sufficient sunshine, and no serious disease and insect problems are essentially needed.

2. Isolation:

Rice pollen grains are very small and light, and can travel very far with the wind. In order to ensure the purity of hybrid seed and avoid pollination by unwanted rice varieties, the hybrid seed production plots should be strictly isolated by the following methods.

Space isolation: A space isolation of 50 – 100 m would be satisfactory for hybrid seed production, which implies that within this range no other rice varieties should be grown except the pollen parent.

Time isolation: Wherever, it is difficult to have space isolation, a time isolation of over 21 days would also be effective. It means that the heading stage of the parental lines in hybrid seed production plot should be 21 days earlier or later than that of other varieties grown within the vicinity.

Barrier isolation: In some places, the natural topographic features such as mountains, rivers, forests can serve as the most effective barrier. A crop barrier with maize, sugarcane, sesbania covering a distance of 30 m would also serve the purpose of isolation. Artificial barrier with polythene sheets of about 2 m height can also be used for small scale seed production. However, the most ideal locations are the areas covered with hillocks and mountains, which act as natural barriers.

3. Favorable climatic conditions:

Climatic conditions have profound influence on the seed yields. Detailed information on the weather data of a given locality is necessary for fixing the seeding dates. Seeding of the parental lines should be planned in such a way that the flowering coincides with the most favorable climatic conditions, which are as follows:

- Daily mean temperature of 24 – 30^{o} c
- Relative humidity ranging from 70 – 80 %
- The differences between day and night temperatures should not be more than 8–10^{o}c, preferably 5 – 7^{o}c
- Sufficient sun shine with moderate wind velocity.
- There should not be rains continuously for three days during the period of flowering.
- Seed yields will be adversely affected if the temperature is below 20^{o}c and above 35^{o}c.
- The Seed Production areas near forest, rivulets and valleys are better for getting higher seed production.

4. Seeding of parental lines in the seedbed

- Puddle the seedbed field properly. Puddle the field twice at an interval of 6-7 days to destroy weeds, weed seeds and germinated rice seeds.
- Prepare raised seedbeds (5-10 cm height) of 1m width of any convenient length.
- Provide drainage channels in between seedbeds to drain excess water.
- Apply recommended fertilizer to the nursery beds
- Sow pregerminated seed uniformly on the seedbed (1-2 kg seed/20m^{2})
- Use 15 kg of `A' line seed and 5 kg of `R' line seed to produce sufficient seedlings to grow one hectare.
- Manage the seedbed properly for getting healthy and vigorous seedlings for transplanting.

5. Transplanting

Commence transplanting seedlings of A and R lines as and when they attain the age of 21-25 days, which ensures timely heading, and flowering of parental lines. Transplanting of older seedlings delays flowering and transplanting of younger seedlings advances flowering. If the transplanting of seedlings of `A' line is delayed, then delay transplanting the `R' line seedlings by the same number of days to synchronize flowering. Transplant one or two seedlings per hill of the `A' line and two seedlings per hill of `R' lines.

5.1 Transplanting in a specific Row Ratio & Row direction: In hybrid rice seed production the seed parent and pollen parent are planted in a certain row ratio at certain spacing. The row ratio and spacing of pollen parent and seed parent have a distinct effect on the hybrid seed yields.

The row ratio or row proportion refers to the number of rows of the male parent (R line) to that of the female parent (A line) in a seed production plot. Suppose if we plant 2 rows of `R' line followed by 8 rows of `A', the row ratio can be taken as 2:8. In hybrid rice seed production plot the recommended male (R) to female (A) row ratio is 2:8. However, the row ratio may vary from region to region, depending on weather, management and parental lines. R and A lines can be planted in several row ratios of 2:8; 2:12; 3:10 etc.

5.2 Factors Influencing Row Ratio: The ratio of pollen parent (R line) to seed parent (A line) is determined by the characteristics of the parental lines.

- Plant height of pollinator
- Growth and vigour of the pollinator
- Size of the panicles and amount of residual pollen
- Duration and angle of floret opening in CMS lines
- Stigma exsertion of CMS lines

To facilitate out crossing, the rows of male and female in the seed production plot should be perpendicular to the prevailing wind direction expected at flowering time of the parents.

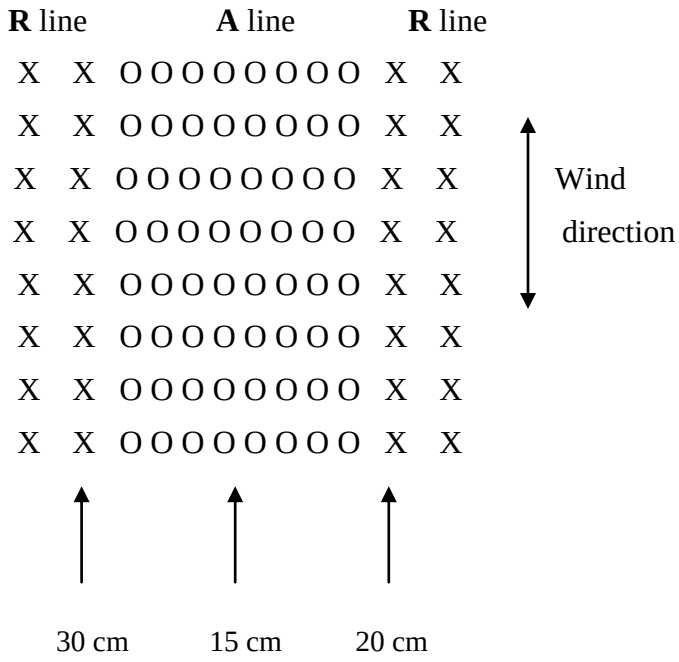
5.3 Transplanting of the R line

- Transplant the seedlings of R line in paired rows
- Leave a space of 145 cms inside block between paired rows of `R' line seedlings for transplanting 8 row blocks of `A' line seedlings.
- Transplant 2-3 seedlings per hill with a row-to-row distance of 30 cms and plant-to-plant spacing of 15 cms.

5.4 Transplanting of CMS line (A line)

- Transplant `A' line seedlings in blocks of 8 rows in between the paired rows of `R' lines
- Transplant with 1-2 seedlings per hill at a spacing of 15 x 15 cms
- Leave a 20 cms wide alleyway between A line rows and nearest R line row.

Field Layout



Spacings:

Between `R' line rows : 30 cms
Between `A' line rows : 15 cms
Between `R' & `A' line blocks : 20 – 30 cms
Between hills (`A' & `R' lines) : 15 cms

Row Ratio : 2R: 8A

5.5 Transplanting Sequence

The transplanting sequence of seed parent and pollen parent in the hybrid rice seed production plot depends on the growth duration of seed parent (A line) and pollen parent (R line)

5.5.1 Seed parent (A line) has 10 day longer growth duration than pollen parent (R line): Transplant 25day old seedlings of the `A' line, 10 days earlier than the second `R' line seedlings. The seedlings of the R line are transplanted when the seedlings from the second R line seeding are 25 days old. At this time the age of seedlings from the first R line seeding will be 21 days old and the age of seedlings from third R line seeding will be 29 days old.

Table – 1: Seeding Sequence and seedlings age for transplanting

S. No.	Seed/pollen parent	Seeding sequence	Seedling age for transplanting (days)
1	A line	0 day	25
2	First R line	6th day	21
3	Second R line	10th day	25
4	Third R line	14th day	29

5.5.2 Seed parent (A line) has 10 day shorter growth duration than pollen parent (R line): The seedlings of the R line are transplanted when the seedlings from the second R line seeding are 25 days old. At this time the age of seedlings from the first R line seeding will be 21 days old and the age of the seedlings from the third R line seeding will be 29 days old. Later transplant 25 days old seedlings of the A line 10 days later than the second R line seedlings.

Table – 2: Seeding Sequence and seedlings age for transplanting

S. No.	Seed/pollen parent	Seeding sequence	Seedling age for transplanting (days)
1	First R line	0 day	21
2	Second R line	4th day	25
3	Third R line	8th day	29
4	A line	14th day	25

5.5.3 Seed parent (A line) has same growth duration as pollen parent (R line): The planting of both R and A lines can be done simultaneously. First complete the A line plantings with 25 day old seedlings followed by R line plantings with the seedlings ages of 21day old first R line, 25 days old second R line and 29days old third R line.

Table – 3: Seeding Sequence and seedlings age for transplanting

S. No.	Seed/pollen parent	Seeding sequence	Seedling age for transplanting (days)
1	First R line	0 day	21
2	Second R line and A line	4th day	25
3	Third R line	8th day	29

6. Roguing

The purity of hybrid rice seeds used in commercial production must be more than 98%. To meet this requirement, the purity of the restorer and CMS lines must be more than 99%. Therefore, in addition to ensuring strict isolation, it is necessary to remove all rogues from the seed production plots. Roguing is the removal of undesirable rice plants from the hybrid seed production plots. Undesirable rice plants are those plants either in A or R line rows that differ from plants that are true to type. Roguing helps to prevent the off-types from cross pollinating the true to type A line plants and thus enhancing the purity of hybrid seed.

The undesirable plants come from many sources. They may be voluntary plants from the previous crop. Contamination due to improper isolation also result in the occurrence of off-types. Admixing during the process of harvesting, threshing, packing and handling are also other sources from which the off-types occurred. Therefore, due care is to be taken to remove the off-types during the cropping season.

Roguing can be done at any time during the crop stage. Off-type rogues can be removed whenever they are identified – earlier the better. The most important stages for roguing are at maximum tillering, flowering and just before harvesting.

6.1 Roguing at maximum tillering: We can identify the off-types by their morphological differences from the true to type plants. Therefore, it is essential to know the characteristic features of parental lines, which help in easy identification of rogues and efficient roguing. As a basic step, any plant found out side the rows has to be removed as they may be volunteer plants. Remove all those plants which are either too tall or too short than the seed or pollen parent. We can also identify the off-type plants by difference in their leaf blade size, shape and leaf sheath colour.

6.2 Roguing at flowering: Roguing at flowering is extremely important as it is the stage when we can identify many off-types which look similar to the parental lines during the early stages of growth. All the off-type plants that flower very early or very late are to be removed. The plants which differ from parental line plants in respect of leaf size, shape, angle, panicle shape, size and pigmentation are to be carefully removed. Remove all the plants from A line that have plumpy yellow anthers. Plants in the A line should not have fertile pollen. The off-types in A lines can also be distinguished from their fully exserted panicles. Care should be taken to remove the plants which are highly infested from pests and diseases.

6.3 Roguing just before harvest: This is the last opportunity to keep away the off-types in order to maintain high purity. Before harvesting, the plants in A line rows are to be thoroughly checked and those plants which show normal seed set are to be removed. It is necessary to remove all the off-types that have different grain characters as compared to that of A line plants. The grain size, shape, colour and pigmentation of A line plants have to be critically examined for effective roguing.

7. Promotion of exertion of panicle:

Most of the male sterile lines based on WA cytoplasm have imperfect exertion of panicle, with the result as much as 15% spikelets remain enclosed in the flag leaf and are not exposed for out crossing. Through following methods, the exertion of the panicles can be promoted to a great extent.

7.1 Application of gibberellic acid (GA_3): It is an efficient and effective growth hormone, which stimulates the cell elongation, thus can be used to enhance panicle exertion in CMS line. Besides, GA_3 has the following favorable effects:

i. Increases the duration of floret opening
ii. Increases stigma exertion and receptivity
iii. Promotes plant height
iv. Influences flowering and hence flowering in parental lines can be adjusted
v. Widens the flag leaf angle
vi. Promotes exertion and growth rate of secondary and tertiary tillers.

In hybrid seed production plots of rice, 5-10% panicle emergence stage is most appropriate for first spraying (40%) and the remaining 60% of GA3 should be sprayed on the following day. The ideal time for spraying is from 8 to 10 AM and from 4 to 6 PM. Spraying should be avoided during cloudy weather and when the wind velocity is high. A dose of 45-60 g/ha of GA_3 is optimum. The harmone does not dissolve in water and it should be dissolved in 70% alcohol (1 g of GA_3 in 25-40 ml of alcohol).

7.2 Flag leaf clipping: Normally the flag leaves are erect and longer than the panicles and they come in the way of easy pollen dispersal thus effecting the out crossing rate. The clipping of flag leaf helps in free movement and wide dispersal of pollen grains to give higher seed production. The flag leaves should be clipped when the main culms are in booting stage. Only half or two-third portion of flag leaf should be removed. However, flag leaf cutting is not advisable in the plots infested with diseases as this operation may spread the disease further.

8. Supplementary pollination:

Rice is basically a self-pollinated crop and hence there is a need to go for supplementary pollination in order to enhance the extent of out crossing. Supplementary pollination is a technique of shaking the pollen parent so that the pollen is shed and effectively dispersed over the A line plants. Supplementary pollination can be done either by rope pulling or by shaking the pollen parent with the help of two bamboo sticks. Timing and frequency of supplementary pollination is very important. The first supplementary pollination should be done at peak anthesis time i.e. when 30-40 % of the spikelets are opened. This process is repeated 3 – 4 times during the day at an interval of 30 minutes. Supplementary pollination has to be done for 7-10 days during the flowering period.

9. Harvesting, threshing and processing

From the point of view of maintaining high purity, extreme care is needed while harvesting, threshing and processing of the hybrid rice plots.

9.1 Harvesting: Harvest all R lines rows first. Remove the R line harvest and keep it in a safe place separately. Carefully remove the left over R line panicles in the field.

9.2 Threshing: During threshing, the `A' line parent and `R' line parent harvests must be kept separate from each other. The A and R lines should be threshed separately. Before starting threshing, all the threshing equipment, threshing floor and tarpaulin to be thoroughly cleaned.

Use new gunny bags for storing the seeds. Prepare two labels for each bag – one to place inside the bag and one to attach to the bag outside. Each label should contain the following information.

1. Name and Address
2. Name of the parent
3. Name of the location
4. Season and year
5. Date of harvest

9.3 Seed drying:

- Seed drying helps seeds maintain their ability to germinate and their vigour for a longer period.
- Drying controls mold growth and the activity of the other organisms, that reduce the quality of stored grain
- Drying reduces seed discoloration
- Seeds can be safely stored when they have been dried to a moisture content of less than 13 %.

9.3.1 Seed drying methods: Seeds can be dried by two methods viz., sun-drying and forced air-drying.

Sun drying: The seeds can be dried by placing them on jute bags or on a tarpaulin. Do not dry the seeds directly on the concrete threshing floor. While drying, stir the seeds occasionally to ensure uniform drying.

Forced air-drying: Seeds can be dried in a batch – type dryer by forced air heated to 40-45^{o}c. The seed layer in a batch type drier should not be more than 45 cm deep. Dry the seeds slowly and do not dry abruptly to 13% moisture content.

9.4 Seed Processing: Seed Processing has to be done to remove impurities like trash, leaves, broken seeds sand etc., weed seeds and to remove immature, shriveled, unfilled and empty spikelets.

Seed processing usually done by public and private seed agencies by using Air screen machines. Air screen machines in addition to cleaning the seeds, grading also will be done by separating the seeds of uniform size from over size and under size seeds.

For **seed certification standards for paddy hybrids,** the manual on "Indian Minimum Seed Certification Standards" published by The Central seed Certification Board (Department of Agriculture & Cooperation, Ministry of Agriculture, Government of India, New Delhi, July 1988, pp 20-22) may kindly be referred.