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Hybrid Seed Production Technology of Rice

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Seed Production of Hybrids Using Three-Line System:

The success of hybrid rice cultivation depends on the success of the hybrid rice seed production programme which enables seed producers to produce high quality seed at an economical price. Hybrid rice seed production requires specialized techniques which must be fully understood by the production staff. Hybrid rice seed production using the CMS system, i.e. the three-line system: A line (female), B line (maintainer) and R line (restorer) involves three steps:

1. Multiplication of A line
2. Multiplication of B and R lines
3. Production of hybrid seed (A x R)

In order to obtain the best quality F1 seed in the hybrid seed production programme, high genetic and physical purity of the parental lines is a prerequisite. Even a very low percentage of impurity or contamination in a parental line can cause the production plots to reject the seed. A slight impurity in parental lines can also lead to high costs because of the enormous efforts in rouging which can be very costly for the hybrid seed producer. Impure parental lines lead to variation in plant type, duration, plant height and grain size, and ultimately the quality of the F1 hybrid is affected.

Selection of land:

The land selected for seed production should be fertile, preferably light-textured, with adequate irrigation and a proper drainage system. The field should be free from weeds and volunteer plants from the previous paddy crop. In order to achieve synchronous flowering, a homogenous plot with an even topography is required. The field should not be infested with serious pests and diseases. Hybrid rice seed production fields should be isolated as rice pollen

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can travel longer distances with the wind; negligence leads to impurity of F_1 seed. When selecting for isolation of land, the following points must be considered:

Space isolation:

Space isolation of at least 100 m from seed production plots to other rice varieties is normally satisfactory for quality hybrid seed production. It is safer to have an isolation distance of up to 200 m for male sterile (A line) multiplication, while for B and R line multiplications in varieties, an isolation distance of 3 to 5 m is sufficient.

Time isolation:

When space isolation is not possible, time isolation of about 30 days is satisfactory. This means that the flowering stage of the parental lines in the seed production field should be at least 30 days earlier or later than that of other varieties grown within the area to avoid contamination by pollen.

Barrier isolation:

Tall and compact trees or bushes or some tall crops (e.g. sorghum, pigeon pea and sugar cane) with 30-40 m distance can serve as barrier isolation.

Space isolation is the most important factor to be considered for the production of quality seed.

Seeding time:

Seeding of the parental lines should be planned in such a way that flowering coincides with the most favorable climatic conditions listed below:

- daily mean temperature of 24°-30°C
- relative humidity of 70-80%
- differences between day and night temperature of 8°-10°C
- sufficient sunshine with moderate wind velocity
- no 3 days' continuous rain during flowering period
- These conditions are well met in the dry season.

Nursery bed preparation and sowing:

Given the high cost of seed, it is essential to raise the nursery in a well-managed field if healthy and robust seedlings are to be obtained. Optimum seed rate should be applied and every seed must be utilized by adopting good nursery management practices. A sparse well-managed nursery gives healthy seedlings for the main field. The normal recommendation is 1

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kg of parental line seed in an area of 40 m^2. For 1 ha of main field, 12.5 kg of A line seed and 5 kg of R line seed are required.

Staggered sowing of parental lines for flowering synchrony:

Hybrid seed set on the female line depends primarily on its flowering synchronization with the R line; the sowing of male and female lines must therefore be planned to achieve this. For example, if the duration of the male line is 10days more than that of the female line, the male line is sown in 2-3 staggered sowings so as to ensure a continuous pollen supply. In such cases, 3 sowings of the R line (i.e. 13, 9 and 5 days ahead of the female line) are carried out. However, in countries such as China where the technology has been perfected, only 1 or 2 sowings of the male line are necessary.

Transplanting:

Conventional high-yielding varieties may be transplanted once the nursery crop is 25-30 days old; but in hybrid seed production plots transplanting may commence (depending on the difference in duration of the A and R lines) when 21-35 days old. Timely transplanting ensures good picking of parental lines. Transplanting of too young or very old seedlings may either delay or accelerate flowering and affect tiller number.While pulling out the nursery and during transplanting, special care should be taken to avoid mixing seedlings of male and female parents. It is also important to avoid mixing seedlings of different ages of the male parent, which could affect the uniform distribution and availability of pollen. The long-duration parental line must be transplanted first in order to obtain good synchronization at flowering.

Transplanting R lines:

- Paired rows with 15 cm spacing between plants.
- Seedlings of different ages transplanted in a sequential order (e.g. I, II, III, then again I, II, III).
- Single seedlings per hill with row-to-row spacing of 15 or 30 cm (as per recommendation) in the main field.

Transplanting A lines:

- Six rows with 15 cm spacing between the paired rows of R line seedlings is the normal recommendation in many Asian countries.
- One seedling per hill with a spacing of 15 x 15 cm.

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- In India, spacing of 30 cm between A line and R line rows to facilitate bumper male growth and supplementary pollination. In China, A: R row ratio varies from 2: 8 to 2: 14.

Row ratio, spacing and direction:

Years' experience in hybrid rice seed production indicates that row ratio and spacing play a major role. Seed parents and pollen parents planted in a specific row ratio and with specific spacing have a marked effect on seed yields. A row ratio of 6: 2 seed parent to pollen parent has proven very effective. Row direction perpendicular to the prevailing wind direction at flowering stage allows easy pollen dispersal on the seed parent.

Ideal synchronization:

For optimum synchronization of flowering, the female parent should flower 2-3 days earlier than the male parent.

- If A and R lines have the same growth duration, the A line should flower 1-2 days earlier than the R line in all panicle developmental stages.
- If the A line has shorter duration than the R line, the R line should be one stage earlier than the A line during the first three panicle development stages.
- If the A line is longer than the R line in growth duration, the A line should be 2-3 days earlier than the R line during the first three panicle development stages.

Adjustment of flowering:

If the difference in predicted flowering is more than 3 days between the parental lines, measures should be taken to synchronize flowering. The application of quick-releasing N fertilizers on an early-developing parent in the early panicle development stages tends to delay flowering. Similarly, spraying phosphatic solution (1%) on the later-flowering parent tends to enhance flowering by 2-3 days. If the pollen parent (R line) reveals a tendency towards heading earlier than the seed parent (A line) after the third stage of panicle initiation, root zone placement of N fertilizer is helpful in delaying panicle development.

Leaf clipping:

Leaf clipping of A and R lines is helpful for better out-pollination and seed set. Long and erect flag leaf may obstruct pollen dispersal from the R to the A line and affects the outcrossing rate. Flag leaves should be clipped off in such cases, when the main culms are still in the boot leaf stage. Flag leaf clipping gives uniform distribution of the pollen over A

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line plants. However, it is not advisable to perform leaf clipping in areas where diseases such as bacterial leaf blight, sheath blight and bacterial leaf streak prevail, as they may spread further and reduce seed yield.

Use of GA_3:

GA_3 is used to enhance panicle exertion. Female lines with WA cytoplasm have poor or incomplete panicle exertion. Spraying GA_3 not only helps exert the panicle but also increases the duration of floret opening, improves stigma exertion and stigma receptivity, and widens the flag leaf angle. Spraying GA_3 increases plant height by 10-15 cm and it can also be used to adjust the plant height, in particular of R line in relation to A line. In India, a dose of 50 g GA_3/ha has been found to be optimum (30 g GA_3 sprayed at 5-10% heading and another 20 g GA_3 1 day later, i.e. a 1-day gap between the two sprayings). If the male line is no higher than the female line, it is advisable to give one extra dose of GA_3 to the R line to increase its plant height. GA_3 should preferably be sprayed in the evening (15.00-18.00 hours) and on sunny days.

Supplementary pollination:

Rice is basically a self-pollinated crop. Supplementary pollination serves to enhance the outcrossing rate in order to increase seed set. Supplementary pollination should be done by shaking the pollen parent with the help of ropes or sticks so that the pollen is shed effectively on A line plants. Supplementary pollination needs to be done 3-4 times at 20- to 30-minute intervals and should be continued for 10-12 days during flowering. With improved management of parents and effective supplementary pollination, hybrid seed yield can be increased significantly.

Roguing:

Purity of the hybrid seed is top priority for the production of quality seed. Roguing of off-types and voluntary plants at several stages is essential for obtaining physical and genetic purity. Roguing is the removal of undesirable rice plants from both parents (male and female). Undesirable plants include off-types (e.g. maintainer or B-type plants in A line). Off-type plants can be identified by their morphological characters (e.g. height, leaf size, leaf shape and colour, panicle shape, panicle size and pigmentation) in the late vegetative/early flowering period. B line plants with similar morphological features to A line plants can be identified by their plumpy anthers, completely exerted panicle and 3-4 days earlier flowering

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compared to the A line. These plants in the A line row must be uprooted as soon as they are identified. Roguing at an appropriate time (flowering initiation) ensures good seed quality. Roguing is normally done from the vegetative to the flowering stage.

Seed Production of a Line:

For nucleus seed production of A line, the originating breeder hand-crosses true-to-type A/B plants. For breeder seed production of A line, the breeder plants A/B rows in a ratio of 2 female: 2 male rows with a minimum isolation distance of 200 m. Timely roguing of the plot is carried out at various crop growth stages from vegetative to harvesting.For foundation seed production of A line, the process is supervised by a foundation seed expert. The seedlings are planted in a ratio of 4 female: 2 male rows with a minimum isolation distance of 150 m. There are normally two sowings of the male line, sowing the B line 3 and 6 days after the female line.

Seed Production of B and R Lines:

Nucleus, breeder and foundation seed of B and R lines are multiplied adopting practices similar to those used for conventional varieties. However, care must be taken not to harvest B and R line seed from A/B or A/R seed production plots. Separate multiplication of B and R line plots helps maintain purity and produce quality seed.