Agri Articles
(e-Magazine for Agricultural Articles)
Volume: 04, Issue: 04 (JULY-AUG, 2024)
Available online at http://www.agriarticles.com
©Agri Articles, ISSN: 2582-9882

A Guide to Successful Hybrid Rice Seed Production at the Farmer Level

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Abstract
Paddy (*Oryza sativa*),a cereal food crop, belongs to the poaceae family. It is one of the most widely consumed staple foods over half of the world's human population, commonly in Asia and Africa. It is a self-pollinated crop cultivated in both kharif and rabi seasons. Hybrid is the F1 progeny resulting from the cross between two genetically diverse parents. Rabi season suits well for hybrid seed production due to favorable environmental conditions like temperature, limited precipitation, and a longer photoperiod that allows more time for seed development and maturation. Telangana and Andhra Pradesh states cover 85% of total hybrid seed demand in India. The production of hybrid rice is 20-30% high compared to normal inbred lines (Virmani et al 1996). The production of hybrid seed is influenced by several factors, like choice of field, season of production, isolation distance, rouging, flowering synchronization etc. The demand for hybrid rice positively correlates with the passage of time. This technology provides good returns for farmers, generates more income, and provides job opportunities, especially in rural areas.

Key words: Hybrid, *kharif* season, *rabi* season, isolation distance, hybrid seed, photoperiod and rouging.

Introduction
The efficiency of hybrid rice technology is primarily influenced by the genetic purity, timely accessibility, and affordability of hybrid seeds for farmers. Production of genetically pure hybrid seeds in rice requires more skill since it is a self-pollinated crop. There are 3 methods of hybrid seed production in rice, i.e., the 3-line system, the 2-line system, and using gametocides. The three-line system of hybrid seed production is commonly used. Under this system, three distinct lines (parents), i.e., A-line, B-line, and R-line, plays an important role in the production of hybrid seeds.

Three-line system: This system involves three distinct lines, namely the A-line (male sterile line), the B-line (maintainer line), and the fertility restorer line, also known as the R-line. In this technique, hybrid rice is produced by utilizing thecytoplasmic genetic male sterility (CGMS), while the male sterile cytoplasm is sourced from wild abortive plants. For the production of hybrid seed, the A-line (male sterile line) has to be crossed with the R-line(restorer line).

A line: It is the cytoplasmic male sterile line used as a female parent in hybrid seed production. Farmers can also produce the seed of the A line by crossing it with the B line.These two lines are iso-genic except for the sterility locus, where the A line possesses sterile (S) cytoplasm, while the B line, possesses fertile (N) cytoplasm.

B line: It is used as a pollen parent (male parent) in hybrid seed production and isogenic to A line, except for the sterility locus,by having fertile cytoplasm.
R line: It is used as a fertility restorer line in hybrid seed production. Farmers can produce the hybrid seed by crossing A line with the R line.

Hybrid Seed Production through Three-Line System

The hybrid seed production technology differs significantly from the production of high-yielding varieties. The hybrid seeds are not fit for sowing next season due to segregation of genes that are responsible for traits like yield in the F2 generation. Hence, the farmers need to purchase fresh seed for every season. The cost of hybrid seed is more compared to normal rice varieties (chau and scrimgour 2022).
Season: Compared to the kharif season, the rabi season is best for seed production as it has a daily mean temperature of 24-30c and a good amount of light, which are ideal during flowering.
Location and Land Requiremnt: The successful cultivation of hybrid seeds requires fertile soil, adequate irrigation, and an efficient drainage system. The location should be free from diseases and insects that could limit seed production. So, the Farmers has to chose a site where previous crop was not rice, to avoid the voluntary plants.
Climate: The seed yield is affected by climatic conditions. The following conditions are optimal for hybrid seed production:
1. A daily mean temperature of 24-30°***C***
2. Relative humidity of 72-80%.
3. The difference in daytime and night time temperature should be inthe range of 8 to 10C, with an optimum of7-**10**°*C*
4. Bright sunshine with moderate wind velocity andlack of precipitation during the flowering period is essential for good seed set.

Nursery Management and Seed Rate

Wet raised beds (10cm) of nearly 1metre width and convenient length with good drainage facility should be prepared. 50 Kg FYM, 1kg of N, and ½ kg of potash and phosphorus for every 100 sq m. The dose of phosphorus should be doubled (up to 1 kg) to reduce the effect of low temperature on seedlings.

Spatial seeding at the rate of 25-30 sq m in nursery is desirable to ensure multi-tillered (4-5) seedlings and easy for uprooting in 20—25 days.15 Kg seed of A line, 5 Kg of B line/R line would be required for planting one hectare of land. The parental seeds have to be soaked in water 10-15 hours before planting followed by treatment with carbendazim (50%WP)@4g/Kg of seed. For better sprouting the seeds should be placed in gunny bags.
Isolation distance: The rice pollen grains are very small and light weight so they can easily spread through the wind. Hence, the seed production fields have to follow the isolation distance in order to maintain genetic purity by avoiding unwanted pollination with other rice varieties. We can also maintain purity by the following methods like time isolation, barrier isolation.
1. Barrier isolation: This can be achieved by providing physical barriers:
a). Natural means by growing taller crops like sorghum, maize, pearl millet, sugarcane, sesbania, etc., These acts as a barrier to the foreign pollen to enter in to field.
B). Artificial means by keeping plastic sheet/iron sheet of above 2m height.
2. Time isolation: When space isolation is not possible farmers can go for time isolation which is as effective as space isolation. This can be achieved by planting the parental lines in such a way that flowering of surrounding rice varieties does not coincide. The time isolation above 21 days is more effective.

3. Space isolation: In case of space isolation there should be no other rice variety grown near 100 meters except the pollen parent. The distance should be even more (500m) for the A-line.

Planting Pattern

The seeding sequence of the A line and the R line depends on their growth duration. The synchronization of flowering can be achieved by planting them on different dates (Rahman et al., 2012). The male parental line should be sown on three staggered dates to maintain complete synchronization of flowering. If the A line has a longer duration, then sowing of the A line is done first followed by three staggered sowing of the R line with a gap of 4 days.

If the A line has a shorter duration, then, the staggered sowing of the R line is done first followed by the A line.

Row Ratio: It is the ratio of number of male parent rows to female parent rows. For hybrid seed production, the farmers are advised to follow the ratio of R line to the A line is 2:10.The layout of the row ratio depends on

1) Growth and vigor of the pollen parent.
2) Pollinator height.
3) Duration of floret opening in cytoplasmic male sterility lines.
4) Amount of residual pollen.
5) Stigma exertion of Cytoplasmic male sterility line.

Row Direction: The direction of A-line and R line should be perpendicular to the direction of the wind so that the pollen will disperse evenly which ensures complete pollination (Hasan *et al*., 2010).

Spacing and transplanting: At the age of 21-25 days seedling has to be transplanted at the rate of 2-3 seedlings per hill.

Roguing: To maintain the genetic and physical purity of hybrid rice, rouging should be done in addition to isolation distance. Rouging is the removal of undesirable plants i.e., off types volunteer plants, weeds from the seed production field. Rouging should be done at the tillering stage, flowering stage, and before harvesting.

Vegetative phase: Farmers has to identify off types on the basis of vegetative characteristics like leaf morphology, shape, and pigmentation.

Flowering phase: Late or early flowering, color of anther, presence or absence of awns, and panicle morphology are used to identify the off types.

Before harvesting: The off types are identified based on grain size, the color of grain, etc

Weed management: Hand weeding is necessary to ensure a healthy crop. Farmers are advised to apply2.5 to 3kg of Butachlor mixed with 50-70 kg of sand and apply this mixture to 1 hectare after 5-6 days of transplanting.

Nutrient management: The recommended dose ratio of N:P:K is 150:60:80. Full dose of phosphorus applied at basal. ¼ th urea is applied after 30 days of planting and remaining ¼ of urea and potash applied after 70 days after planting.

Ways to improve out-crossing rate: Since the paddy is a self-pollinated crop so out crossing rate is very low. To increase the out-crossing rate, farmers are advised to follow below mentioned methods.

Flag leaf clipping: The flag leafs are large and acts as a major obstruction for pollen dispersal. The flag leaf clipping has to done at least 1-2 days before heading stage. It enhances pollen movement and dispersal which results higher seed set. The top 2/3rd portion of the flag leaves should be clipped. Care must be taken by the farmers by avoiding the leaves that are infected with bacterial blight and viruses.

Application of Gibberellic acid (GA_3): The panicle exertion is incomplete in hybrid rice so the ¼th of spikelet are not available for out-crossing. Farmers are advised to dissolve GA3 in alcohol atleast one day before and maintain optimum water level of 2-5 cm in the field while

spraying. Spraying of GA3 has to be done twice, first spray when 15-20% of plants started heading with 40% chemical (20gr GA3 in 500 lit water) while second spray at 50% flowering with 60% chemical (30gr GA3 in 500 lit water). Wang *et al*., (2011) stated that spraying of GA3 will improves the panicle exertion and rate of photosynthesis which in turn increases yield.

Rope pulling: Rope pulling should be done in the morning time around 8:30 AM and should be done 3-4 times daily during the peak flowering period. It helps in the dispersal of pollen and increase out crossing rate.

Harvesting: Harvesting is done 20-25 days after full the heading. The farmers are advised to harvest The R line first and remove from the field then harvest A line. All the panicles having more than 70% seed set in A-line are removed because they may result in selfing or off types. The seed-borne on the female parent is a hybrid seed.

Threshing: Thresh the A-line and R line separately by beating the plants on a hard surface or by using a tractor or machine with optimum speed. The floor must be clean before the start of threshing. Farmers are requested to Thresh the seeds at optimum moisture content which reduce the cracking of grains. Care must be taken by the farmers to avoid the mixing of parental lines.

Yield: The seed yield of hybrid rice seed production may range from 1500kg -2500kg/ha depending on the management practices.

Conclusion

Hybrid rice seed production is an optimistic solution for farmers to increase productivity, income and national food security. Although the initial cost is high but the outcome is much more than normal varieties. Hybrid rice contributes to environmental sustainability by promoting resilience against pest and diseases. Hence the farmers can take up hybrid seed production undoubtedly by following the above-mentioned practices so that they will get maximum yield.

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