

HOT PEPPER (*Capsicum chinense*, Jacq.) INHERITANCE OF REACTION TO POWDERY MILDEW

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ABSTRACT: The pepper species *C. chinense* has been considered one of the most important resistance sources to powdery mildew *Capsicum* spp. However, the inheritance in this species was unknown. The purpose of this work was to study its reaction inheritance. Two powdery mildew resistant parents, 'Pimenta Cheiro' 1 and PI 152225 and two moderately susceptible ones, 'Pimenta Doce' IH-1761 and 'Pimenta Índio', were used to obtain three F₁ and their respective F₂ generations: 'Pimenta Doce' IH-1761 × 'Pimenta Cheiro' 1, 'Pimenta Índio' × PI 152225 and 'Pimenta Doce' IH-1761 × PI 152225. The powdery mildew epidemic was natural using inoculum from a highly-sporulating susceptible pepper host. Powdery mildew host reaction evaluations were carried out during the fruiting stage using a rating system based on disease severity scales varying from 1 (resistant) to 5 (highly susceptible). The experimental design was completely randomized. The following genetic parameters were estimated: gene action, heritability coefficient and expected selection gain in the F₃ generation. The transgressive segregation in F₂ indicated oligogenic inheritance. Results show the presence of additive, dominant, and epistatic gene action. The dominant and epistatic effects detected in crosses presented negative values, tending towards susceptibility. The heritability and selection gain estimates were moderate, with values of 35.5% and 1.7% for 'Pimenta Doce' IH 1761 × 'Pimenta Cheiro' 1, from 50.4% to 3.5% for 'Pimenta Índio' × PI 152225, and 49% and 2.7% for the 'Pimenta Doce' IH 1761 × PI 152225 crosses, respectively. These gene action results are favorable for breeding programs and exploration of hybrids.

Key words: *Leveillula taurica* (LEV.) Arn., *Capsicum chinense*, genetic resistance, gene action

HERANÇA DA REAÇÃO AO OÍDIO EM PIMENTA (*Capsicum chinense*, Jacq.)

RESUMO: A espécie de pimenta *C. chinense* tem sido considerada uma das mais importantes fontes de resistência ao oídio, porém a herança dessa resistência ainda é desconhecida. O objetivo deste trabalho foi obter informações sobre a herança dessa reação. Dois progenitores resistentes, Pimenta Cheiro 1 e PI 152225 e dois moderadamente suscetíveis, Pimenta Doce IH-1761 e Pimenta Índio, foram utilizados na obtenção de três híbridos e respectivas gerações F₂: Pimenta Doce IH-1761 × Pimenta Cheiro 1, Pimenta Índio × PI 152225 e Pimenta Doce IH-1761 × PI 152225. A epidemia de oídio ocorreu de maneira natural a partir de inóculo mantido em plantas de pimentão suscetíveis. As avaliações das reações ao oídio foram feitas na fase de frutificação, através de uma escala de notas de 1 (resistente) a 5 (altamente suscetível). O delineamento experimental utilizado foi inteiramente casualizado. Foram estimados: tipo de ação gênica, coeficiente de herdabilidade e ganho de seleção esperado em F₃. A segregação transgressiva em F₂ indicou que a herança é oligogênica e o tipo de ação gênica envolveu os componentes aditivos, dominantes e epistáticos. Os efeitos de dominância e epistasia detectadas nos cruzamentos se mostraram negativos para a suscetibilidade. Os valores de herdabilidade e ganho de seleção foram moderados, sendo de 35,5% e 1,7% para o cruzamento Pimenta Doce IH-1761 × Pimenta Cheiro 1, de 50,4% e 3,5% para Pimenta Índio × PI 152225 e de 49,0% e 2,7% para Pimenta Doce IH 1761 × PI 152225. Os resultados sobre ação gênica favorecem programas de melhoramento visando variedades híbridas.

Palavras-chave: *Leveillula taurica* (LEV.) Arn., *Capsicum chinense*, resistência genética, ação gênica

INTRODUCTION

Brazil is an important biodiversity center of domesticated hot pepper of the *Capsicum* genus. The vari-

ability of *C. chinense* is quite large, especially in the Amazon Valley and Northeastern part of Brazil (Bertão, 1993).

Among pepper diseases, powdery mildew caused by *Leveillula taurica* is a quite serious world-

wide pathogen of greenhouse crops. In Brazil it is an endemic disease especially under greenhouse conditions. Losses due to powdery mildew in sweet pepper can reach 75% (Daubeze et al., 1995). This disease is considered to be difficult to control. Systemic fungicides with specificity to powdery mildew have not been effective. Crop management methods like sprinkle irrigation, crop rotation, bicarbonate and monopotassium phosphate could minimize powdery mildew damage. The best control practice would be by resistant varieties. Heredity studies of *C. annuum* showed that resistance to powdery mildew is controlled by three genes with additive as well as epistatic effects (Shifriss et al., 1992, Daubeze et al., 1995, Blat et al., 2005b). Murthy & Deshpande (1997) found resistance to be dominant and polygenic. Lima (2002) found higher occurrence of *C. baccatum*, *C. chinense*, and *C. frutescens* accessions resistant to powdery mildew while in *C. annuum* no typically susceptible accession was found. Most of *C. chinense* reaction to powdery mildew was highly resistant, like 'Pimenta Peixe-de-boi', or resistant like 'Pimenta Olho de Ganso', 'Pimenta de Cheiro', 'Pimenta do Maranhão', and 'Pimenta Picante'. The only moderately resistant accessions found were 'Pimenta' and 'Pimenta de Cheiro'.

According to Blat et al. (2005a), Lima (2002), and Souza & Café-Filho (2003) the best resistance sources were found in the species *C. chinense* and no susceptible accessions were found. Therefore, inheritance in this species and its resistance reaction mechanism and expression are unknown. This paper tries to elucidate the resistance reaction of *C. chinense* to powdery mildew.

MATERIAL AND METHODS

Two powdery mildew-resistant parents, 'Pimenta Cheiro' 1 and PI 152225, and two moderately susceptible ones, 'Pimenta Doce' IH-1761 and 'Pimenta Índio', were used to obtain three hybrids and their respective F_2 generations: 'Pimenta Doce' IH-1761 \times 'Pimenta Cheiro', 'Pimenta Índio' \times PI 152225, and 'Pimenta Doce' IH-1761 \times PI 152225. These hybrids were meant for the study on the genetic basis of resistance. The 'Pimenta Índio' \times PI 152225 hybrid was autopollinated and also backcrossed to its PI 152225 resistant parent to increase gene resistance and to elucidate the powdery mildew resistance reaction.

The experiment was carried out using a plastic high tunnel in Piracicaba, SP, Brazil (22°42'30" S 47°38'00" W, at an elevation of 546 meters). The powdery mildew epidemic occurred naturally. The initial in-

oculation was obtained and maintained via susceptible sweet pepper plants with a high degree of sporulation. Plants that disseminated the pathogen were intercalated at a ratio of one susceptible plant to each fifteen tested accessions.

Seedlings were transplanted into eight-liter pots containing a plant substrate from Multiplanta® consisting of: Pinus bark, vermiculite, peat, macro and micro fertilizers, and Humix, plus 5% sand. The experimental design was completely randomized with five plants per pot and 13 treatments, as follows: three hybrids, three F_2 populations, four parents, one backcross, and two susceptible checks, totaling 2,098 plants.

Powdery mildew reaction evaluations were made at fruit development, 116 days after seeding. A rating scale was used according to affected leaf area, proposed by Ullasa et al. (1981), where: 1 – resistant, no symptoms, 2 – moderately resistant, with 10% of the leaf area affected; 3 – moderately susceptible, with 11-20% of the leaf area affected; 4 – susceptible, with 21-50% of the leaf area affected and 5 – highly susceptible, with 51% or more of the leaf area affected. Hybrids 'Margarita' and 'Magali' R were used as susceptible checks, while variety HV-12 and line PI 152225 were used as resistant checks. Populations were evaluated when reference check plants achieved a maximum score of 5.

The following estimates were obtained: (a) type of gene action, using the additive-dominant and epistatic model in accordance to Mather & Jinks (1981), with significance verified by the t test according to Gomes (1990); (b) broad sense heritability coefficient (h^2), and (c) selection gain (Gs) expected in F_3 according to Vencovsky & BARRIGA (1992). The broad sense heritability coefficient was employed to predict the expected gain from selection (Gs) in F_3 , and was adequate in cases of absence of dominance. With any evidence of dominance, the Gs value is overestimated, serving only as a reference.

RESULTS AND DISCUSSION

As mentioned, *C. chinense* is considered a resistance good source and Blat et al. (2005a) found that 85% of all examined accessions a collection were highly resistant, without typical susceptible plants like in *C. annuum*. Few accessions were identified as moderately susceptible, such as 'Pimenta Doce' IH-1761 and 'Pimenta Índio'. These presented scores between 2 and 3, with average values of 2.56 and 2.63, respectively (Tables 1 and 2) and had different reactions in comparison with those identified in *C.*

annuum. In others words, the susceptibility reaction of *C. annum* is much more severe to powdery mildew than that of the *C. chinense* genetic background (Blat et al., 2005a).

An interesting reaction expression of *C. chinense* was defoliation, observed even in resistant accessions. Lima (2002) also observed this phenomenon in *C. chinense*, *C. baccatum*, and *C. frutescens*. This author explained the defoliation reaction expression as being due to a phenological characteristic and to temperature and humidity variations. This defoliation reaction of a resistant in accesses *C. chinense* can be explained as a host hypersensitivity due to high pathogen pressure (Carver et al., 1995). Under low powdery mildew pressure, the source of *C. chinense* resistance shows more intense leaf retention.

The F_1 generation means from the cross between resistant and susceptible parents ranged from 1 to 2, indicating resistance. These F_1 means were specifically as follows: 1.74 for the 'Pimenta Doce' IH 1761 \times 'Pimenta Cheiro' 1 hybrid; 1.73 for 'Pimenta Indio' \times PI 152225, and 1.18 for 'Pimenta Doce' IH 1761 \times PI 152225, which was the lowest mean. For the corresponding F_2 generations, the reactions means of disease severity were also low, at 1.47, 1.56, and 1.43, respectively. In these segregating generations plants with scores of 3 and 4 were quite rare, occurring with frequencies of 4.0%, 6.6%, and 4.8%, re-

spectively. No plants with a score of 5 were found. Heterosis estimates indicated that the inheritance of the reaction to powdery mildew is dominant towards resistance. Dominance epistatic effects were detected in all crosses, acting to increase resistance, in comparison with the expected under an additive-dominant model. These results are favorable for programs for hybrid variety exploration.

Significant epistatic effects were found in the ('Pimenta Indio' \times PI 152225) \times PI 152225 backcross, confirming the F_2 results. In fact, the F_2 mean found was 1.56, while the backcross mean was 1.32, with a 2.9% increase in plants with scores 1 and 2 (Tables 1 and 2).

Transgressive segregants observed in the F_2 populations can be considered an evidence that the reaction of *C. chinense* to powdery mildew is of an oligogenic nature. In fact, plants with scores of up to 4 were found within all three segregating generations; this value is beyond the parental scores of 1 (resistant) and 3 (susceptible) (Table 1).

Estimates for broad sense heritability and expected gain from selection were moderate, 35.5% and 1.7% for the segregating generation of 'Pimenta Doce' IH 1761 \times 'Pimenta Cheiro' I, 50.4% and 3.5% for 'Pimenta Indio' \times PI 152225, and 49.0% and 2.7% for 'Pimenta Doce' IH 1761 \times PI 152225, respectively (Table 2).

Table 1 - Number of segregating plants of *Capsicum chinense* for reaction to *Leveillula taurica* under greenhouse conditions, using a disease severity rating scale, Piracicaba, 2003.

| Generation | | R | MR | MS | S | AS |
|--|-------|---------|---------|---------|---------|---------|
| | | Score 1 | Score 2 | Score 3 | Score 4 | Score 5 |
| 'Pimenta Cheiro' 1 | PR | 30 | 25 | 0 | 0 | 0 |
| PI 152225 | PR | 38 | 12 | 0 | 0 | 0 |
| 'Pimenta Doce' IH-1761 | PMS | 0 | 24 | 31 | 0 | 0 |
| 'Pimenta Índio' | PMS | 0 | 22 | 38 | 0 | 0 |
| HV-12 | TR | 40 | 0 | 0 | 0 | 0 |
| 'Magali' R | TS | 0 | 0 | 0 | 0 | 40 |
| 'Margarita' | TS | 0 | 0 | 0 | 0 | 40 |
| 'Pimenta Doce' IH-1761 \times 'Pimenta Cheiro' 1 | F_1 | 13 | 37 | 0 | 0 | 0 |
| | F_2 | 298 | 203 | 19 | 2 | 0 |
| 'Pimenta Índio' \times PI 152225 | F_1 | 15 | 40 | 0 | 0 | 0 |
| | F_2 | 277 | 227 | 31 | 5 | 0 |
| | RC | 76 | 26 | 4 | 0 | 0 |
| 'Pimenta Doce' IH-1761 \times PI 152225 | F_1 | 45 | 10 | 0 | 0 | 0 |
| | F_2 | 291 | 156 | 21 | 2 | 0 |

PR - resistant parent, PMS - moderately susceptible parent, TS - susceptible checks, TR - resistant check, RC - resistant parental backcross. R - resistant, MR - moderately resistant, MS - moderately susceptible, S - susceptible, AS - highly susceptible.

Table 2 - Number of plants (n) and mean disease severity scale estimates, respective variances, heritability (h^2), heterosis (H and H%), and epistasis (C) with significance by the t test and expected selection gain in F_3 (Gs) for *Capsicum chinense*, Piracicaba 2003.

| Generation | | n | Means | Variances | H ^{a,b} | Gs ^b | H ^a | | C ^a |
|---|----------------|-----|-------|-----------|------------------|--------------------|----------------|-------|----------------|
| | | | | | | | % | | |
| 'Pimenta Cheiro' 1 | PR | 55 | 1.45 | 0.252 | | | | | |
| PI 152225 | PR | 50 | 1.24 | 0.186 | | | | | |
| 'Pimenta Doce' IH-1761 | PMS | 55 | 2.56 | 0.250 | | | | | |
| 'Pimenta Índio' | PMS | 60 | 2.63 | 0.236 | | | | | |
| HV-12 | TR | 40 | 1.00 | 0.000 | | | | | |
| Magali R | TS | 40 | 5.00 | 0.000 | | | | | |
| Margarita | TS | 40 | 5.00 | 0.000 | | | | | |
| 'Pimenta Doce' IH-1761 × 'Pimenta Cheiro' 1 | F ₁ | 50 | 1.74 | 0.196 | | | -0.26*** | -13.0 | |
| | F ₂ | 522 | 1.47 | 0.346 | 35.5 | -1.70 [▲] | | | -0.40*** |
| 'Pimenta Índio' × PI 152225 | F ₁ | 55 | 1.73 | 0.202 | | | -0.20*** | -10.4 | |
| | F ₂ | 540 | 1.56 | 0.417 | 50.4 | -3.53 [▲] | | | -0.27*** |
| | RC | 106 | 1.32 | 0.296 | | | | | |
| 'Pimenta Doce' IH-1761 × PI 152225 | F ₁ | 55 | 1.18 | 0.151 | | | -0.72*** | -37.9 | |
| | F ₂ | 470 | 1.43 | 0.361 | 49.0 | -2.73 [▲] | | | -0.11*** |

[▲]Gain of overestimated selection, calculated with h^2 in a broad sense. PR - resistant parent, PMS - moderately susceptible parent, TR - resistant checks; TS - susceptible checks, RC - Resistant parental backcross. ^aIn accordance with Mather and Jinks, (1981). ^bIn accordance with Vencovsky and Barriga (1992). ***Significance based on the t test at 0.1% probability

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