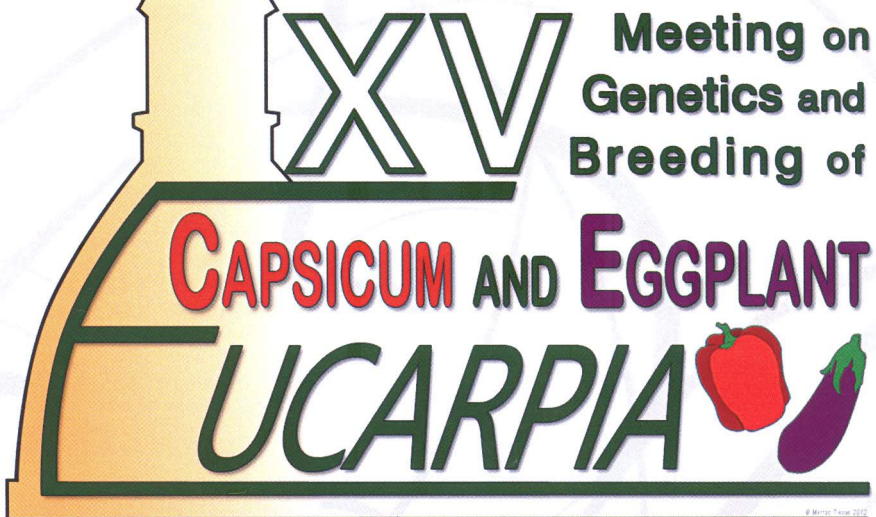




Breakthroughs in the Genetics and Breeding of Capsicum and Eggplant

Torino, 2-4 September 2013



EDITORS

Sergio Lanteri

Giuseppe Leonardo Rotino

Development of new *Capsicum* cultivars at EMBRAPA (Brazil)

Reifschneider F.J.B.¹, Ribeiro C.S.C.², Carvalho S.I.C.²

¹EMBRAPA International Relations, CNPq Fellow, Brasília-DF

²EMBRAPA Hortaliças Caixa Postal 218, CEP 70359-970, Brasília-DF, Brazil.

Abstract

Brazil has a relatively long history of public and private *Capsicum* breeding programs. In the early 1980's, EMBRAPA Vegetables, one of the research centers of the Brazilian Agricultural Research Corporation (EMBRAPA) launched its breeding program. Today this program is considered to be the largest public investment in hot and sweet pepper breeding. The strategy adopted by the program since its beginning considered as key elements: 1) the establishment of an ample germplasm collection to support the breeding effort; 2) a clear focus in the development of specific products demanded by the market, with about 80% of the total resources allocated to this segment; 3) allocation of about 20% of our breeding efforts to explore new opportunities; 4) capacity strengthening, through the involvement of a large number of trainees at the undergraduate and graduate level; 5) cooperative work with public and private universities, and 6) the establishment of agreements with the private sector. The germplasm bank established in the early 1980's has been efficient in providing germplasm with variability, adaptability, yield and characteristics demanded by the breeding program. Some of the most recently-developed cultivars include: **BRS Brasilândia** (*C. annuum*, F1 hybrid for paprika, sweet), **BRS Sarakura** (*C. annuum*, OP for sauce, Jalapeño type, pungent), **BRS Garça** (*C. annuum*, OP for sauce, Jalapeño type, pungent), **BRS Seriema** (*C. chinense*, OP for pickled and fresh market, pungent), **BRS Moema** (*C. chinense*, OP for fresh market and pickled, sweet), and **BRS Mari** (*C. baccatum*, OP for fresh and dehydrated markets, pungent). The breeding program has targeted different pepper types and species at different times. Most recent efforts address the development of new, uniform, high yielding, high nutrition, disease resistant *Malagueta* peppers (*C. frutescens*) as well as Habanero type cultivars (*C. chinense*), as recently demanded by the Brazilian market. Yellow Jalapeño, orange-fleshed Biquinho and multiple disease resistant F1 rootstocks for bell pepper are soon to be released as well.

Keywords: Chile pepper, breeding, disease resistance, genetics, variety

Introduction

Brazil has a relatively long history of public and private *Capsicum* breeding programs. An effort deserving to be highlighted was the public program led by Hiroshi Nagai in the 1960's-1980's, which released several peppers known as the Série Agrônômico. Cultivar Agrônômico 10, a conical sweet pepper, was a real landmark for the pepper producers due to its yields, adaptability and resistance to viruses.

In the early 1980's, EMBRAPA Vegetables, one of the research centers of the Brazilian Agricultural Research Corporation (EMBRAPA) launched its breeding program. Today this program is considered to be the largest public investment in hot and sweet pepper breeding. Initial focus was given to the development of disease resistant lines and populations, and *Phytophthora capsici* was a major pathogen together with a potyvirus, *PVY*. A few years later, a tospovirus (TSWV - Tomato Spotted Wilt Virus) also became widespread in the *Capsicum*-producing areas in the country and the breeding program dedicated a substantial effort to finding sources of resistance to this virus.

The emphasis on disease resistance reflected not only the importance of diseases, the major production constraint in that period, but also the existence of a large group of plant pathologists at EMBRAPA Vegetables and at the Universidade de Brasília, an important partner of EMBRAPA.

The strategy adopted by the program since its beginning considered as key elements:

the establishment of an ample germplasm collection to support the breeding effort;

a clear focus in the development of specific products demanded by the market, with about 80% of the total resources allocated to this segment;

an allocation of about 20% of our breeding efforts to explore new opportunities;

capacity strengthening, through the involvement of a large number of trainees at the undergraduate and graduate level;

cooperative work with public and private universities UnB, UENF, UFRRJ, USP/ESALQ, UFG, FTB,UCB), and

the establishment of agreements with the private sector.

Furthermore, the breeding program was structured taking into consideration the multiple functions that it actually performs in a developing country, i.e., the program serves as:

a *Capsicum* R&D platform, generating new cultivars, lines and population of interest to Brazil;

a *Capsicum* Knowledge Management & Knowledge Sharing platform (national meetings and an e-platform for discussion), moderated by the senior breeders, which have put together more than 500 professionals, mostly from the private sector, who have an interest in *Capsicum*-related issues in Brazil;

a *Capsicum* Services platform comprised of a genebank, seed production activities (with the private sector), and lab analysis of interest to the program and to the private sector (for example capsaicin/HPLC). The genebank, with over 4,000 accessions from different species, serves as the backbone to the research & development program.

Since the 1980's, the *Capsicum* program has released several cultivars, inbred lines, populations and hybrids resistant to different pathogens which have had major impact in the country. As an example, one of the most recently-released cultivars, BRS Sarakura (Figure 1), an OP cultivar protected in the country, is responsible for a large share (>50%) of the hot pepper sauce made in Brazil, with over 2,000 ton harvested in 2012.

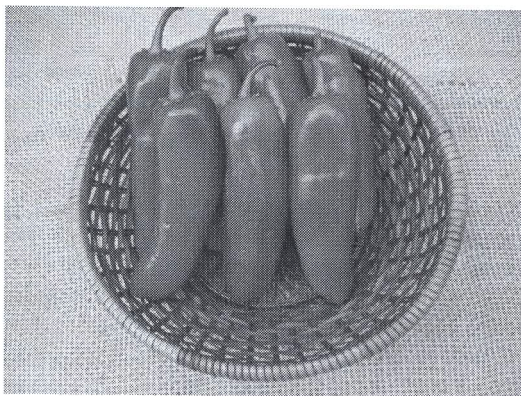


Figure 1: cultivar BRS Sarakura.

Materials and Methods

Germplasm bank

The genebank is a continuous undertaking initiated in 1980 and now over 4,000 accessions from Brazil and elsewhere are available to the breeding program. It has proven to be an invaluable source of new genotypes of interest to the Brazilian market as well as a source of important traits, such as disease resistance. Innovative approaches have been used to enrich the genebank, including the engagement of high school students. The passport information is organized in a databank (Figure 2) which includes photos of the accessions, and over 50 descriptors are used to characterize each genotype (http://www.cnph.EMBRAPA.br/paginas/servicos/banco_germoplasma_capsicum.htm). Morphological and molecular characterization is routinely performed in the collection, and a large percentage of the bank has been morphologically characterized following internationally-suggested descriptors (IPGRI). Control of seed stocks in the genebank is achieved through the use of a simple barcode system.

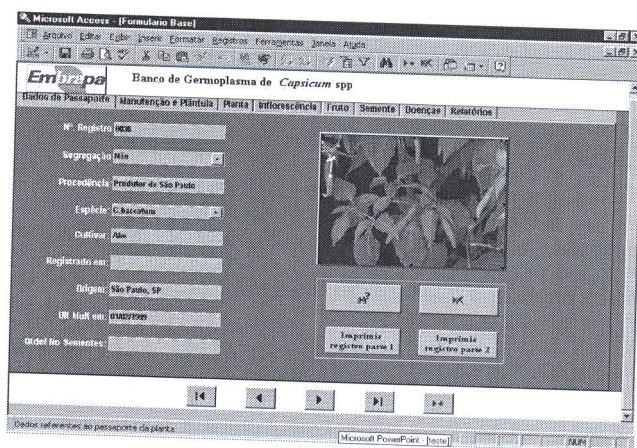


Figure 2: Screenshot of EMBRAPA' *Capsicum* genebank.

Breeding new cultivars

Various breeding methods, including mixed methods, have been used to generate new hot and sweet peppers adapted to the different Brazilian regions. The first cultivar developed by the program was "Tico", a block-type sweet pepper developed for the Northeast of Brazil, resistant to *Cercospora*. Breeding projects have been mostly financed by public funds (EMBRAPA and CNPq), but projects funded by the private sector were also extremely important in bridging eventual demand gaps between these two sectors. In 2003, EMBRAPA gave stronger emphasis and support to breeding programs designed to assist small-scale farmers growing typical Brazilian peppers, in addition to the development of genotypes of interest to the medium and large farmers and agribusiness. At that time, most of those small-scale farmers pepper types were of limited interest to seed companies. All new cultivars have been registered in the National Cultivar Registry (RNC). Since this program is a public breeding effort, innovative arrangements had to be developed to ensure that the private sector, both Brazilian and international, timely produced and delivered seeds to growers. Non-exclusive licensing has been used and national and international companies have been marketing the new cultivars (Figure 3).



Figure 3: An example of a folder of the new BRS Capsicum marketed cultivars.

The flowchart below (Figure 4) provides a general graphic representation of the operation and flow of the breeding program.

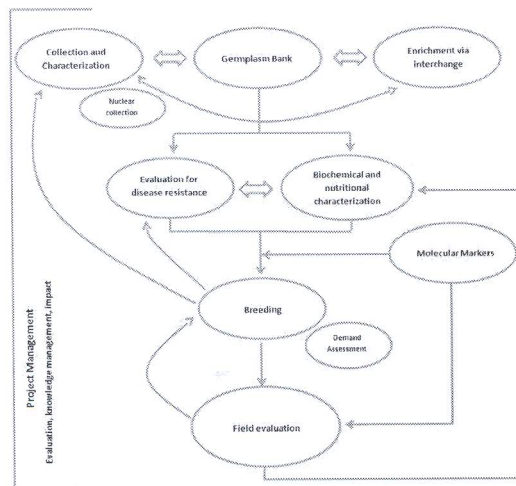


Figure 4: Flow chart of the various phases of the breeding program.

Molecular markers

Marker-assisted selection has more recently been used by the program, and molecular markers are being developed by the program (Embrapa Genetic Resources and Biotechnology). Perhaps the most significant contribution has been the development of a molecular marker to identify pungency, with 100% reliability, validated on hundreds of accessions and segregating populations (Figure 5).

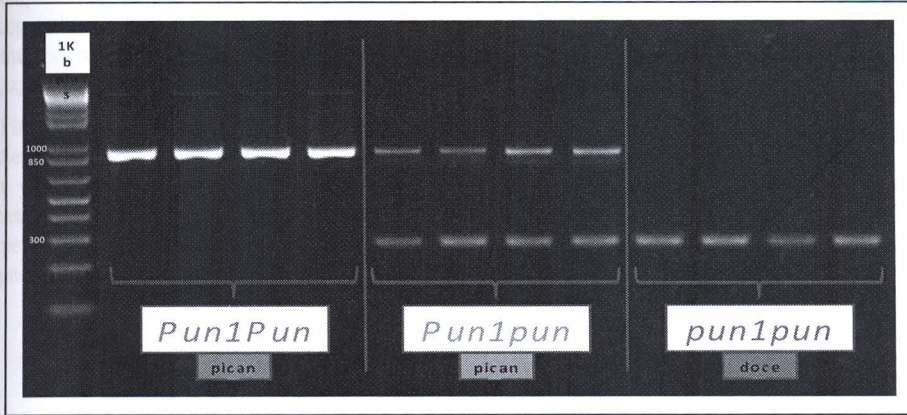


Figure 5: Molecular markers associated with pungency: homo- and heterozygous pungent (Pun1) and sweet (pun1) accession of *Capsicum*

Breeding beyond higher yields

In the past few years, increased attention has been given to pepper fruit quality, in addition to high, stable and sustainable yields. Vitamin C and aroma (volatiles) are considered important traits in the development of any new cultivar: An example for BRS Seriema is illustrated in Figures 6 and 7.

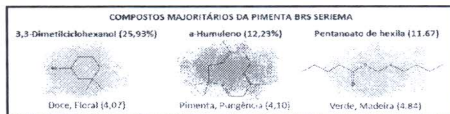


Figure 6: Major volatiles in the fruit of cultivar BRS Seriema.

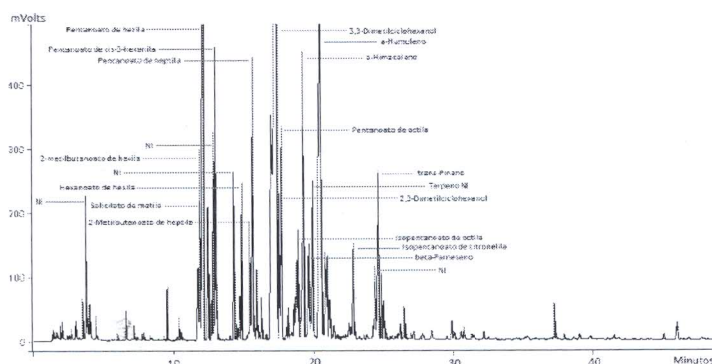


Figure 7: Complete chromatograph of volatiles for the newly released cultivar

Results and Discussion

The germplasm bank has efficiently supplied germplasm with variability, adaptability, yield and characteristics demanded by the breeding program. Some of the most recently-developed cultivars include:

- BRS Brasilândia** (*C. annuum*, F1 hybrid for paprika, sweet)
- BRS Sarakura** (*C. annuum*, OP for sauce, Jalapeño type, pungent)
- BRS Garça** (*C. annuum*, OP for sauce, Jalapeño type, pungent)
- BRS Seriemã** (*C. chinense*, OP for pickled and fresh market, pungent)
- BRS Moema** (*C. chinense*, OP for fresh market and pickled, sweet)
- BRS Mari** (*C. baccatum*, OP for fresh and dehydrated markets, pungent)

‘BRS Mari’ (*C. baccatum*), ‘BRS Moema’ (*C. chinense*), and ‘BRS Seriemã’ (*C. chinense*) are the first three cultivars developed by EMBRAPA to support the small farmer as well as the larger entrepreneur. The breeding method used to develop these cultivars was mass selection and/or stratified mass selection for several cycles coupled with self-pollinations. ‘BRS Mari’ (Dedo-de-Moça type) is suitable for processing as dehydrated flakes or sauce, as well as for fresh market. This cultivar has shown multiple resistance to diseases, mainly Pepper Yellow Mosaic Virus (PepYMV), average resistance to *Oidium sicula*, *Xanthomonas* spp. and *Colletotrichum* spp. In Central Brazil, ‘BRS Mari’ showed high plant uniformity, excellent fruit quality and great potential yield, reaching 35 t/ha in six months (6,667 plants/ha). The most important traits of ‘BRS Mari’ are the high capsaicin content, approximately 90,000 Scoville Heat Units, and resistance to anthracnose. ‘BRS Moema’ (Biquinho type) is resistant to *Meloidogyne javanica* and PepYMV. This cultivar has presented high fruit and plant uniformity, with sweet, aromatic, flavored, and crunchy fruits, and it is consumed fresh or pickled. ‘BRS Moema’ has yielded 20 t/ha in six months of harvest (10,416 plants/ha). Finally, ‘BRS Seriemã’ (Bode type) is a uniform, pungent and well-adapted cultivar to Central Brazil, consumed fresh or pickled.

The breeding program has been constantly challenged by – abiotic, biotic, economic and social factors, and today perhaps the biggest challenge in Brazil is the lack of labor for harvesting, which has demanded a new major effort to develop cultivars adapted to mechanical harvest, at both micro as well as macro scales of production.

New market demands include, in addition to the ever present demand for high yields, the development of cultivars adapted to organic production, high nutritional quality of fresh fruit and sauces, cultivars from previously unexplored groups, such as *Murupi*, and taste and aroma typical for the specific group of peppers, such as *Malagueta*, *Murupi*, *Bode*, *Cambuci*, *Cumari*, *Dedo-de-Moça*, among others.

Finally, it is noteworthy that the breeding program has targeted different pepper types and species at different times. Most recent efforts are concentrated on the development of new, uniform, high yielding, high nutrition, disease resistant *Malagueta* peppers (*C. frutescens*) as well as Habanero type cultivars (*C. chinense*), a more recent demand by the Brazilian market. Yellow Jalapeño, orange-fleshed Biquinho (Figure 8) and multiple disease resistant F1 rootstocks for bell pepper will soon be released as well.



Figure 8: Fruit of orange-fleshed Biquinho.

Acknowledgements

The authors wish to thank CNPq, the Brazilian National Research and Development Council; Fuchs AgroBrasil; and Sakura Nakaya Alimentos Ltda for their support, as well as the Brazilian network of pepper researchers (Grupo *Capsicum*) from the public and private sectors for their invaluable support.

References

- IPGRI. International Plant Genetic Resources Institute. *Descriptors for Capsicum (Capsicum spp.)*. 1995. 49p. IPGRI.
- Lima M. F., Ulhoa A.B., Reifschneider F.J.B. 2011. *Programa de melhoramento de Capsicum da Embrapa: Avaliação de híbridos e linhagens avançadas de pimenta malagueta a viroses em campo*. www.sbfito.com.br/tpp/suplemento_2011_Bentogoncalves.pdf, pp 1351.
- Lopes C.A., Boiteux L.S. 2004. *Biovar-specific and broad-spectrum sources of resistance to bacterial wilt (Ralstonia solanacearum) in Capsicum*. *Crop Breeding and Applied Biotechnology*, v.4: 350-355.
- Lopes C.A., Quezado-Duval A.M. *Reaction of Capsicum Genotypes to Bacterial Wilt and Bacterial Spot*. 2001. In *Plant Pathogenic Bacteria*, pp 306-308. De Boer S. (ed.). Kluwer Academic Publishers.
- Nass L.L., Sigrist M.S., Ribeiro C.S. da C., Reifschneider F.J.B. 2012. *Genetic resources: the basis for sustainable and competitive plant breeding*. *Crop Breeding and Applied Biotechnology*, S2, pp 75-86 (Special edition).
- Poulos J. M., Reifschneider F. J. B., Coffmam W. R. 1991. *Heritability and gain from selection for quantitative resistance to Xanthomonas campestris pv. vesicatoria in Capsicum annum L*. *Euphytica*, v.56: 161-167.
- Ribeiro C. S.C. *Criando novas variedades*. 2000. In *Capsicum: pimentas e pimentões no Brasil*, pp. 68-80. Reifschneider F. J. B. (org.). Embrapa Transferência de Tecnologia/ Embrapa Hortaliças.
- Ribeiro C. S. C., Lobo Júnior M., Henz G. P., Reifschneider F. J. B. 2003. *Evaluation of Capsicum spp. genotypes for resistance to Phytophthora capsici in Brazil*. *Capsicum & Eggplant Newsletter*, v.22: 125-126.
- Ribeiro C. S. da C., Reifschneider, F. J. B. *Genética e melhoramento*. 2008. In *Pimentas Capsicum*, pp 55-56. Ribeiro C. S. da C., Lopes C. A., Carvalho S. I. C., Henz G. P., Reifschneider F. J. B. (eds.). Embrapa Hortaliças.
- Reifschneider F. J. B., Ribeiro C. S. da C. *Reviewing 30 years of Capsicum breeding at Embrapa Vegetables, Brazil*. 2012. In *Book of Abstracts*, pp 43. International Pepper Conference, 21.