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Breeding *Panicum maximum* in Brazil. 1. Genetic resources, modes of reproduction and breeding procedures

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Summary

Apomixis is widely distributed among tropical forage grasses, and has long been merely regarded as an impediment to breeding. *Panicum maximum* is presented as the first opportunity for Brazilian geneticists to develop and test original breeding schemes adapted to an apomictic species.

A large and representative germplasm of *P. maximum* has been introduced and is currently being evaluated. Basic knowledges on biology and reproduction are also available, which demonstrate an easy

caught along the western coast of Africa, while the species diversity was mainly restricted to East Africa (Combes & Pernes, 1970), the plants introduced at this time only exhibited the reduced polymorphism of marginal populations, an extremely low variability being therefore available for Brazilian farmers. One can postulate that the same has occured to other cultivated forage grasses, as most *Brachiaria* species, *Melinis minutiflora*, and *Cenchrus ciliaris*. Furthermore, as all these species reproduce through apomixis, roughly defined as asexual reproduction by means of seed (Nogler, 1984), no possibility of genetic recombination was offered to these grasses in their new Latin American home. As such, the present variation within Brazilian cultivars of *P. maximum* is still very low. Although a few introductions were made since the beginning of this century, they were limited to Australian cultivars, and never spread due to low adaptability and/or low seed production. Within the 'Colonião' morphological type, several cultivars have afterwards been identified, which presumably are nothing more than the consequence of guineagrass ability to respond to environmental variations.

For Brazilian agronomists, new introductions from East Africa were a must, and this was made possible in 1982 through the EMBRAPA-ORSTOM agreement. More than 400 apomictic accessions of *P. maximum* were introduced, along with several hundred seeds from sexual genotypes. An agronomical evaluation program was started (Savidan et al., 1985). Similar evaluations of the same material, are now being conducted in Colombia by Centro Internacional de Agricultura Tropical (CIAT), in Mexico by the Colegio de Postgraduados, and in Cuba by the Indio Hatuey Research Center. Another excellent evaluation program is carried out in Japan (Nakajima et al., 1978), although based on a more reduced variation.

Although breeding schemes have already been proposed for the species (Pernes et al., 1975; Smith, 1975), very little has been done in this way,

1. a large and representative germplasm has been collected,
2. basic knowledge on biology and reproduction is available,
3. limiting factors exist within the natural variation, such as very infrequent qualitative traits or poorly combined quantitative traits, we propose to follow up the agronomical evaluation with an original plant breeding scheme, as presented below.

Panicum maximum has been extensively collected by French and Japanese geneticists (Combes & Pernes, 1970; Nakajima et al., 1978), and a large germplasm is now available for breeding. This germplasm can be considered representative of the natural variation and further collects are not necessary.

In relation to the second point, and as most tropical forage grasses are apomictic, basic studies on the nature and inheritance of apomixis are strongly needed before any breeding attempt is made. This basic information is generally unavailable. *Panicum*, however, is an exception to that rule, as will be seen in the next section.

The agronomical evaluation program conducted with *P. maximum* in Brazil demonstrated that several important traits deserve genetic improvement. Many high-yielding forage accessions can be directly selected from the introduced germplasm, and some will be released in the next five years. Very few, if any, combine high herbage production with traits like:

- determinate flowering habit,
- nonshattering seeds,
- good quality seeds,
- insect resistance,
- adaptability to low fertility savanna soils,
- drought tolerance,
- rapid seedling growth,
- creeping habit with rooting at the nodes,
- forage quality, high palatability and digestibility.

Nature and inheritance of apomixis

thenogenesis, i.e. development of an embryo from the unfertilized egg cell (Warmke, 1954; Combes, 1975; Savidan, 1982a).

Breeding of any apomictic species needs availability of totally or highly sexual plants. Sexuality in *P. maximum* was first discovered by Combes & Pernes (1970) in diploid accessions from East Africa. Smith (1972) and Hanna et al. (1973) selected highly sexual tetraploids from South African apomictic accessions. Combes and Pernes' sexual diploids were treated by colchicine, and a few tetraploid plants were obtained, which showed to be entirely sexual.

Sexual and apomictic plants can be screened at two different levels. Progenies from apomicts are homogeneous and show the maternal phenotype. Sexual ecotypes are crosspollinating and produce highly heterogeneous progenies. A far more rapid determination of the reproductive behaviour can be obtained from gametogenesis analyses on the

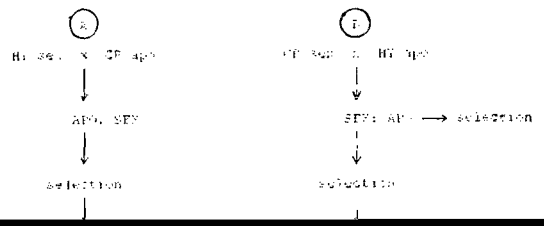
from interspecific hybridizations in *Brachiaria* (Ndikumana, 1985), suggested a similar simple inheritance. Be that as it may, all these data strongly demonstrated an easy manipulation of modes of reproduction in tropical forage grasses. Breeding of such apomictic species is therefore no utopia.

Breeding procedures

Genetic improvement of apomicts can be obtained from crossing (1) sexual × apomict, when sexuality is available, (2) facultative apomict × apomict or (3) obligate apomict × apomict, when sexuality has not yet been discovered.

Breeding procedures for *Panicum maximum*, based on (1) sexual × apomict crosses, have been previously proposed by Smith (1975). These were based on limited knowledge of both natural variability and biology of *Panicum*, thus proving to be

Chaume, 1985), resulting in higher rates of selfing, since crosspollination was less favored than in the plot technique. Selfed plants were easily separated from hybrids, due to inbreeding effects such as wrinkled leaves and general low vigor. In the plot technique, hybrid seeds were collected by shaking



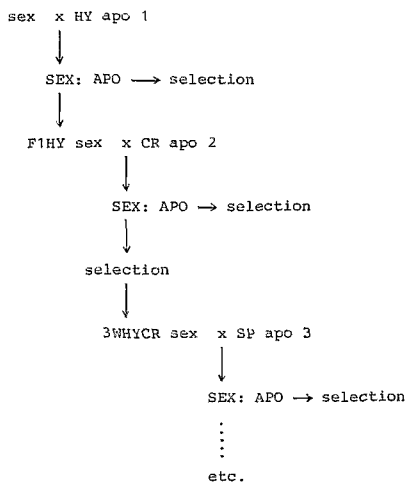


Fig. 2. Breeding scheme to combine several traits such as high forage production (HY) to creeping habit (CR) and good quality seed production (SP). Adapted from Pernes et al. (1975).

types (Savidan, 1982b), resulting from fertilization of either reduced meiotic or unreduced aposporic egg cells. Even when failure of meiosis is complete, one can expect some progress from the selection of accessions with a high rate of (2n + n) genotype production. Breeding through obligate apomict × apomict crosses may seem an extravagant propos-

is may be easily manipulated. Some of the advantages brought by apomixis, such as hybrid vigor fixation, simplification and consequent low cost in hybrid seed production, aroused the interest of many crop breeders in recent years. Transfer of apomixis to wheat, rice, maize, sorghum and millets, is currently being attempted. A first International Conference on 'The Potential Use of Apomixis in Crop Improvement' has been organized in 1986 by the Rockefeller Foundation, and apomixis research specialists gained their own newsletter, the 'Apomixis Newsletter'.* Apomixis is now rising as a new tool in plant breeding (Savidan, 1986). It is a characteristic of the Panicoideae subfamily of the Gramineae (Brown & Emery, 1958), therefore a characteristic of most tropical forage grasses. The need, for tropical countries, to develop and test breeding programs on apomictic forage species as a mean to increase beef and dairy cattle productions, justifies our present efforts to select apomictic and sexual progenitors of *P. maximum* for further crossing experiments.

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