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Short communication

Parallel and interlaced recurrent selection (PAIRS): Demonstration of the feasibility of implementing PAIRS to improve complete and partial resistance to blast (*Magnaporthe grisea*) and some other main traits in rice

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ABSTRACT

The best generation for the evaluation and selection of a trait depends on its polygenic level and heritability. Little attention has been paid to integrating, in the same rice recurrent selection (RS) scheme, the separation of breeding generations. The option we propose is a new parallel and interlaced RS (PAIRS) scheme. We evaluated and selected earliness and grain size in the S0 generation, complete resistance to leaf blast in S1 plants, partial resistance to leaf and neck blast, earliness and yield components in S2 lines, gelatinization temperature, estimated by the extent of alkali spreading in S3 grains, and tolerance to rice delphacid (*Tagasodes orizicolus*) mechanical injuries in S3 plants. Although this innovative scheme may seem complicated overall, this first application of PAIRS highlights that the improvement of every methodological step is very easy. Through a complete recurrent selection and genetic recombination cycle, we obtained good progress for grain length, partial resistance to leaf blast and gelatinization temperature (alkali spreading value), and excellent progress for targeted earliness, complete resistance to leaf blast, partial resistance to neck blast and yield. The population size and the number of plants or lines chosen were adequate and we can recommend them to partners.

1. Introduction

Rice is the most important food crop in the world, so much attention is paid to its genetic improvement, and recurrent selection (RS) is one of the most appropriate methods to achieve this goal. RS involves successive selection and genetic recombination cycles (Gallais, 1977, 1989). Fujimaki (1979) proposed RS for rice using a recessive gene for male-sterility (Singh and Ikehashi, 1981) in order to manage rice as a cross-pollinated species. RS is not popular for other self-pollinated crops because a recessive gene for male-sterility is not available for them. Genetic recombination results from harvesting of male-sterile plants (see line C in Fig. 1), which are spontaneously cross-pollinated. In 1988, Vales (1988, 1990, 1992) initiated the first RS program in Brazil and Côte d'Ivoire using the first broad-based populations made by Taillebois and others (Taillebois and Neves, 1989; Taillebois and Guimarães, 1989). Resistance to rice blast disease (*Magnaporthe grisea*) was the main targeted trait of this first RS program (Vales, 1991).

Blast is the main rice disease in the world and breeders manage two complementary kinds of resistance to stave it off: complete resistance (no symptoms, no epidemics) and partial resistance (few symptoms, slow epidemics). Producers require that a new commercialized variety has complete resistance, but this resistance is always rapidly overcame by blast. We therefore want that this new commercialized variety to have a partial resistance to yield loss after the breakdown of the complete resistance. Lineage exclusion is a recent strategy to improve complete resistance (Zeigler et al., 1999). The main way to improve partial resistance is still selection achieved in fields inoculated with a compatible strain (Notteghem, 1977). Breeders have to select for complete and partial resistance to blast in different generations. Complete resistance to blast is often monogenic, specific, and highly heritable, so breeders can evaluate and select for this resistance in the greenhouse in S0 or S1 generations (S0, S1, etc. are like F1, F2, etc., respectively, when at least one parent is heterozygous). Partial resistance is commonly polygenic and not very heritable, which means breeders have to evaluate and select for this resistance in farmers' field conditions and in the S2 generation.

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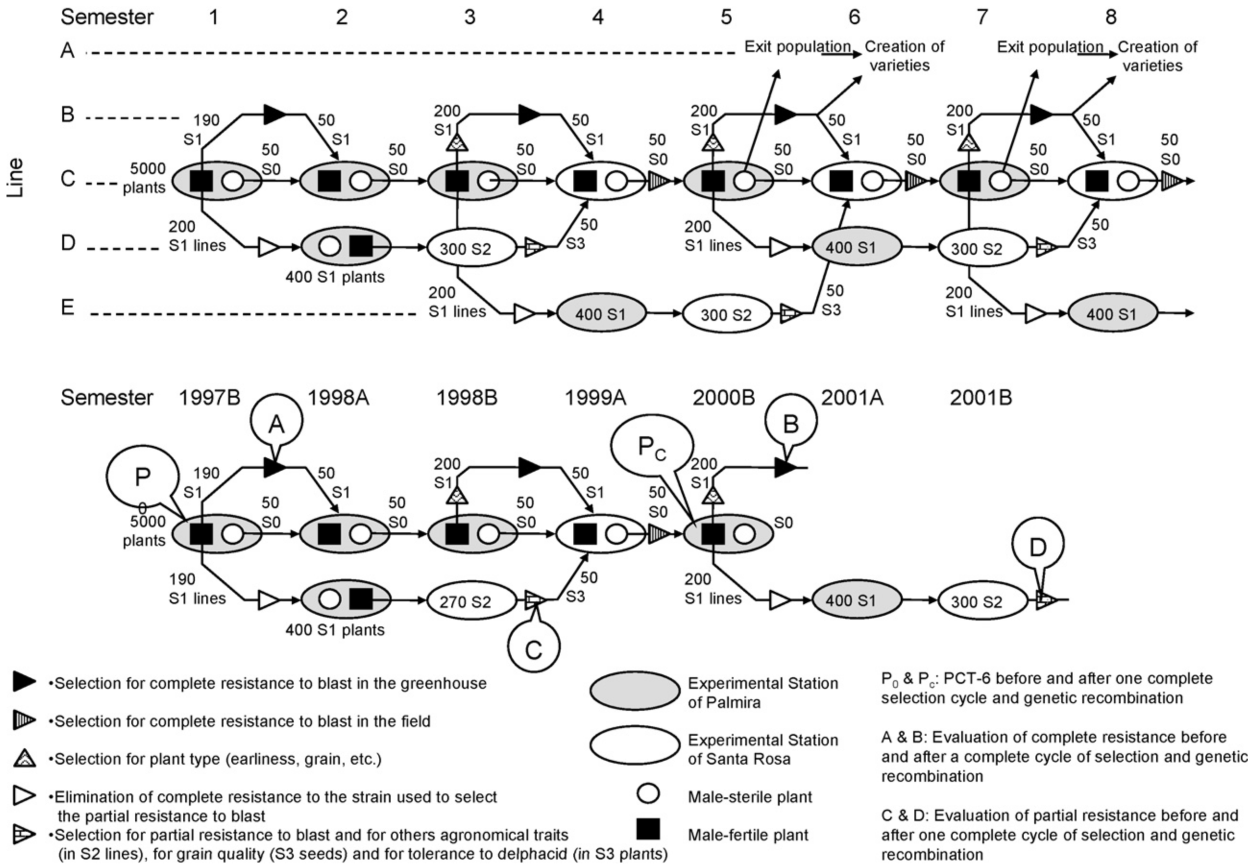

Fig. 1. Complete parallel and interlaced recurrent selection (PAIRS) scheme, and the part of the PAIRS carried out in the PCT-6 population for the study.

More generally, the best generation for evaluation and selection differs depending on the traits. If the trait is mono- or oligogenic, heritable and easy to evaluate, breeders evaluate and select plants or lines in early S0 or S1 generations. If the trait is more polygenic or less heritable and not very easy to evaluate, breeders evaluate and select in the S2 generation. If the trait is highly polygenic, not very heritable or not easy to evaluate, breeders evaluate and select in the S3 generation. Little attention has been paid to trying to integrate in the same RS scheme the separation of breeding generations. This paper proposes a new RS scheme and demonstrates its feasibility.

2. Materials and methods

2.1. PAIRS scheme

In the proposed parallel and interlaced recurrent selection (PAIRS) scheme, some evaluation and selection trials were conducted in parallel, i.e. achieved at the same time, on parallel timelines (e.g. see lines C and D in Fig. 1), in order to save time. In conventional RS schemes, serial trials are conducted for trait evaluation and selection, i.e. they are achieved one after the other, on the same timeline (e.g. see line C in Fig. 1).

In the proposed PAIRS scheme, some evaluation and selection processes are reinitiated without waiting for the end of the previous process (e.g. see lines D and E in Fig. 1) to save time. This results in the crossing of process lines, and these successive lines are interlaced. In conventional RS schemes, the trait evaluation and selection process is never reinitiated before it has terminated, so time is lost.

The size of the recurrent population (5000 plants) and the number (50) of plants or lines evaluated, and then selected, were chosen on the basis of our empirical experience (Fig. 1). To avoid possible genetic drift, a sample of the non-selected population (50 progenies of unselected plants; see arrows, line C in Fig. 1) contributed to every genetic recombination. The hypothesis that these choices are acceptable was tested by studying the breeding efficiency of the first completed PAIRS recurrence cycle (Fig. 1), i.e. by comparison of the recurrent population before selection (see P_0 in Fig. 1) and after selection and genetic recombination (see P_C in Fig. 1). According to the traits, P_0 and P_C were evaluated in A and C, and in B and D, respectively (Fig. 1).

2.2. Population and varieties of rice and strains of *Magnaporthe grisea*

We used the PCT-6 recurrent population of the CIAT-CIRAD rice collaborative project (Table 1). This broad-based tropical irrigated rice population was previously improved for its resistance to rice *Hoja blanca* virus (RHBV) while maintaining its genetic diversity for others traits (Borrero and Triana, 1998).

Different cultivars were included as checks: Fanny as a susceptible check for greenhouse evaluation of complete resistance to blast, and Makalioka as a resistant check for greenhouse evaluation of resistance to delphacid (*Tagasodes orizicolus*) injury. Five other varieties were used as checks for the field evaluation of partial resistance to blast (Delgado and Vales, 1998): Oryzica 1 as a high susceptible check, INIAP 415 as a susceptible check, ICA 10 as a moderately susceptible check, WC 362 as a moderately resistant check, and WC 360 as a resistant check. They were also used as checks for cycle duration (Delgado and Vales, 1998): WC 360 and WC 362 for short cycle, ICA 10 and Oryzica 1 for medium cycle, and INIAP 415 for long cycle. In addition, we used susceptible varieties as spreaders to induce blast epidemics in the field trials: Oryzica Caribe 8 or Fanny was