WWW.IJRPR.COM

International Journal of Research Publication and Reviews

Journal homepage: www.ijrpr.com ISSN 2582-7421

Benchmarking the Hybrid Rice Seed Production Processes to Ensure High Quality Seed to the Farmers

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A B S T R A C T

The study was conducted to ensure that farmers receive high-quality seeds for improved rice output. To acquire the best production potential of all types, a high-quality seed must be sowed. Rice hybrid seed development is a difficult endeavor in terms of creating high-quality seeds and necessitates continual research. The production environment, agronomic approach, and handling processes all have an impact on rice foundation seed quality. To improve seed quality, regular supervision is required during critical stages of crop production such as soaking, sowing, transplanting, vegetative, pre-flowering, flowering, R-line harvesting, and final rouging before A-line harvest, threshing, winnowing, and seed storage with proper moisture content. Each step is critical for improving quality and preventing contamination from other rice crops. The average yield varies according to hybrid. It ranges between 0.8 and 1.5 tonnes per acre. Crop management practices that are effective result in a high percentage of seed germination and a lesser number of odd and abnormal seeds. Increase in physical purity of seed, such as the absence of other distinguishing kinds and ruminants and discovered genetic purity ranging from 98 to 100% depending on parent seed purity.

Keywords: Rice, Hybrid Rice Seed Production Process, Quality Seed, Supply Chain, Isolation Distance, Pollination, Leaf clipping

1. Introduction

Rice is the world's most important food crop. Rice is the primary source of sustenance for about 40% of the world's population. The majority of people who eat rice as a primary dietary source live in developing countries (Dunna & Roy, 2013). Asia is the world's leading rice producer and consumer, accounting around 90% of global production and consumption. By 2025, it is predicted that the world's population would exceed 8 billion people. Population growth demands an increase in both area and per-unit production. Based on current consumption patterns, 35 to 40% more rice production will be needed in 2025 to meet public demand (Shah et al., 2020). However, to boost rice yields in the long run, hybrid seed production and distribution must be encouraged. Rice productivity increases dramatically when hybrid rice is cultivated. Because of their yield advantage and commercial relevance, rice hybrids have been cultivated in over 40 nations, resulting in a substantial seed business globally. Furthermore, this venture offers good service possibilities and develops new jobs for the less fortunate members of society (Rout et al., 2020). Hybrid rice technology is critical in India for increasing rice production and productivity. Under the same growth conditions and with proper care, hybrids can give a yield advantage of 1.0-1.5 t/ha over high-yielding types (IIRR, 2021).To maximize yield potential of all types; high-quality seed must be sown. Superior seed quality leads to lower seed rate, higher emergence (>70%), more uniformity, less replanting, and strong early development, all of which contribute to increased pest and disease resistance. As a result, the yield is expected to increase by 5-20% (IRRI, 2013). Rice hybrid seed development is a difficult term to generate excellent seed, and it demands continual research. The quality of rice foundation seed is affected by the production environment, agronomic procedures, and handling operations. To reduce these factors, regular supervision is essential to keep fields in critical stages of crop such as soaking, sowing, nursery bed, main field preparation, transplanting, vegetative, pre-flowering, booting, flowering, and dough stage, R-line harvesting, and final rouging before A-line harvest.

2. Material and Methodology

2.1. Season and site of selection

Site selection and season of planning are very important in the hybrid seed production of rice. Parent line seedlings should be planned in such a way that the flowering in both parents coincides with the most favourable climatic conditions. Climatic conditions have profound influence on the seed yield. Detailed information on the weather data of a given locality is necessary for fixing the seeding dates (DAC, 2010). During flowering, a daily mean temperature of 24-30 degrees Celsius, relative humidity of 70-80%, and bright sunny days are optimal. Sites that are excellent for seed production include fertile land with good irrigation and drainage facilities (DRR, 2015). To prevent the problem of volunteer plants; choose a location with no previous rice production. Chhattisgarh, Orissa, and Telangana are the most promising states for hybrid rice seed production in the country.

2.2 Seed rate, Seed soaking and staggering

It is required to produce rice hybrid seed at an ideal seed rate. A-line @6 kg and R-line @4.5 kg of seed is required per acre. The seed rate may be low or high, depending on the test weight of seed. The parental lines differing in their growth duration can be sown on staggering dates in the nursery beds, so that they come to flowering at the same time in the main field where hybrid seed will be produced. This is called “staggered” or “differential sowing”. Therefore, to attain the complete synchronization in parental lines and long duration availability of pollens, the male parent (B/R line) must be sown in three staggering dates (at 3-4 days interval). The female line is sown once, followed by the first sowing of R-line 10-18 days later, depending on the hybrid’s staggering recommendations. Soak the parental line seeds for 12-24 hours or until small shoots appear at the end of the seed. In cold weather, seeds may need to be submerged for 36-48 hours. Drain and air dry the seed in the bag for 24 hours in a shade, well-ventilated place. Always please remember that the bag is clean and dry (Sah and Joshi, 2020).

2.3 Nursery bed preparation and seed broadcasting

Fallow land is ideal for nursery beds because it reduces seeding contamination from previous crop volunteers. A reliable water supply, as well as a well-functioning drainage system, should be available in the area. Before seeding, puddle the seedbed field twice (at an interval of 6-7 days) and keep the water continuously for 4-5 days. After that drain the excess water and puddle (2-3 times) in wet condition to destroy weed seeds. Prepare raised seedbeds of 12-15 m length, 1 m width, and 15 cm bed height with 30-50 cm channels between two beds after leveling and final puddling (Figure 1). Spread the sprouting seeds evenly across the seedbed. After the beds have been prepared, they are wetted and 2 kg of urea, 2.5 kg of P_2O_5 and 2 kg of potash need to be applied.

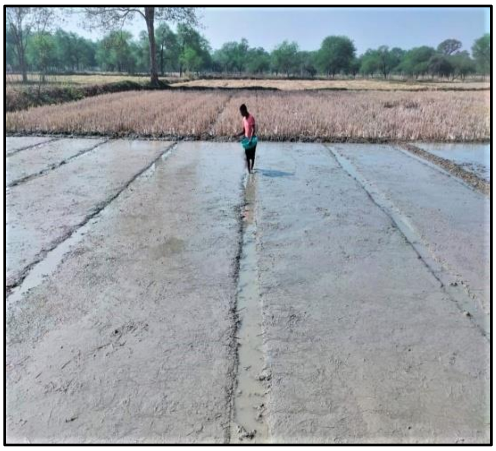

Figure 1. Nursery seed bed preparation

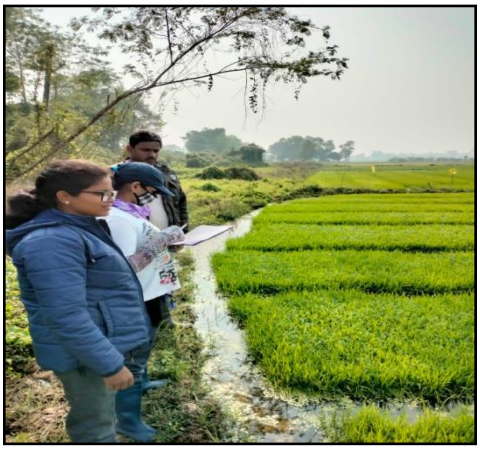

Figure 2. Regular nursery supervision by field supervisor

2.4 Main field preparation and transplanting

Ideally, the area should not have been used for a prior rice crop because there is a high risk contamination from previous volunteer plants. Isolation is important to assure hybrid seed purity and avoid pollination by undesirable pollen. Maintain a 100 meter isolation distance in the scattered field by using male lines with physical barriers or plants with a height of at least 2 meters. After water to the land after the previous rice (*Kharif*) harvest to allow volunteers to germinate 20 days before transplantation. To decompose previously shattered rice seed, apply SSP @50 kg/acre 15-20 days before primary field preparation. Thorough plough that field twice and cultivator once, then leveling and add 50 kg of DAP, 25 kg of urea, and 25 kg of MOP at the end of puddling. In the case of time isolation, there should be at least a 21 days gap between the flowering of mother tillers and daughter tillers, and other varieties are grown in the vicinity. Seedlings that are 20-25 days old are transplanted (3-4 leaf stage). Seedlings from the borderline (30cm from the border line) should be avoided on the seedbed because direct sunlight, water, and fertilizer contact have accelerated their development and height. In both the R and A lines, using such a seedling produces flowering synchronizing concerns. For hybrid rice seed production with a row ratio of 2:6 to 2:10, the rope system transplanting method is suitable. One seedling per hill is sufficient (Figure 3). In the case of parental lines with different maturities, begin transplanting with the parent with the longer duration first, followed by the parent with the shorter. A-line parents have a shorter lifespan than R-line parents. When R lines are longer, begin transplanting with the R_1 parent, then R_2, as described above, and wait for a shorter parental line to be available for transplanting (Sah and Joshi, 2020). The plant population is 44-50 plants per meter square, with R to R line spacing of 15 cm, A to A-line spacing of 15 cm, and R to A line distance is 25 cm.

Figure 3. Rice transplanting by rope system

Figure 4. Distance isolation

2.5 Primordial Panicle Initiation (PPI)

Even if the seeding interval between both parents is perfectly calculated, flowering synchronization may still be difficult due to temperature difference and difference in field management. As a result, by evaluating the primordial start of panicles, it is vital to predicting their flowering date so that necessary change can be made as soon as needed (DRR, 2015). Based on the hybrid life cycle duration, prediction should start from 75-80 DAS. For accurate panicle length measurement (Table no. 1), collect three random samples from different parts of the fields to left two rows near the R-line from A-line in the form of T shaped otherwise L shaped for A-line panicle length and near three samples from R-line for R-line panicle length, and observe every three days (Figure 5). Adjustment of flowering date can be made by applying quick releasing nitrogen fertilizer like Urea 1-2 % on the earlier developing parent and the later developing parent should be sprayed with 2 % solution of DAP.

Figure 5. Plant Sampling and PPI adjustment analysis

Table 1 - Prediction of flowering days by panicle length

Stage	Panicle length (mm)	Day of nicking
I	0.2	1
II	0.4	3
III	1.5	6
IV	2	10
IV	5	11
IV	8	12
V	10	13
V	14	14
V	18	15
V	22	16
V	25	17
VI	80	18
VI	100	19
VI	120	20
VI	140	21
VI	160	22
VI	180	23
VII	190	24

VII	220	25
VIII	260	26
IX	270	28
X	Flowering	30

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To maintain flowering for A & R line, water management is beneficial. Maintain a water level of 4-5 cm to stimulate flowering for both A & R lines. PPI examination helps in prediction of time isolation. Identifying PPI is important in rice production as it denotes the beginning of panicle formation and the start of the reproductive phase. Due to different sowing dates of different hybrids of the same crop at nearby plots, we cannot predict the time isolation, as each hybrid has different life cycle and growth behavior. As a result, there will be the maximum chances of affecting the flowering time. To overcome this, PPI check at 75-80 DAS of hybrid and also near rice fields of their main tillers to later tillers should be more than 21 days difference of flowering for both of the fields (Figure 6).

Figure 6. Estimation of time isolation by PPI check method through both of field samples

2.6 Roguing

Roguing is important for maintenance of genetic purity. The purity of hybrid rice seeds used in commercial production must be more than 98%. To meet this requirement, the purity of the A and R lines must be more than 99%. Plant height, plant part coloration, pubescence, awn features, and flowering duration are all traits that can be utilized to identify a varietal's purity in a field condition (Verma *et al*, 2016). It is crucial to eliminate undesirable plants during the critical periods of the crop to achieve high genetic and physical purity of hybrid rice. Shedder refers to the presence of a B-line plant in an A-line, whereas rogue refers to the presence of a B line plant in R-line. Pollen shedders and off-types contaminate both physically and genetically. Though rouging is a continuous activity that occurs throughout the crop season, it should be done at specified times, such as during the vegetative stage of crop, before and during flowering, and just before harvesting. Remove off-types and shedder with caution, since moist mud particles and pollens will fall into nearby plants, causing a pollination difficulty. When mud particles fall into an open flower, they do not set seed in the panicle. Carefully uprooted a bunch of plants, fold them and immediately dump them in walking row at that place. Because pollens flow down in the open panicle during supplement pollination, we must rogue off-types plants before 11 a.m. and after 3 p.m. because of pollens fall in the open panicle.

2.7 Gibberellic acid application (GA_3)

At vegetative stage:	One the basis of morphological characters of leaf and the plant, leaf shape and pigmentation.
At flowering stage:	Early and late types, absence/presence of awns, panicle exertion, anther color and panicle characteristics etc.
At maturity stage:	Percentage of seed setting on female parent plants, grain type and shape etc.

Application of GA_3 improves panicle exertion and overall seed set, increases the length of floret opening and stigma exertion, as well as the stigma responsiveness (Malik and Baba, 2018). Widens the flag leaf angle, allowing pollen grains to enter more easily. The GA_3 application is appropriate at 5-10 % first heading (when 5-10 tillers out of 100 show initial heading) (DAC, 2010). Because it is insoluble in water, it must be dissolved in a tiny amount of 70% alcohol (1 g of GA_3 in 10 ml of alcohol) before spraying as indicated. Spray GA_3 consistently over both A and R lines with a knapsack sprayer in the morning or after 3 p.m. on a sunny day. Spraying should be avoided when the weather is cloudy and wind velocity is high. GA_3 should be sprayed twice when 15-20% of the tillers was at heading stage and again when 30-40 % of the parent's panicles have emerged two days after the first spraying (Virmani *et al*, 1997). If the isolation distance is inadequate, use GA_3 @ 100 ml in border lines during the pre-booting stage, which will increase height by 2 ft. in comparison to A line, and act as a barrier to prevent pollen transfer to nearby rice fields.

2.8 Leaf clipping

Pollen dispersal is made simpler by correct leaf clipping. During the booting stage, cut the upper one-third to one-half of the flag leaf uniformly using a sharp sickle (Figure 7). Based on the hybrid life cycle duration, leaf clipping starts from 95-105 DAS and panicle length is 190-220 mm. Leaf clipping is done to hybrids, which depends on the genetic characteristics of the parent seed. Some hybrids have leaf canopy characteristics to prevent pollen receptivity, so we need to cut one-third of the leaf which helps in free movement and wide dispersal of pollen grains to give higher seed production. Recommended propiconazole @ 25% EC systemic fungicide was found to be at par with "Tilt" in its efficacy to control the disease.

Leaf clipping is not suggested in a field contaminated with bacterial leaf blight because it may spread the disease (DRR, 2015). When the A-line's PPI advances in 4-5 days, we must clip the upper side of the leaf up to 6 inches to stop panicle growth for 3-4 days.

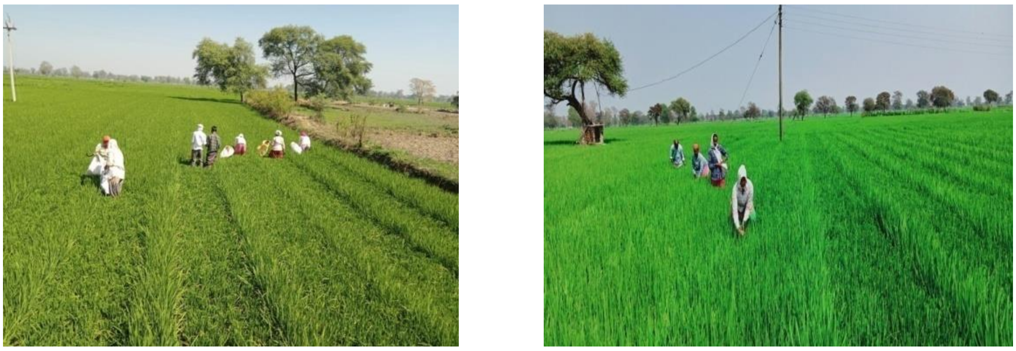

Figure 7. Leaf clipping

2.9 Pollination

Rice is a self-pollinated crop, so pollen distribution and natural crossing are limited. Supplementary pollination is used to promote out-crossing and seed set. Shaking the pollen parent plants aids in pollen dispersal and shedding over the A-line. When the weed velocity is less than 2.5 m/sec, this can be done either by rope pulling or by shaking the pollen parent with two bamboo sticks (Malik and Baba, 2018). When 30-40 % of spikelet are open and anthers are fully exerted, the first supplementary pollination should be done. During peak anthesis, do supplementary pollination 6-10 times a day at 15–30 minute intervals, starting at 11:00 a.m. and continuing at 01:00 p.m., depending on weather condition and location. This process should be done for 12-17 days during flowering period. Because most hybrids with panicles are securely covered by flag leaf and take time to come outside, it is also beneficial to remove the panicle in a thick leaf sheath. By applying pressure to the leaf sheath using rope or stick, the boot is shattered, and the upper side is exposed, allowing for prompt flowering for good pollination.

2.10 Harvesting and threshing

Harvest the R-line first and then the A-line (Figure 8). Check the field for any R-line panicles that may have fallen to the ground or on the A-line plants (DRR, 2015). Take up the final roguing in the A-lines, paying special attention to seed set greater than 70% (Figure 9). Panicles with a seed set of more than 70% should be removed because they may be self-pollinated, shedders, or off-types (Verma et al., 2016). Harvest and thresh the A-line rows separately, after properly cleaning the thresher. When using a combined harvester, we must ensure that the harvester seed tank is clean. A single harvester, similar to a thresher, is used to harvest one hybrid at a time. Use a clean harvester and thresher during harvesting and threshing to reduce the possibility of mixing other distinguishing varieties. Dry the harvested seed for 4-7 days to achieve a moisture percentage of 11%. Clean the seeds and place them in well-aerated gunny bags. Before packing, labelling, and storing seed with a moisture level of up to 11%, old gunny bags should be completely cleaned. Each label should provide complete seed information such as name and address, parent name, location, season and year, and date of harvesting.

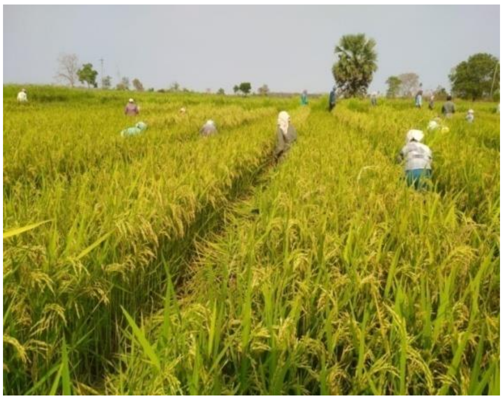

Figure 8. R-line harvesting

Figure 9. Final roguing before A-line harvest

2.11 Yield

Average yields of 0.8 to 1.5 tonnes/acres can be achieved with proper planning and management. It depends on the region as well as hybrid average yield.

3. Results and Discussion

According to the findings, regular field supervision is required to maintain crop quality and reduce physical and genetic contamination of other rice crops. Based on the results, hybrids produce an average yield of 0.8-1.5 tonnes/acre with 98-100% genetic purity, 100% physical purity, and high germination percentage. The range was determined by the parent seed purity. For optimum storage, sun-dry the seeds with a moisture level of 11%.

4. Conclusion

The above-recommended package of practices results in average seed yields of 0.8-1.5 tonnes/acres with good quality seed in seed production sites. Hybrid seed production and their maintenance aid in improving seed quality, such as physiological purity (viability & vigor, germination test), physical purity (odd, abnormal, damaged& diseased, and free of other distinguish varieties), and genetic purity (more than 99 %) with optimum moisture content. As a result, appropriate management aids in the improvement of seed quality in Rice hybrid seed production.

Acknowledgements

We thanks to all team of Supply Chain Management, especially Mr. Bhargav Reddy, Mr. Alok Jain, Mr. Subbu Subbanarasaraju, Mr. Amit Kumar Tiwari, Mr. Robin Singh and Mr. Gaddam Sadanandam, who provided the technical staff, weekly meetings, and cooperation for this project.

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