ORIGINAL RESEARCH ARTICLE OPEN ACCESS

Breeding strategy for improvement of rice maintainer lines through composite population for short term diversity

Kemparaju KB*, MS Ramesha, K Sruti, AS Hari Prasad, RM Sundaram, P Senguttuvel and P Revathi

ICAR-Indian Institute of Rice Research, Rajendranagar, Hyderabad 500030, India
* Corresponding author (email: KB.Kemparaju@icar.gov.in)

Received: 11th Nov. 2018 Accepted: 23rd Dec. 2018

Abstract

Hybrids commercially grown in the country gives 15-20% yield advantage over the best inbred varieties. There is a need to increase the magnitude of heterosis level to 20-30% besides improving grain quality and other desirable traits like plant type, number of productive tillers, flowering duration, desirable plant height, grain type, yield, maintenance ability, disease and insect pest resistance etc. In present study we developed base composite populations suitable to local conditions using original gene pool obtained from International Rice Research Institute (IRRI) by adding 10 component lines for above mentioned different traits. More than 950 productive segregants selections were made and stabilized through pedigree method for desirable traits. The developed lines are superior for different traits. This indicates population improvement strategy is bringing the superior allele into one line in short period of time from different genotypes. This method is very useful to increase diversity in hybrid rice parental lines within known time.

Key words: Hybrid rice, parental line improvement, composite population, diversity

Introduction

More-than half of Indian population and many parts of the world especially in Asia depends mainly on rice for their calorie requirements. Now-a-days food security is main concern with available resources like declining of land, labour, agricultural inputs with changing climate (Arunachalam, 1981). Also food security must be achieved with lesser environment pollution. To meet above challenge one of the practical and feasible options is exploitation of heterosis in food crops (Donghui *et al*., 2014). Heterosis is superiority or inferiority of F_1 over its parent for different traits. The utility of heterosis was first practically exploited in maize and in case of rice it was first utilized by China. In India, although first hybrids developed during 90's and now area under rice hybrids is less than 3 m ha till date. The main reason for less popularization hybrid rice is due to magnitude of heterosis level is only 15-20% and amenable to many pest and diseases along with nutrition and quality concern (Arunachalam and Katiyar, 1982). In order to increase the rice productivity and area under hybrids of our country, it is very much essential to increase heterosis level to 25-30%. To achieve this goal we have to improve the hybrids parental line performance through diversifying its genetic background. The highly commercialized hybrids analysis shows parents are more diverse (Melchinger and Gumber, 1998). Hence, it is very much essential to select more diverse parental lines viz., CMS line, maintainers and restorer. But, right now our breeding program depends only on very narrow genetic base parental line stocks. Recombination breeding and genetic male sterility (GMS) facilitated population improvement are the two most important breeding approaches which are being used for genetic improvement of parental lines (maintainers and restorers) of hybrid rice to create variability and to exploit higher heterosis in hybrids. The required objective can be achieved within short period of time through GMS based composite population facilitated with recurrent selection (Arunachalam, 1981) since, conventional breeding approach have its own drawbacks to create variations for all traits within a stipulated time. Recurrent selection breeding approach is applicable where natural crossing mating system is available. In rice, GMS provides opportunities to natural crossing and recurrent selection provides for continuous recombination, accumulation of favourable genes, broadening of the genetic base and breaking of undesirable linkages.

In the present study, parental line (maintainer) was diversified through genetic male sterility facilitated composite population with recurrent selections for different traits like plant type, number of productive tillers, flowering duration, desirable plant height, floral traits, disease and insect pest resistance etc.

Materials and methods

Two IRRI Philippines bred maintainer composite populations viz., IR 71590-CP-140 (ME) and IR 71591-CP-141 (M) belonging to medium early and medium maturity group respectively, were used as base population.

For development of new Indian Institute of Rice Research (IIRR) bred maintainer composite population, genetically diverse and indigenously bred maintainers were used with several desirable traits viz., plant type, number of productive tillers, flowering duration, desirable plant height, grain type, yield, maintenance ability, floral traits, disease and insect pest resistance as component lines. In the first generations of gene pool development 8-10 component lines were crossed with GMS plants selected from the respective base populations. The breeding procedure is according to developed at IRRI using male sterility facilitated recurrent selection (Figure 1). This method involves genetic male sterility in the background of maintainer and component lines are diverse with desirable traits.

Results and discussion:

Population improvement is a medium to short term breeding approach for development of genotype of interest (Arunachalam and Katiyar, 1982). In each breeding cycle, individual plants are selected and best performing individuals are recombined. As against quick fixation of genes during selfing generations of recombination breeding, the genetic male sterility facilitated recurrent selection provides for continuous recombination, accumulation of favourable genes, broadening of the genetic base and breaking of undesirable linkages.

At IRRI, two composite populations of maintainer viz., IR 71590-CP-140 and IR 71591-CP-141 were developed by genetic male sterility facilitated recurrent selection (Table 1). By using IRRI bred populations as GMS source, at IIRR, Hyderabad, two maintainer composite populations (DRCP-104 & DRCP-105) were developed (Table 2) by adding 10 component lines to genetic male sterility composite population through producing F_2 for each component lines individually with GMS line as female. After producing F_2 with each component line, was mixed

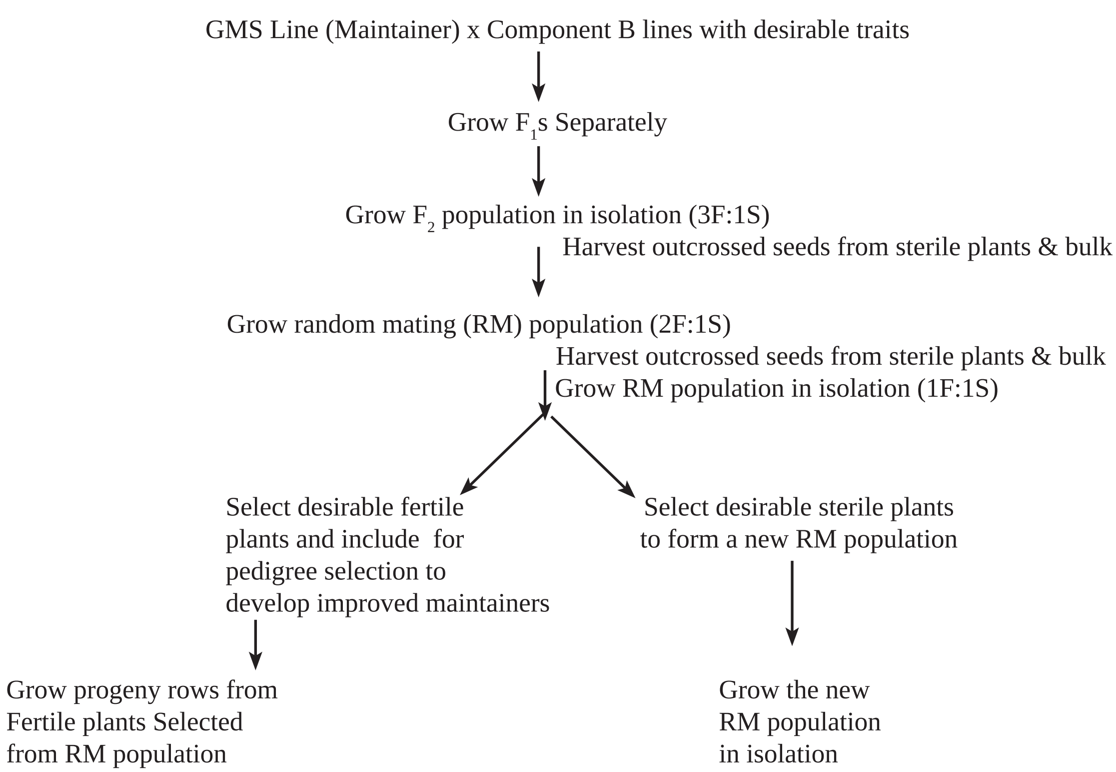

Figure 1: Schematic representation used to develop new random mating maintainer composite populations facilitated with recurrent selection at IIRR

in equal or varied quantity of seeds depends on trait of interest in order to maintain genetic heterogygosity or variability over a period of time (Xiao *et al*., 1996). This is called as composite population. In the subsequent season onwards, isolation was maintained at field condition after planting to avoid any contamination from other field or pollen source and to select productive segregants for trait of interest.

Table 1: Composition of original populations developed at IRRI

Name of populations	Male sterility source	No. of lines	Special attributes
IR 71590-CP-140(ME)	**IR 70413 (ms)**	**4**	Good grain quality, high yield potential, multiple disease and insect resistance, high GCA, good maintenance ability.
IR 71591-CP-141(M)	**IR 58025B (ms)**	**7**	

In our study, the main selection criteria used were semi-dwarf plant stature, moderate to heavy panicle, synchronous tillering, high rate of stigma exsertion, medium to long slender grains, sturdy culm and different maturity group (Figure 2). Large number of productive segregants selected from the populations is being handled by pedigree method (Arunachalam and Srivastava, 1980). Newly bred genetically diverse parental lines were first tested for its maintainer ability/reaction. The details of the newly developed populations were given in the Table 2.

Table 2: Maintainers Gene pools developed at IIRR, Hyderabad

Maturity group	No. of gene pools	No. of component lines added	No. of Lines developed	Special attributes
Medium	1	10	460	Better grain quality (LS, MS grains); Good maintenance ability; Improved plant type traits; High out-crossing ability (Stigma exsertion); Multiple disease and insect pest resistance; Better combining ability for yield and yield contributing traits, productive tillers, plant type, intermediate plant height, desirable flowering duration and synchronous tillering ability.
Medium Early	**1**	**8**	**510**	
Total	**2**	**18**	**970**	

Figure 2: Field view of composite population newly developed at IIRR

Some of the key points taken in to consideration while developing new populations are (i) Constituting populations based on maturity group, (ii) Growing populations in isolation, (iii) Continuous recombination and breakage of undesirable linkages, (iv) Accumulation of favourable alleles, (v) Flexibility in reconstituting the populations, (vi) Maintain heterogeneity of pollen by supplementary pollination, (vii) Fertile and productive segregants are handled by pedigree method, (viii) Seeds set on sterile plants are bulked to constitute next population, (ix) Bulking of seeds of selected fertile plants which segregate for male sterility to develop new population and (x) Introduction of new lines and reconstitution of populations.

The greatest advantage of the composite population is that, recombination and transgressive segregants. To achieve this, we have grown more-than three thousand plants in isolation with supplementary pollination. When the crop is grown in isolation, there may be chances for a high frequency of selfing too. Then population become less variable and selection in that population become less effective or phenotypically similar after 6-8 generations. After this process, the selected individual genotypes have traits of all component lines with genotypically uniform. The population can be regenerated again after adding up desired component line after tested for trait of interest (Katiyar and Arunachalam, 1981).

In order to broaden the genetic base of maintainers and also to increase the frequency of favourable alleles for wide range of desirable traits this novel method of genetic male sterility facilitated population improvement is a boon to hybrid rice breeders as this method allows for continuous recombination, helps to break the unwanted linkages thus widening the genetic base of the parental lines of hybrid rice.

References

Arunachalam V. (1981). Genetic basis of population improvement with particular reference to pearl millet. In '*Trends in Genetical Research on Pennisettum Ed. V. p. Gupta & J. L. Minocha, PAU Ludhiana pp*. 35-40.

Arunachalam V and Katiyar RK. (1982). Viable short-term strategy for breeding composite populations. *Indian Journal of genetics and plant breeding 42*: 32-37.

Arunachalam V and Srivastava PSL. (1980). Assessment of genetic potential of multiple crosses in triticale. *Genetics and agriculture 35:*117-12.

Donghui Fu, Meili Xiao, Alice Hayward, Ying Fu, Gui Liu, Guanjie Jiang and Haihuan Zhang. 2014. Utilization of crop heterosis: a review. *Euphytica*, 197:161–173

Katiyar RK and Arunachalam V. (1981). Single and three way crosses for generating composite populations in rapeseed. *Indian Journal of genetics and plant breeding 41*: 95-103.

Melchinger AE, and Gumber RK 1998. Overview of heterosis and heterotic groups in agronomic crops,in:*Concepts and Breeding of Heterosis in Crop Plants*.pp. 29-44, edited by K. R. Lamkey and J. E. Staub. CSSA, Madison, WI.

Xiao J, Li J, Yuan L, McCouch SR and Tanksley SD (1996). Genetic diversity and its relationship to hybrid performance and heterosis in rice as revealed by PCR-based markers. *Theoretical and Applied Genetics 92*: 637– 643.