



Morphologic characterization and genetic diversity of *Capsicum chinense* Jacq. accessions along the upper Rio Negro - Amazonas

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ABSTRACT – The genetic diversity of 38 accessions of the genus *Capsicum* from the upper Rio Negro in the Amazon region was characterized by 51 morphologic descriptors. The similarity of the accessions was calculated based on 17 essential descriptors and on the general similarity coefficient of Gower. Grouping analyses and a dispersion diagram of the accessions were established based on the similarity coefficients using, respectively, the UPGMA method and the principal coordinate analysis (PCO) as criterion of grouping and dispersion. A great variation of classes were identified in the fruit traits: nine colors, four shapes and a great range of variation in fruit size and weight. Only three accessions were not pungent, since this study focused on the pungent accessions of the genebank. The following pepper morphotypes were identified: three olho-de-peixe types, three pimenta-de-passarinho, four dedo-de-moça, four curabiá, nine murupi and 15 pimenta-de cheiro.

Key words: peppers, genetic resources, germplasm.

INTRODUCTION

Peppers and sweet peppers (*Capsicum* spp.) belong to the family Solanaceae; they generally have a bushy shape and produce sweet or hot fruits (Pickersgill 1971). Pepper plants represent an important part of the fresh vegetable market of Brazil and also of the segment of condiments, spices and preserves at the international level (Rufino and Pentelado 2006).

The botanic species of the genus *Capsicum* are native to the tropical regions of Latin America. Peppers were a constant element of the American Indians' alimentation and the Europeans began the domestication (Andrews 1984, Moreira et al. 2006).

The Amazon is an important center of diversity of the genus *Capsicum*, particularly of the species *Capsicum chinense*, although over the last decade the degradation of the genus due to anthropic pressure been intense. In the region of the upper Solimões river (AM) the genetic resources of *Capsicum* spp. are being studied and described (Silva Filho et al. 2001), which is not the case in the region of the upper Rio Negro (AM) where a wide variability of the genus has been observed. It is believed that the germplasm of *Capsicum* spp. in the region of the upper Rio Negro is a potential source of genes of important agronomical traits such as disease resistance, color, fruit type and yield, which justifies

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the characterization and evaluation of the genetic diversity of these accessions.

Unlike in the case of sweet pepper, there are few breeding programs of *Capsicum* spp. peppers in Brazil, so few cultivars are available on the market (Ribeiro 2004). Specifically of *C. chinense*, the species under study, only two cultivars (Caribbean Red Habanero and Caribbean Yellow Habanero) were registered (by 01/30/2006) by the Serviço Nacional de Proteção de Cultivares; the two were identified as sweet pepper habanero and were not originated from native Brazilian germplasm (Carvalho et al. 2003).

The morphologic characterization, the evaluation of the genetic diversity and the documentation of a genebank are essential to maintain an active basis for the exploration of the genetic variability in breeding programs (Carvalho et al. 2001, Viana et al. 2006, Arriel et al. 2007, Lannes et al. 2007). Therefore, a detailed understanding is needed of the extension of the genetic variation available in the cultivated species as well as in the wild relatives (Buso et al. 2003).

To estimate the genetic variability of the genus *Capsicum* in the region of the upper Rio Negro for its conservation, appreciation and use in benefit of the society, a *Capsicum* genebank was established at the Faculdade de Ciências Agrárias of the Universidade Federal do Amazonas. This study aimed to characterize part of the collection morphologically and to quantify the genetic similarity in the accessions by multivariate techniques to identify those with maximal divergence and good performance *per se*.

MATERIAL AND METHODS

From the *Capsicum* spp. Genebank of the Faculdade de Ciências Agrárias of the Universidade Federal do Amazonas (FCA/UFAM), 38 accessions of *Capsicum chinense* were evaluated. All accessions are native to the region of the upper Rio Negro, state of Amazonas (AM) and were provided by the horticulture sector of the Escola Agrotécnica Federal of São Gabriel da Cachoeira - AM. The identification of the accessions is given in Table 1.

The accessions were sown on March 21, 2005. After 20 days, the plantlets were transplanted to 200 mL plastic cups and 45 days after sowing transplanted to the field (horticulture sector, FCA/UFAM; lat 03°06'121''S, long 59°58'547''W; 42 m asl), Manaus,

AM, located in the humid tropical forest biome with predominance of tropical rainy climate. The soil acidity was corrected and the plants fertilized based on the results of soil analysis and crop recommendations.

Table 1. Identification of 38 accessions of *Capsicum chinense* from the region of São Gabriel da Cachoeira, upper Rio Negro, Amazonas, of the *Capsicum* spp. collection of the Faculdade de Ciências Agrárias of the Universidade Federal do Amazonas

Index code	Origin	Popular name
RIH01	Comunidade de Taracuí	Taracuí
RIH02	Comunidade do Balaio	Unknown
RIH03	Bairro da Serra	Tariana
RIH04	Bairro do Dabarú	Unknown
RIH05	Bairro do Dabarú	Murupizão
RIH06	Bairro do Tirirical	Unknown
RIH07	Bairro do Dabarú	Unknown
RIH08	Bairro da Praia	Murupiaçu
RIH09	Bairro da Praia	Murupi salmão
RIH10	Bairro da Fortaleza	Otero
RIH11	Bairro Dabarú	Unknown
RIH12	Bairro Areial	Pepper Doce
RIH13	Bairro Dabarú	Curabiá-Yellow
RIH14	Bairro Dabarú	Unknown
RIH15	BR-307-KM-05	Caroço of Ingá
RIH16	Bairro Dabarú	Unknown
RIH17	Bairro Areial	Dedo-de-Moça
RIH18	Bairro Dabarú	Unknown
RIH19	Bairro Dabarú	Murupizinha Yellow
RIH20	Bairro Dabarú	Unknown
RIH21	Bairro Dabarú	Olho-de-Peixe
RIH22	Bairro Areial	Unknown
RIH23	Bairro Pe. Cícero	Pimenta-de-passarinho
RIH24	Bairro Dabarú	Unknown
RIH25	Bairro Dabarú	Pepper Doce
RIH26	Bairro Dabarú	Unknown
RIH27	Bairro Dabarú	Unknown
RIH28	Comunidade do Areial	Unknown
RIH29	Bairro Dabarú	Murupizão
RIH30	Bairro da Praia	Pimenta de cheiro
RIH31	Bairro Dabarú	Unknown
RIH32	Bairro Dabarú	Unknown
RIH33	Bairro Dabarú	Unknown
RIH34	Bairro Tirirical	Unknown
RIH35	Bairro Dabarú	Unknown
RIH36	Bairro da Praia	Unknown
RIH37	Bairro Areial	Malaguetinha
RIH38	Bairro Areial	Unknown

Rows were spaced 1.0 m and plants 0.5 m apart; six plants were sown per accession. The common cultural treatments for the crop were used during cultivation (Pinto et al. 2007).

Fifty-one descriptors, established by the International Plant Genetic Resources Institute (IPGRI) for the genus *Capsicum* (IPGRI 1995), were used with slight modifications. The seedling traits were: 1) hypocotyl color; 2) hypocotyl pubescence; 3) color of the cotyledon leaf and 4) cotyledon leaf shape. The following plant and stem traits were analyzed: 5) stem color*; 6) presence of nodal anthocyanin (on the whole adult plant); 7) stem shape; 8) stem pubescence (of the adult plant, except for the first two nodes below the crown); 9) plant height* in cm (at fruit maturation); 10) plant growth habit (with 50% mature fruits); 11) canopy length / crown width in cm (immediately after the first harvest at the widest point of the crown); 12) branching density; 13) tillering below the first bifurcation and 14) foliation density. The leaves were evaluated when 50% of the fruits were ripe, considering the following traits: 15) leaf color; 16) leaf shape; 17) sheath margin; 18) leaf pubescence; 19) length of the mature leaf in cm (leaves taken from the main branches); 20) width of mature leaf in cm (measurement at widest leaf part). Fully opened flowers were evaluated, considering the following traits: 21) days to flowering* (period from sowing to the opening of the first flower in 50% of the plants, in days); 22) number of flowers per axil*; 23) flower position at anthesis; 24) corolla color*; 25) corolla shape; 26) anther color* (observed in the bud, before anthesis); 27) filament color (at anthesis); 28) stigma position in relation to the anther (at full anthesis); 29) calyx pigmentation; 30) calyx margin and 31) annular constriction of the calyx.

The fruits were evaluated in the first harvest for the following traits: 32) days to fruit set* (from transplanting until fruit maturation in the first and second bifurcation in 50% of the plants); 33) spots or stripes of anthocyanin (before maturation); 34) fruit color in the intermediate stage* (shortly before maturation); 35) fruit position; 36) duration of the fruit set (period in days, from the first to the last harvest); 37) mature fruit color*; 38) fruit shape*; 39) fruit length* in cm (evaluated in the second harvest); 40) fruit width* in cm (measurement at the widest part of the fruit, in the second harvest); 41) fruit weight* in g (evaluated at the second harvest); 42) peduncle length in cm (evaluated

at the second harvest); 43) fruit shoulder at the pedicel insertion; 44) "neck" at the fruit base*; 45) shape of fruit tip; 46) appendix on the fruit tip; 47) transversal fruit section (1/3 of the end of the pedicel); 48) fruit surface*; 49) persistence of mature fruit on the pedicel and 50) pungency*. Of the seed traits only 51) seed color* was considered.

Variability was found in the collection for the values of the 17 starred descriptors, defined as essential by the IPGRI (1995). The descriptors with measurement units were considered quantitative continuous and the other categorical, including the dichotomic and multicategorical descriptors in the latter group.

All descriptors were used for the characterization of the accessions. In the analysis of the relative contribution of traits and in the evaluation of the genetic diversity only the 17 essential descriptors were considered.

The relative contribution of the traits was estimated by the method of Singh (1981), based on Mahalanobis' generalized distance, using software Genes (Cruz 2006). In the study of genetic diversity the similarity in the accessions was computed using the general similarity coefficient of Gower (Gower 1971, Sneath and Sokal 1973). A dendrogram was constructed, based on the similarity matrix, using the UPGMA method as grouping criterion. The dispersion diagram of the accessions was also analyzed based on the method of principal coordinate analysis (PCO) (Gower 1966, Dias 2006). All analyses were performed using the Multi-Variate Statistical Package (MVSP v.3.13; <http://www.kovcomp.com/mvsp>).

RESULTS AND DISCUSSION

For only eight of the 51 descriptors (leaf shape, corolla color, corolla shape, calyx pigmentation, annular constriction of the calyx, days to fructification, duration of fructification and seed color) no variation was observed, i.e., the genetic variability in the study collection is remarkable.

Based on the traits analyzed, mainly flower traits, the most important for species identification, the 38 accessions belong to the species *Capsicum chinense*. The seeds of all accessions were yellow; calyx with annular constriction; corolla of yellow-greenish color; anther color varying from yellow (31.6% of the accessions) to light blue (3% of the accessions), purple

(47% of the accessions), and yellow with blue spots (18.4%). Besides, two or more flowers per node were observed; in some accessions the number of flowers per node was variable, but never less than two flowers per node in all nodes.

In the evaluation of the accessions for fruit traits, the predominance of certain classes or values was observed, such as dark red color of mature fruit (42.0%), elongated fruits (36.8%) and triangular fruits (42.1%), fruit length between 2.0 and 4.0 cm (39.5%) and 4.0 and 8.0 cm (39.5%), fruit width between 1.0 and 2.5 cm (44.7%), fruit weight of over 27 and less than 81 g (89.4%), wrinkled fruit surface (42.1%), fruit persistence on the pedicel (73.7%) and hanging fruit position (68.4%).

Seven different fruit colors were identified in the intermediate maturation stage and nine in the mature stage, four fruit shapes and great variation in fruit size and weight. In terms of pungency, only three non-pungent accessions were identified since the study focused on the pungent accessions of the collection. Of the 38 accessions, 5.3% had yellow/lime, 15.8% yellow/orange, 5.3% orange, 18.5% red, 42.0% dark red, 2.6% purple, yellow and pale yellow and 5.3% salmon mature fruits. The fruit shape of 36.8% of the accessions was elongated, 7.9% rounded, 42.1% triangular and 13.2% bell-shaped. The great genetic variability evidenced in the diversity of fruit colors and shapes is inherent to the species *C. chinense* (Carvalho et al. 2003, Lannes et al. 2007).

Great variation was observed in fruit size: fruits with up to 1 cm (2.6%), between 1 and 2 cm (15.8%), between 2 and 4 cm (39.5%), between 4 and 8 cm (39.5%), between 8 and 12 cm (12.6%). Three classes of fruit width were verified: 29% of the accessions below 1 cm, 44.7% between 1 and 2.5 cm and 26.3% over 2.5 cm. The fruit weight of the accessions varied from 3 to 9 g (5.3%), 9 to 27 g (5.3%) and 27 to 81 g (89.4%). The fruit surface was either smooth (10.5%), half-wrinkled (31.6%), wrinkled (42.1%) or smooth and striped (15.8%). In 73.7% of the accessions the fruits were persistent on the pedicel, while in 23.7% and 2.6% of the accessions the fruits were little and moderately persistent, respectively. The fruit position of 68.4% of the accessions was hanging, in 2.6% intermediate, in 18.4% upright, in 2.6% intermediate and upright and in 2.6% all positions were found.

The persistence of the mature fruits on the pedicel is an important agronomic trait when accessions are selected for the development of pepper populations and lines (Reifschneider 2000). The genetic improvement aiming at pepper varieties for cultivation under the open sky should breed moderately persistent fruits that do not easily drop by wind and rain, but do drop easily at harvest. Only one accession of the collection (RIH10) was moderately persistent.

Among the 38 accessions the morphotype were represented as follows: three peppers of olho-de-peixe (7.9%), three of passarinho (7.9%), four dedo-de-moça (10.5%), four curabiá (10.5%), nine murupi (10.5%) and 15 pimenta de cheiro (39.5%), in other words, the pepper morphotypes of the species *Capsicum chinense* native to the region of the upper Rio Negro are well represented. The pepper dedo-de-moça was identified as a morphotype of the species *C. baccatum*. However, due to the similarity of the fruits, the same denomination was given to *C. chinense* accessions of the collection analyzed, since this is the popular name of this pepper morphotype at the collection sites (Reifschneider 2000, Barbosa et al. 2002, Carvalho et al. 2003).

In the trait weight analysis it was found that of the 17 essential descriptors, the trait plant height contributed least to genetic diversity (4.01%). The trait days to flowering contributed second least (5.92%) and the trait "neck" at the fruit base contributed most (9.11%).

The dissimilarity values in the 38 accessions studied varied from 0.07 to 0.93, indicating that the collection contained neither totally similar nor totally different accessions, in relation to the 17 traits used in the estimation of the dissimilarity measurement. The Amazon region is assumed as the main center of diversity of the species (IPGRI 1995), and our results demonstrate the great genetic variability in the germplasm of *Capsicum chinense* in the region of the upper Rio Negro in the Amazon. According to the measurements of genetic similarity there are no redundant accessions in the collection, indicating the importance of the maintenance of all accessions analyzed.

Based on the similarity coefficients between the pairs of accessions the dendrogram was obtained (Figure 1). The grouping was compared with the pepper morphotypes and the locations of origin of the accessions. The provenance was not related with the

grouping, besides, no strong relation between the pepper morphotype and the grouping of the accessions was verified. Only peppers of the murupi morphotype were grouped in the dendrogram, and of the nine accessions of this morphotype only one was not included in the group with the others.

The diagram of distances between accessions along two Cartesian axes based on the principal coordinate analysis (PCO) is shown in Figure 2. The concordance with the results by the UPGMA method was verified, considering the most and least similar accessions, with the projection of these accessions in a bidimensional space by the PCO. As mentioned above, the PCO allowed a clearer and simpler way of visualizing the morphotype groups of the collection.

The dispersion diagram showed that the dispersion area of accessions of pimenta de cheiro was greatest, evidencing higher genetic variability in this morphotype than in the others, although one must take into account that this morphotype was most frequent in the collection (15 accessions).

The area of concentration of the murupi morphotype accessions was rather distant from the other morphotypes, with exception of accession RIH22, which again, as in the dendrogram, was closer to pimento-de-cheiro accessions. This accession is the only of the murupi morphotype with triangular fruit (predominant shape of pimento-de-cheiro accessions) and red color when ripe.

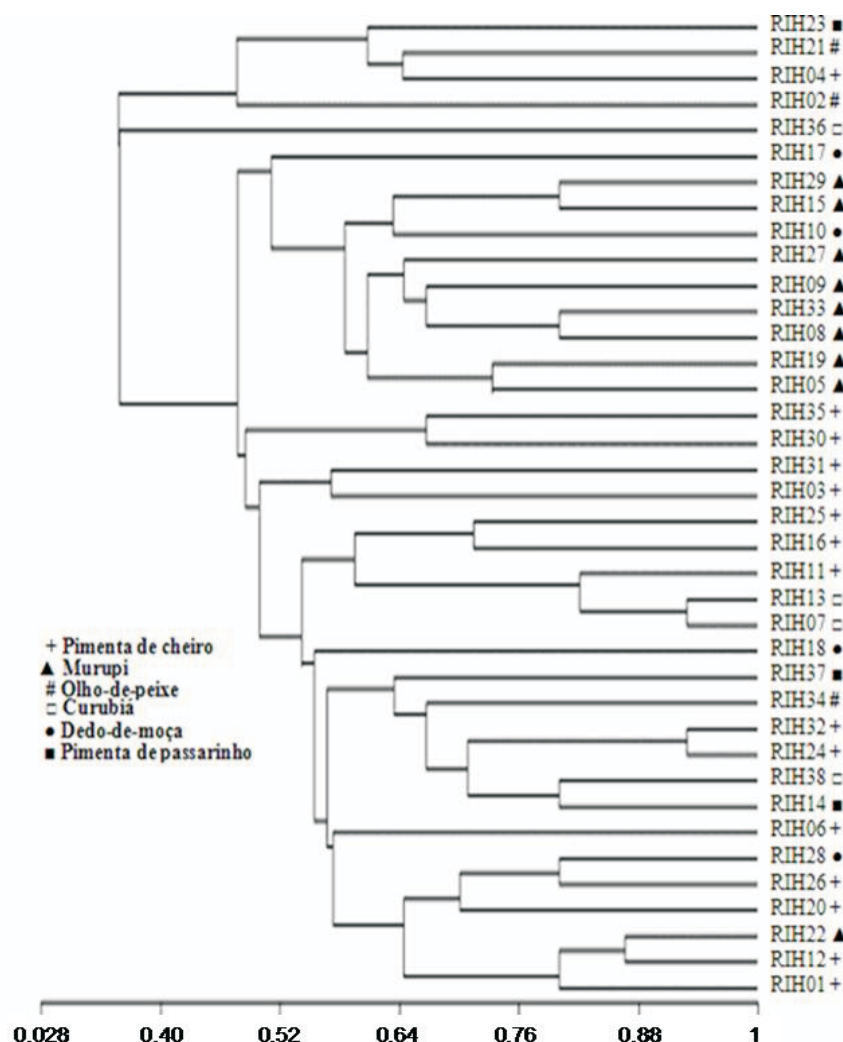


Figure 1. Hierarchical clustering (UPGMA) of 38 *Capsicum chinense* accessions of the *Capsicum* genebank of the Faculdade de Ciências Agrárias of the Universidade Federal do Amazonas

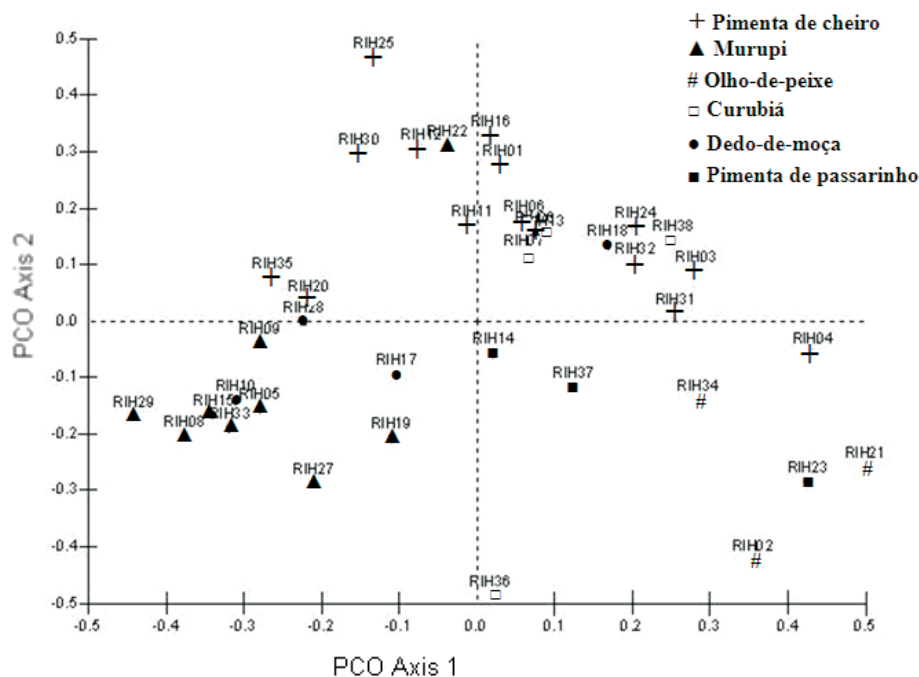


Figure 2. Dispersion diagram of 38 *Capsicum chinense* accessions of the *Capsicum* genebank of the Faculdade de Ciências Agrárias of the Universidade Federal do Amazonas, by the method of principal coordinate analysis (PCO) on the first two axes

Three of the four of dedo-de-moça accessions are located in the area of concentration of the murupi accessions. Similar to the morphotype murupi, they have elongated fruits; only accession RIH18 with triangular-shaped fruit is somewhat distant from the others, located near pimenta de cheiro and curubiá.

The curubiá accessions are concentrated in the area that includes the scattered cheiro pepper accessions, with exception of RIH36, which is more distant from the other accessions of the collection, coherently with the similarity coefficients and the hierarchical UPGMA grouping. The location of the curubiá accessions indicates genetic similarity with pimenta de cheiro.

The accessions of passarinho and olho-de-peixe pepper were scattered in another area than the other morphotypes. Despite the low representation in the collection (three accessions per morphotype), they are genetically divergent.

CONCLUSIONS

The genetic variability in the collection of *Capsicum chinense* accessions of the Faculdade de

Ciências Agrárias of the Universidade Federal do Amazonas is pronounced in plantlet, leaf, flower and fruit traits.

Six different pepper morphotypes were identified in this collection; olho-de-peixe, murupi, dedo-de-moça, pimenta-de-cheiro, pimenta-de-passarinho and curubiá.

The pimenta-de-cheiro most frequently found and their genetic variability in the collection is the greatest.

The genetic variability verified indicates a wide diversity of pepper morphotypes of the species *C. chinense* in the region of the upper Rio Negro.

The analysis of genetic similarity shows that the accessions are all morphologically distinct and should be maintained in the collection to preserve the genetic variability.

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Caracterização morfológica e diversidade genética de acessos de *Capsicum chinense* Jacq. do Alto Rio Negro - Amazonas

RESUMO – A diversidade genética de 38 acessos do gênero *Capsicum* da região do Alto Rio Negro no Amazonas foi caracterizada com o uso de 51 descritores morfológicos. Utilizando-se 17 descritores essenciais foram calculadas as similaridades entre os acessos usando-se o coeficiente de similaridade geral de Gower. Análises de agrupamento e dispersão gráfica dos acessos foram realizadas com base nos coeficientes de similaridade utilizando como critério de agrupamento e dispersão os métodos do UPGMA e da análise de coordenadas principais (PCO), respectivamente. As características de fruto apresentaram grande variação de classes. Foram identificadas nove cores, quatro formas e grande variação no tamanho e peso dos frutos. Apenas três acessos não apresentaram pungência em função do trabalho ter sido direcionado para os acessos pungentes da coleção. Foram identificadas três pimenteiras do morfotipo olho-de-peixe, três passarinho, quatro dedo-de-moça, quatro curabiá, nove murupi e 15 pimentas de cheiro.

Palavras-chave: pimentas, recursos genéticos, germoplasma.

REFERENCES

- Andrews J (1984) **Peppers: the domesticated *Capsicum***. University of Texas Press, Austin, 170p.
- Arriel NHC, Di Mauro AO, Arriel EF, Unêda-Trevisoli SH, Costa MM, Bárbaro IM and Muniz FRS (2007) Genetic divergence in sesame based on morphological and agronomic traits. **Crop Breeding and Applied Biotechnology** 7: 253-261.
- Barbosa RI, Luz FJF, Nascimento Filho HR and Maduro CB (2002) Pimentas do gênero *Capsicum* cultivadas em Roraima, Amazônia Brasileira. I. Espécies domesticadas. **Acta Amazonica** 32: 177-192.
- Buso GSC, Amaral ZPS, Machado FRB, Bem L and Ferreira ME (2003) Variabilidade genética e análise filogenética de análise de espécies brasileiras de pimenta e pimentão (*Capsicum* spp.). In: **II Congresso Brasileiro de Melhoramento de Plantas**. SBMP, Porto Seguro, CD-ROM.
- Carvalho SIC, Bianchetti LB, Bustamante PG and Silva DB (2003) **Catálogo de germoplasma de pimentas e pimentões (*Capsicum* spp.) da Embrapa Hortaliças**. Embrapa, Brasília, 49p.
- Carvalho SIC, Bianchetti LB and Bustamante PG (2001) Conservação e Caracterização da Coleção de Germoplasma de *Capsicum* da Embrapa Hortaliças. In: **LII Congresso Nacional de Botânica**. SBB, João Pessoa, p.312-312.
- Cruz CD (2006) Programa GENES – **Análise Multivariada e Simulação**. Editora UFV, Viçosa, 285p.
- Dias LAS (2006) Análises multidimensionais. In: Alfenas AC. (Org.) **Eletroforese e marcadores bioquímicos em plantas e microrganismos**. Editora UFV, Viçosa, p. 405-475.
- Gower JC (1966) Some distance properties of latent root and vector methods used in multivariate analysis. **Biometrika** 53: 325-338.
- Gower JC (1971) A general coefficient of similarity and some of its properties. **Biometrics** 27: 857-874.
- IPGRI (1995) **Descriptors for *Capsicum* (*Capsicum* spp.)**. International Plant Genetic Resources Institute, Rome, 49p.
- Lannes SD, Finger FL, Schuelter AR and Casali VWD (2007) Growth and quality of Brazilian accessions of *Capsicum chinense* fruits. **Scientia Horticulturae** 112: 266-270.
- Moreira GR, Caliman FRB, Silva DJH and Ribeiro CSC (2006) Espécies e variedades de pimenta. **Informe Agropecuário** 27: 16-29.
- Pickersgill B (1971) Relationship between weedy and cultivated forms in some species of chilli peppers (Genus *Capsicum*). **Evolution** 25: 683-691.
- Pinto CMF, Caliman FRB, Moreira GR, Mattos RN, Rocha PRR, Venzon M and Paula Júnior, TJ (2007) Pimenta (*Capsicum* spp.). In: Paula Júnior TJ and Venzon M. (eds.) **101 Culturas: manual de tecnologias agrícolas**. EPAMIG, Belo Horizonte, p. 625-632.
- Reifschneider FJB (2000) ***Capsicum*: pimentas e pimentões no Brasil**. Embrapa, Brasília, 113p.
- Ribeiro CSC (2004) Pesquisas com *Capsicum* na Embrapa. In: **I Encontro Nacional do Agronegócio de Pimentas (*Capsicum* spp.)**. I Mostra Nacional de Pimentas e Produtos derivados. EMBRAPA, Brasília, CD-ROM.
- Rufino JLS and Pentelado DCS (2006) Importância econômica, perspectivas e potencialidades do mercado para pimenta. **Informe Agropecuário** 27: 7-15.

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Silva Filho DF, Pessoa Filho MACP and Cunha RMS (2001) Grau de variabilidade genética em acessos de *Capsicum* spp. (Solanaceae) através de RAPD: Resultados preliminares. In: **LII Congresso Nacional de Botânica**. SBB, João Pessoa, p. 312-312.

Singh D (1981) The relative importance of characters affecting genetic divergence. **Indian Journal of Genetics and Plant Breeding** **41**: 237-245.

Sneath PEA and Sokal R (1973) **Numerical Taxonomy**. Freeman, San Francisco, 573p.

Viana AP, Pereira TNS, Pereira MG, Souza MM, Maldonado JFM and Amaral Júnior AT (2006) Genetic diversity in yellow passion fruit populations. **Crop Breeding and Applied Biotechnology** **6**: 87-94.