Crop Protection 52 (2013) 10–13

Contents lists available at SciVerse ScienceDirect

Crop Protection

journal homepage: www.elsevier.com/locate/cropro

Resistance to gummosis in wild cashew genotypes in northern Brazil

R.C. Moreira, J.S. Lima, L.G.C. Silva, J.E. Cardoso*

Embrapa Agroindústria Tropical, Rua Sara Mesquita, 2270, CEP 60 511-110 Fortaleza, CE, Brazil

ARTICLE INFO

Article history:
Received 9 February 2012
Received in revised form
10 October 2012
Accepted 24 April 2013

Keywords:
Anacardium occidentale
Lasiodiplodia theobromae
Disease reaction
Clone

ABSTRACT

Gummosis disease (*Lasiodiplodia theobromae*) is the most limiting problem for cashew production in semi-arid northeastern Brazil; nevertheless, there is no efficient method of control other than genetic resistance. Although genetically improved dwarf clones with a high resistance have been released, there is still a need for sources of resistance in wild common cashew populations. The reactions to gummosis disease of twenty cloned wild cashew genotypes were evaluated during seven consecutive years in a commercial orchard located in an area under high disease pressure in semi-arid northeast Brazil. The disease incidence and severity (0 to 4 severity scale) were assessed at 4-month intervals, and the area under the disease progress curve was estimated for each genotype. The first gummosis symptom was observed after twelve months of planting. The disease progressed very rapidly after twenty months in most of the genotypes, but three of them showed resistance. The area under the disease progress curve was found to be a good parameter to differentiate among the genotype reactions. A significant correlation between the disease incidence and severity was detected upon Pearson coefficient analyses. This is the first report on screening wild-common cashew genotypes for the resistance to gummosis.

1. Introduction

The cashew industry, accounting for the largest share of the northeastern Brazilian economy, is one of the main sources of income and labor in rural areas, and cashew cultivation is expanding from the coastal zone into the semi-arid hinterland, an area that is very well suited for both nut and apple production. However, this semi-arid climate in Brazil is characterized by a very low rainfall (<350 mm/year), a high daylight temperature (30–35 °C) with cool nights (18–23 °C), and a low relative humidity, conditions that impose stress on cashew plants. However, as this region is regarded as the center of origin of cashew species (Barros, 1995), the plant is well adapted to this environment.

Cashew gummosis, caused by *Lasiodiplodia theobromae*, is the most important disease of cashew plants in the semi-arid conditions of northeastern Brazil. Gummosis infection in cashew plants typically presents as dark cankers spread throughout the trunk or woody branches that occasionally crack and ooze a transparent resin-like gum. These symptoms can only be observed after the second year when woody tissues are present (Cardoso et al., 2004); eventually, branch dieback occurs (Freire et al., 2002). The damage from gummosis is caused by reduction of water and nutrient transport, destruction of branches, reduction of photosynthesis, dieback, and plant death (Bezerra et al., 2003). Severe outbreaks of gummosis have been reported as a result of the conducive environmental conditions and expansion of the area with the susceptible dwarf clone CP 76 (Freire, 1991; Freire et al., 2002).

Disease dissemination is proposed to occur through asymptomatic infected transplants (Cardoso et al., 2009; Freire and Cardoso, 1997); dissemination of the Botryosphaeriaceae, including *Lasiodiplodia theobromae*, can also occur via grafting shears and pruning tools (Fourie and Halleen, 2004; Cysne et al., 2010).

There are a number of strategies that provide control for these fungi, such as sanitation throughout cultivation of the crop (Michailides and Morgan, 2004), the removal of potential competing plants (Swart and Wingfield, 1991), and the application of fungicides (Cysne et al., 2010). However, these methods are presently impractical and economically unrealistic, and the only feasible method of controlling gummosis in the present situation is through disease resistance (Cardoso et al., 2006). However, to date, only two commercial clones have been reported to be resistant to gummosis (Cardoso et al., 2006). The variability of wild cashew plants under the conditions of northeastern Brazil has been demonstrated using molecular markers (Cavalcanti, 2004).

The objective of this work was to evaluate the responses of selected, cloned wild plants of common cashew to gummosis under highly selective disease pressure.

* Corresponding author. Tel.: +55 85 3391 7357; fax: +55 85 3391 7109.
E-mail address: emilson@cnpat.embrapa.br (J.E. Cardoso).

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http://dx.doi.org/10.1016/j.cropro.2013.04.008

2. Material and methods

Twenty wild plants of common cashew (Table 1) cloned by the cashew breeding program of Embrapa Agroindústria Tropical were selected and used in this study. Most of the plants (named CNPAT) were selected from 17 thousand hectares of seed-propagated plants at the commercial farm 'Planalto' where this study was conducted. This farm is located at 6°31′30 S latitude, 40°47′19 W longitude and 605 m elevation in Pio IX county, Piauí State. The soil description of the experimental area was Yellow Alic Latosol, pH 4.5. A high incidence of gummosis has been reported in the region (Cardoso et al., 1999, 2004, 2007). The experiment was established in February 2003 in two blocks of 200 plants each, spaced 10 m by 10 m apart. Each replication consisted of a row of ten plants of the same entry in each block. Disease assessments were performed by recording the gummosis incidence and severity at 4-month intervals, starting with the first detection. The data were recorded by incidence based on the presence of typical disease symptoms and by severity using an arbitrary numerical scale (Cardoso et al., 2006), as follows: 0 (no symptoms); 1 (small and few cankers on the trunk and branches, small cracks without gum exudation); 2 (larger, cracked cankers on the trunks and branches, reaching up to 1/3 of the diameter, with little or no gum exudation); 3 (cracked cankers on the trunks and branches, larger than 1/3 of the diameter, with abundant gum exudation); and 4 (cracked cankers completely girdling the trunk or branches, foliage yellowing, dieback and gum exudation). Both the incidence and severity were evaluated at the same time. The gummosis severity (GS) was estimated by the following equation: $GS = \sum(x_i n_i)/n$, where x represents the disease grade ($x = 1, 2, 3,$ and 4), n_i represents the number of diseased plants with an ith grade on the disease scale, and n is the total number of diseased plants evaluated. The gummosis incidence ($GI = x/N$)) was the proportion of the diseased plants, which consisted of the number of diseased plants (x) divided by the total number evaluated (N).

The experiment was arranged in a complete randomized design, with 20 treatments (cashew clones) and 20 plants per treatment. The disease data were collected from February 2004 to July 2010, for a total of 21 observations. The cropping practices were strictly based on the local grower's management, which included no fungicide application (Barros et al., 1984). The data were analyzed with standard analyses of variance by the date of assessment and pooled as a split plot design, with the date as the subplot, using the SISVAR (Sisvar 5.1 Build 72, Universidade Federal de Lavras, Lavras, Minas Gerais, Brazil) package. The GI values of each 4-month period were used to calculate the area under the gummosis progress curve (AUGPC) according to the following equation (Campbell and Madden, 1990):

$$AUGPC = \sum_{i}^{n-1}(y_i + y_{i+1})/2 \cdot (t_{i+1} - t_i)$$

where n is the number of evaluations, y is the GI value, and t is the number of 4-month periods. The AUGPC values were used to present the disease progress throughout the entire experiment. Both the GS and AUGPC values were used to examine the disease reactions among the treatments by applying the Scott–Knott test at $P < 0.05$. The Pearson coefficients for GI and GS were estimated.

3. Results

The first symptoms were observed at twelve months after planting (MAP) on clones FAGA 11, CNPAT 02, CNPAT 07, and CNPAT 10, whereas the disease could only be observed by 27 and 31 MAP on most of the clones. The last clone to show symptoms was CNPAT 06 after 35 MAP. Most of the tested clones showed a small number of healthy plants by the last evaluation (Table 2). Clones CNPAT 08, CNPAT 06, CNPAT 11, CNPAT 12 and CNPAT 13 reached 100, 95, 85, 75 and 70% gummosis incidence, respectively.

The plant mortality was very high after 92 months and, by this date, no healthy plants were found for clones CNPAT 05, CNPAT 07, CNPAT 09 or CNPAT 014, and Common 16, Common 21, FAGA 11 and CNPAT 15 showed the highest number of dead plants. CNPAT 07 and CNPAT 09 exhibited the highest percentage of maximum grades on the severity scale; therefore, these clones were the most susceptible.

As shown in Table 2, clones CNPAT 08, 06 and 11 showed the least percentage of diseased plants: zero, five and fifteen percent, respectively. Moreover, these clones demonstrated a very low percentage of plant death by the end of the study. When compared with the other clones, CNPAT 06 displayed desirable resistance traits.

Table 1
List of selected and cloned cashew plants used in this study.

Treatment number	Clone	Genotype origin
01	COMMON 5	MALVINAS 19 (Uruanã farm/CIONE)
02	COMMON 16	LAGOA NOVA 31 (CURVA Y) (Uruanã farm/CIONE)
03	COMMON 21	LINDOLFO 47 (Curva Y) (Uruanã farm/CIONE)
04	COMMON 31	238/4 – Selection from heterosis trial
05	FAGA 1	Garrote farm
06	FAGA 11	Garrote farm
07	CNPAT 02	Selection from Planalto farm/CIONE
08	CNPAT 03	Selection from Planalto farm/CIONE
09	CNPAT 04	Selection from Planalto farm/CIONE
10	CNPAT 05	Selection from Planalto farm/CIONE
11	CNPAT 06	Selection from Planalto farm/CIONE
12	CNPAT 07	Selection from Planalto farm/CIONE
13	CNPAT 08	Selection from Planalto farm/CIONE
14	CNPAT 09	Selection from Planalto farm/CIONE
15	CNPAT 10	Selection from Planalto farm/CIONE
16	CNPAT 11	Selection from Planalto farm/CIONE
17	CNPAT 12	Selection from Planalto farm/CIONE
18	CNPAT 13	Selection from Planalto farm/CIONE
19	CNPAT 14	Selection from Planalto farm/CIONE
20	CNPAT 15	Selection from Planalto farm/CIONE

Table 2
Summary of the gummosis severity in cashew clones at 92 months after planting (MAP).

Clone	Diseased plants (%)				Dead plants (%)	Healthy plants (%)
	Score 1	Score 2	Score 3	Score 4		
COMMON 5	5	15	35	25	10	10
COMMON 16	10	15	10	0	55	10
COMMON 21	15	0	0	5	40	40
COMMON 31	15	30	20	15	10	10
FAGA 1	15	0	5	25	15	40
FAGA 11	30	15	5	10	30	10
CNPAT 02	45	15	0	5	0	35
CNPAT 03	20	20	10	10	5	35
CNPAT 04	25	30	20	0	0	25
CNPAT 05	15	45	25	5	10	0
CNPAT 06	0	0	0	0	5	95
CNPAT 07	0	25	25	40	10	0
CNPAT 08	0	0	0	0	0	100
CNPAT 09	20	5	5	55	15	0
CNPAT 10	15	15	0	5	20	45
CNPAT 11	0	0	0	0	15	85
CNPAT 12	15	0	0	0	10	75
CNPAT 13	5	20	0	0	5	70
CNPAT 14	0	30	55	10	5	0
CNPAT 15	0	0	0	0	40	60