

RGA – A new breeding method

for rapid advancement of breeding cycle in rice – *Do more with less*

Suvarna Rani Chimmili^{1*} and K Sruthi

ICAR- Indian Institute of Rice Research, Rajendranagar, Hyderabad 500 030

Quick development strategy is needed to breed new high yielding rice varieties to meet the increasing rice demand. Especially in the climate change scenario, the rapid replacement of cultivated varieties is taking place because of increasing the pressure of biotic and Abiotic stresses. So fast development and release of high yielding varieties is the pressing need. Generally, to develop a new variety takes around 10 to 12 years through conventional breeding such as pedigree method. A new breeding technique called Rapid Generation Advancement (RGA) can accelerate the rice breeding process. In RGA, segregating populations are grown at close spacing, low nitrogen and high temperature and short days to shorten the breeding cycle thus making possible five generations (F_5) in two years. The RGA method has been successfully used to shorten the breeding cycle in crops like tomato, chickpea, soybean and rice. Adoption of the accelerated breeding method has major implications in rice breeding program such as rapid attainment of homozygosity, reduce the space, time and resources for varietal development. Faster variety development contributes significant economic benefits to the farming community.

Keywords: Rapid Generation Advancement, Rice Breeding

THE global population would increase by 25% and reach up to 10 billion over the next 30 years. In order to feed the growing population, rapid technology has to be integrated with time. Conventional breeding has been upgraded to molecular breeding with the advancement of DNA technology, high throughput genotyping and next generation sequencing. Even with the advent of technologies, the breeders and plant scientists are under pressure to improve existing crops and develop new varieties that are high yielding, more nutritious, pest and disease resistant and climate smart in a particular time frame and the developed variety should not be outdated as it takes 9-10 years to release a variety with the pedigree method. The pedigree breeding method usually takes 3-4 years to develop genetically fixed lines, accommodating 1-2 generations per

year, which is very expensive. Hence, it is imperative to use techniques that are cheaper and can shorten the time needed to develop breeding lines and ultimately be able to release new varieties after a shorter time period. Rapid Generation Advance (RGA) is a breeding approach used in conjunction with the single seed descent method, which was first reported by Gouliden in 1939. In Japanese rice breeding programs, a greenhouse-based rapid generation-advancement technique was the primary tool used to breed the cultivar 'Nipponbare'. Development of experimental lines such as recombinant inbred lines (RILs), backcrossed inbred lines (BILs), chromosome segment substitution lines (CSSLs) and isogenic cultivars can accelerate the progress of rice genomics using rapid generation advanced method of breeding. The segregating populations were raised

in an environment using close spacing, low N input, high temperature and short days to minimize the growth duration and make several generations per year, as the stress factors hasten the flowering and seed set earlier than normal field condition. The study aims to discuss rice customized speed breeding method, as in general speed breeding suits for day neutral and long day crops with enhanced day length under controlled greenhouses.

Procedure

In RGA, after the development of segregating material, as contrary to the pedigree method, selection will be delayed till F_6 generation. Segregating material will be grown in greenhouses, seedling trays or raised beds of the fields with older seedlings, closer spacing, lower fertilizer, higher temperature with restriction in root growth results in

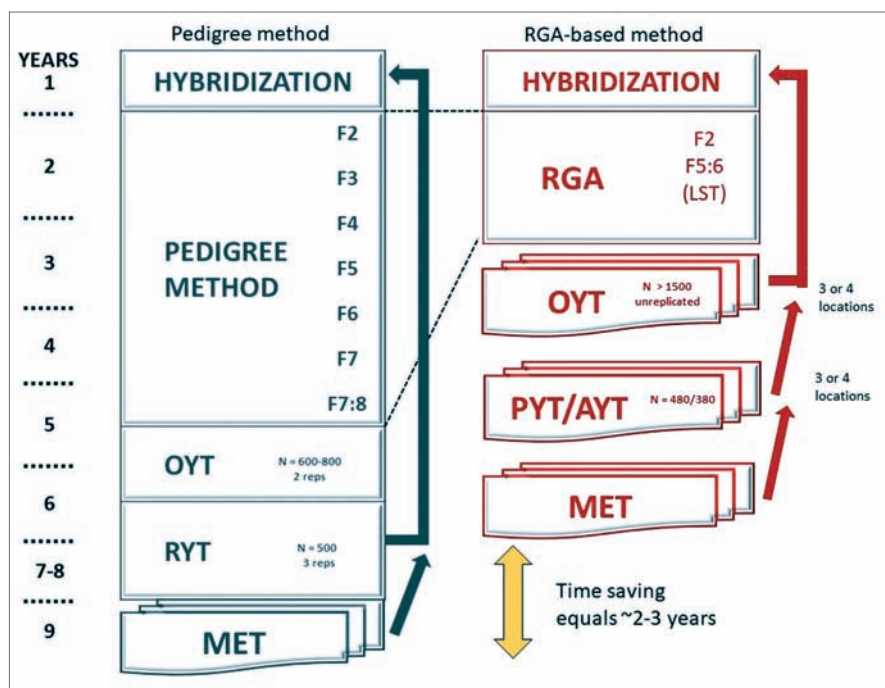


Fig 1. Schematic representation of pedigree and RGA based breeding methods.
Source: Collard B *et al.*, 2019

early flowering and maturity thereby reducing the crop duration. Once the target generation had been achieved (e.g. F₅ or F₆), the panicles were planted in the field (i.e. ‘panicle rows’) as a seed increase step (i.e. usually F₅:6 seed). However, this stage was also used to check the uniformity of each line (i.e. check for segregation due to outcrossing or mixtures) and apply selection. Screening for disease and pest resistance will be carried out at F₆ generation as Line stage Testing (LST) and the identified elite lines will be forwarded for varietal release programme (Fig. 1).

Need to adopt

As new races, pathotypes and biotypes are emerging day to day in the climate change scenario, the rice breeders need to adopt faster breeding methods to increase the rate of genetic gain and to reduce the operational costs. Rice breeders can transform their breeding method by adopting RGA as their main breeding scheme with simple reallocation of resources which is currently spent on the expensive pedigree method.

Classification

RGA method can be applied in green house and in field. In the

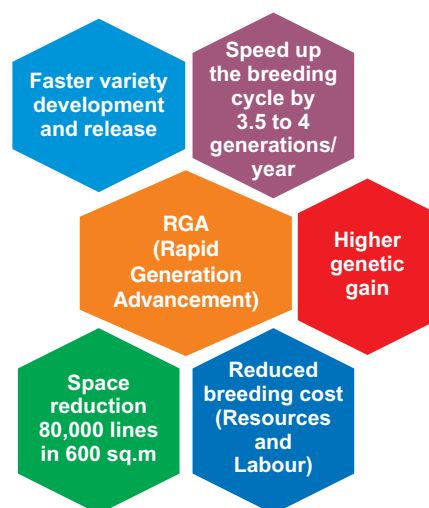


Fig 2. Major benefits of RGA method

greenhouse, Biotron breeding system can rapidly advance the generations in rice breeding. This system uses growth chamber where segregating generations will be grown in seedling trays, minuro tray or wooden boxes or metal trays with controlled CO₂, day length by maintaining appropriate root volume which significantly decreases the days to heading. However in greenhouses, we cannot accommodate a large number of crosses with large population, cost effectiveness, nutrient and pest management.

Field RGA, when greenhouse facilities are not available or not sufficient to screen large number of crosses, RGA can be performed in field. In field RGA, adopted by BRRI, seeds directly can be sown or transplanted (older seedlings of 36 days) in the selected raised beds with very close spacing (5cm × 5cm) and low fertilizer or in other method sown in seedling trays with high density not directly in soil. In both these methods the selected field area should have access to irrigation. IRRI adopted the modified FRGA method, by placing the seedling trays directly into the soil which permit the roots to grow into the ground from the hole of the seedling tray (Fig. 3).

Advantages of FRGA over greenhouse RGA

- Artificial microclimate can be avoided which often encounter in green houses and reduce the pest outbreak
- Temperature is more suitable

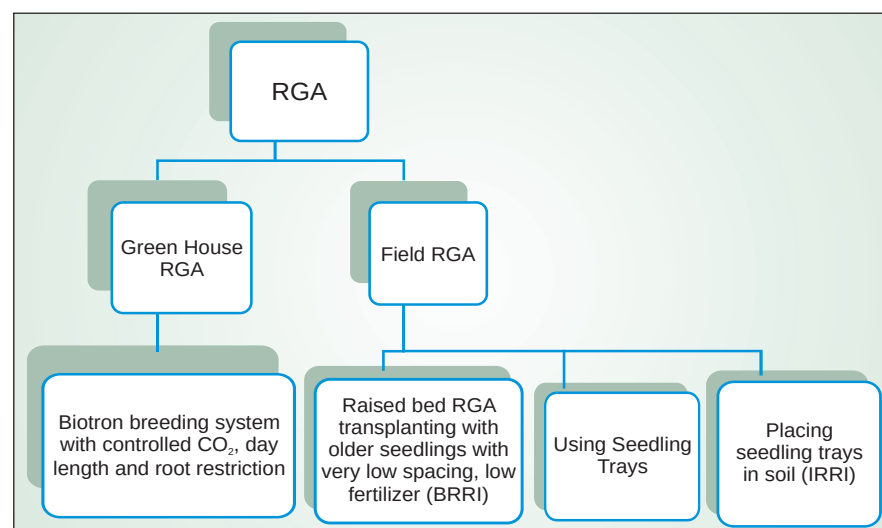


Fig 3. RGA Classification

Table 1. Achievements

Country	Name of Variety	Designation	Distinguishing features	Year of release	References
Philippines	IRRI 142	IR68333-R-R-B-22	Grain Quality	2008	Ha <i>et al.</i> , 2011
	IRRI 165	IR71896-3R-8-3-1	Salinity tolerance	2011	Gregorio <i>et al.</i> , 2013
Bangladesh	BINA dhan8 (FL449)	IR66946-3R-149-1-1	Salinity tolerance	2010	Gregorio <i>et al.</i> , 2013
	BRRRI dhan 61	BR7105-4R-2	Salinity tolerance	2013	http://www.brri.gov.bd/
	BRRRI dhan 62	BR7517-2R-27-3	First Zn enriched variety	2013	http://www.brri.gov.bd/
	BRRRI dhan 67	BR7100-R-6-6	Salinity tolerance	2014	http://www.brri.gov.bd/
	BRRRI dhan 72	BR7527-2R-19-HR10	Zn enriched variety	2015	http://www.brri.gov.bd/
India	Luna Sankhi (CR Dhan 405)	IR72046-B-3-3-3-1	Salinity tolerance	2012	Gregorio <i>et al.</i> , 2013

compared to RGA in green houses without any control

Disadvantage

- There is a chance of genetic drift and possible loss of material due to field pest and natural disasters

Advantages of RGA

- Advantages includes technical simplicity, easy to maintain populations during selfing
- Space can be reduced, this method

can accommodate 12 times higher plant population at the same area in FRGA method compared to conventional pedigree method.

- Varietal development time can be reduced, within three years homozygous fixed lines can be developed
- No need to maintain tedious pedigree records
- Selection can be practiced on genetically fixed lines after F₆ generation not in early segregating

generations

- Inexpensive method. Because of reduced fertilizer and water consumption and can able to save 5 to 10 times resources as compared to pedigree method
- This method can be applied in green houses, seedling trays and in field
- Genetic gain can be enhanced because of handling large number of population with wide variation
- Natural selection does not influence the population
- Chance of varietal replacement is high due to rapid breeding procedure

The way forward

- Too warm in dry season (panicle sterility)
- Control of insects
- Four generations per year
- Management of huge amount of breeding lines from different customers
- Inclusion of phenotyping system
- Inclusion of high-throughput genotyping system

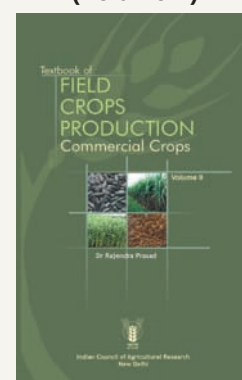
¹Scientist (Plant Breeding and Genetics).
Corresponding email: suvarnarani90@gmail.com

Textbook of Field Crops Production – Commercial Crops

Availability of high-yielding varieties/hybrids and increased irrigated facilities have resulted in the development of production-intensive cropping systems in several parts of India, and this has catalyzed further agronomic research based on the cropping-system approach. Many changes have also taken place in the crop-production technologies. And this necessitated the revision of the earlier publication brought out in 2002. The revised textbook is in two volumes: First is covering Foodgrains and second is on Commercial Crops.

The discipline of Agronomy has no longer remained mere field trials without application of discoveries emanating from the related disciplines of Genetics, Soil Science and Agricultural Chemistry, Plant Biochemistry, etc. The future Agronomy Landscape will face challenges of climate change, transboundary issues, TRIPS and other trade-related barriers, biotic and abiotic stresses, consequences of biotechnology and genetic engineering and increased market demands in terms of quality assurance, customized food crops, global competition, ecosystem services on land and social equities etc. The Agronomy must measure up to these futuristic challenges with well-defined metrics and methodologies for performance. The advent of hydroponics, precision farming, bio-sensors, fertigation, landscaping, application of ICT, GPS and GIS tools and micro-irrigation is in the horizon. This revised edition in two volumes covers fundamentals of the subject and at the same time will inspire and prepare teachers and students for the emerging frontiers.

(Volume II)



TECHNICAL SPECIFICATIONS

Pages : i-xiv + 612 • Price : ₹ 800 • ISBN No. : 978-81-7164-146-8

For obtaining copies, please contact:

Business Unit

Directorate of Knowledge Management in Agriculture
Krishi Anusandhan Bhavan-I, Pusa, New Delhi 110 012
Tel : 011-25843657, Fax 91-11-25841282; e-mail : businessuniticar@gmail.com