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Rapid Generation Advance (RGA): A Fast-Track Irrigated Rice Breeding Pipeline From IRRI

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Abstract

To meet the needs of the growing world population, rice production must increase in the future. To achieve this, it is necessary to develop new and improved rice varieties that yield higher quantities in a shorter time. One approach to expedite breeding is the rapid generation advancement method, which utilizes the single seed descent (SSD) technique in a small greenhouse or glasshouse. This method comprises a set of tools to accelerate the development of homozygous lines from segregating populations. Traditional breeding methods typically take 3-4 years to create homozygous lines, requiring substantial expenses and time. Consequently, employing techniques that can reduce both the time and cost of developing new breeding lines facilitates the release of new rice varieties in a shorter timeframe compared to traditional approaches that can take three to six years, with or without off-season facilities. By combining these strategies, breeders can efficiently produce superior rice varieties within a relatively brief period of time.

Keywords: Homozygous lines, Rapid generation advance and Rice Breeding

Introduction

Pedigree, bulk, modified bulk, single seed descent (SSD), and doubled haploid (DH) are the primary breeding strategies used to develop new varieties for self-pollinating crops (Mackill et al. 1996; Poehlman and Sleper 1995; Sharma 1994; Stoskopf et al. 1993). To summarize, the pedigree technique involves a meticulous selection of single plants and screening of traits during successive generations until yield testing. The bulk technique entails planting entire populations and postponing the selection of individual plants until subsequent generations, followed by yield tests. Among the different approaches utilized in rice breeding,

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the pedigree method has been the most widely adopted (Khush and Virk 2005), with mass breeding coming in second (Collard et al. 2013). On the other hand, the DH approach creates genetically homozygous lines in one step but requires a stage based on tissue culture.

The SSD method is employed to fix lines early on in the generations by making them homozygous within a segregating population. This process leads to the creation of "fixed lines" and progresses one generation through self-pollination. The SSD technique is effective for self-pollinated field crops where growth conditions can be controlled in a greenhouse or screenhouse, allowing earlier flowering and seed set compared to natural conditions. Consequently, this enables the completion of multiple generations or cycles, from F2 to F6, more rapidly than would otherwise be possible. As the name suggests, the rapid generation advance technique speeds up the completion of multiple generations.

Overview of Rapid Generation Advance (RGA)

The F_2 research material from an enterprise is received at the RGA facility at IRRI; after that, a QR code is labelled on it, including the information provided by the enterprise. To speed up blooming and early-set seed than in the field, plants are cultivated in seedling trays in a screenhouse or glasshouse under mild stress (very close spacing, little N intake, and high temperature). RGA allows for growth at a rate of 3.5–4 generations annually, where only one or two per year are feasible in the field. In the end, breeding lines are created more quickly and for less money. RGA has been the primary breeding technique since 2012, when IRRI's irrigated breeding pipeline underwent a makeover.

Fig. 1 RGA Cycle

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1. **Planning and preparation:** In this step, the soil is separated according to granular size using a 3 mm or 5 mm wired mesh. Then it is placed in an electric sterilizer at 180°C for 8 hours to sterilize it. The soil is cooled overnight, and sterilized soil is filled in a plastic seedling tray. Generally, ammonium sulphate fertilizer is mixed in the soil as a basal nutrient source, and the N:P: K ratio of the soil is maintained at 40:40:40. The seedling trays will be stored in a blue-coloured crate.
2. **Seedling:** The single seed of F2 generation from the enterprise material is placed in an individual cell of the seedling tray. Generally, a 104-celled seedling tray is used for more seed harvesting in earlier generations of advancements and a 35-celled tray for the final generation.
3. **Crop care and maintenance:** The crop is monitored at 30, 60, and 90 days after sowing. The crop pruning, insect, pest, and disease monitoring, and disease and pest management were done by the Zeigler Research Station.
4. **Data collection:** Days to 50 percent flowering and days to 50 percent harvesting maturity are recorded.
5. **Harvesting:** After maturity, the generation seed is harvested from each individual carat and stored to remove seed dormancy in an oven for 5 days at 50 °C. Too much soil quantity also affects the flowering. Early maturity is obtained by removing the flag leaf and other leaf within 5 days.
6. **Seed processing:** Harvested seed is sent to an automated seed processing plant, where it is cleaned, deformed, or other impurities are discarded, packaged, and ready for the next cycle.

Advantages

An RGA cycle usually lasts from 90 to 105 days. RGA boosts the breeding cycle to 3.5 to 4 generations per year, from F_2 to F_5 or F_6, allows for more rapid progress. With extensive throughput of over 80,000 lines in a 600 square meter area, the establishment of breeding lines is accelerated, leading to an enhanced rate of genetic improvement. This approach also reduces the required number of controlled environments and ensures effective dispersal. Consequently, breeding expenses related to labour, resources, and space are reduced, resulting in faster creation and release of new varieties.

Disadvantages

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Panicle sterility in the dry season is caused by excessive heat. Insect control is essential. Each year, four generations of a breeding line are aimed. Managing numerous breeding lines from different clients. It involves systems for phenotyping and high-throughput genotyping.

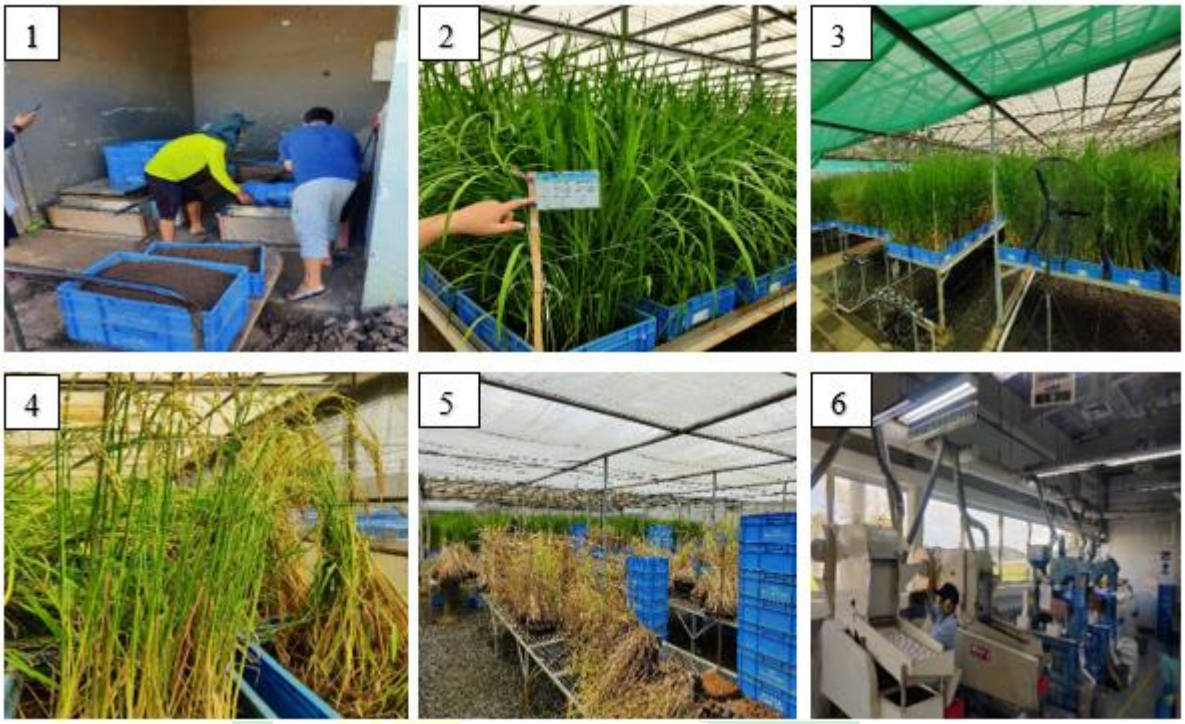

Fig2. RGA system used in irrigated breeding programme at IRRI. (1) Soil Preparation (2) Vegetative stage (3) Glass house set-up (4) Harvesting stage (5) Crop stubbles after harvesting (6) Seed Processing.

Conclusion

RGA is a highly adaptable method that can be tailored to the available resources at any breeding station, utilising an existing glasshouse, greenhouse, or field area. It allows the multigeneration of research material from subsequent generations of F_2 within the fixed costs of greenhouse maintenance and within a constrained timeframe.

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