SEED GERMINATION OF THREE PINEAPPLE PROGENIES IN DIFFERENT TEMPERATURE REGIMES

Germinação de sementes de abacaxizeiro em diferentes regimes de temperatura

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Data do recebimento: 23/03/2015 - Data do aceite: 03/07/2015

RESUMO: Objetivou-se avaliar o melhor regime de temperatura para germinação de sementes de abacaxizeiro, em apoio ao programa de melhoramento genético desta fruteira. Foram utilizadas sementes obtidas do cruzamento entre as cultivares Perolera (PE) e Primavera (PRI) e dois retrocruzamentos: entre a cultivar BRS Imperial com a cultivar Smooth Cayenne (SC) e entre o híbrido selecionado PE x SC-60 e a cultivar Smooth Cayenne. As sementes foram submetidas à temperatura constante de 25°C e alternadas de 25-20, 30-20 e 35-25°C, com 14 horas de fotoperíodo. O delineamento experimental foi o inteiramente casualizado, num esquema fatorial 4x3, com quatro regimes de temperatura, três progênies e quatro repetições de 75 sementes. As sementes foram avaliadas duas vezes por semana, em intervalos de três ou quatro dias, quanto à percentagem e velocidade de germinação, contados a partir do vigésimo primeiro dia até 60 dias após a semeadura. Os resultados evidenciam que há diferenças de germinabilidade e velocidade de germinação entre as progênies e que a temperatura ótima para a germinação de sementes em todas as progênies é a temperatura constante de 25°C.

Palavras-chave: *Ananas comosus* var. *Comosus*. Abacaxi. Melhoramento genético. Temperatura ótima

ABSTRACT: Evaluation of best temperature regime for pineapple seed germination was the aim of this study, in support to pineapple breeding program. Seeds obtained from crosses between Perolera (PE) and Primavera cultivars and from two backcrosses: BRS Imperial x Smooth Cayenne (SC) and (PE x SC-60) hybrid x Smooth Cayenne, were used. Seeds were kept under constant temperature of 25°C and alternating 25-20, 30-20 and 35-25°C within a 14 hour photoperiod. Experimental design was completely randomized in a 4x3 factorial arrangement with four temperature regimes, three progenies with four replicates of 75 seeds. Seeds were assayed twice a week, in three or four day intervals to measure percentage and germination rate, ranging from twenty five to 60 days after sowing. Results show differences in percentage of seed germination and germination rate among progenies and optimum temperature for seed germination in all progenies is 25°C.

Keywords: *Ananas comosus* var. *Comosus*. Pineapple. Breeding. Optimum temperature

Introduction

Pineapple (*Ananas comosus* var. *comosus*) is a monocot, perennial herb within Bromeliaceae family. *A. comosus* is the most important species from an economic point of view, with four out of five botanical varieties cultivated for fruit, fiber or ornamentation consumption (COPPENS D'EECKENBRUGGE; LEAL, 2003). Amazon region has harbored the largest number of valid species until now, being regarded as a center of origin (COPPENS D'EECKENBRUGGE; DUVAL, 2009). Pineapples stand at 8^{th} position worldwide of tropical fruits production behind bananas/plantains, coconuts and mangoes (FAO, 2012). Brazil is the third largest pineapple producer, behind Thailand and Costa Rica with production in 2012 of 2,478,178 tonnes or 1,697,734,000 fruits (FAO, 2012). Despite the great diversity of varieties in the Amazon region, 'Pérola' and 'Smooth Cayenne' still prevail in pineapple commercial plantations in Brazil. Both 'Pérola' and 'Smooth Cayenne' are susceptible to fusariosis (*Fusarium guttiforme*), main biotic constraint, which justifies development of new cultivars.

Pineapple breeding is conducted by different research institutions worldwide focusing on development of higher yielding and fruit quality cultivars. In addition to these features, the main purpose in Brazil is to obtain fusariosis resistant cultivars, and other desirable traits such as thorn less leaf edges, short stalk and fruits weighing 1.5 to 2.5 kg (CABRAL, 2000). Breeding program of Embrapa Cassava & Fruits uses 'Pérola', 'Gold' and 'Smooth Cayenne' commercial cultivars resistance and 'Perolera', 'Primavera' and 'Roxo de Tefé' as male parents in crossings aiming fusariosis. The program is using backcrosses composed by selected hybrids crossed with commercial cultivars (CABRAL et al., 2003). As the result of controlled pollination, each year tens of thousands of seeds of different genetic combinations are obtained comprising the starting point for selection of new cultivars.

Seed germination is affected by a number of intrinsic and extrinsic conditions, among which humidity, temperature, light and oxygen, are highlighted. As to environmental factors, temperature is one which significantly influences germination (MAYER; POLJAKOFF-MAYBER, 1989). Variations in temperature affect not only percentage of germination, but also speed and uniformity of the process. Little is known about the factors affecting germination and establishment of pineapple seedlings. Although there are some published results demonstrating fixed temperatures of 25ºC (BENEGA et al., 1995), 30ºC (LUZ et al., 1999) or ranging from 30 to 35ºC (IYER et al., 1978), little is focused on optimum temperature regime for pineapple germination.

This research was designed to evaluate the best temperature regime to promote seed germination from three pineapple (*Ananas comosus* var. *comosus*) progenies under laboratory controlled conditions.

Materials and Methods

Seeds obtained from crosses between ‘Perolera’ (PE) and ‘Primavera’ (PRI) and backcrosses between ‘BRS Imperial’ (IMP) and ‘Smooth Cayenne’ (SC) and between the hybrid PE x SC-60 with Smooth Cayenne were used for experiments conducted at Embrapa Cassava & Fruits, Cruz das Almas – BA, Brazil. The seeds were carried out with the aid of a blender (COLLINS, 1960), and dried at 42°C during 48 hours and counted. Before proceeding to germination tests, seeds underwent a pre-soaking treatment in distilled water, which favors increase in rate and uniformity of germination (LUZ, 1990), for a maximum of an eight hours period . Subsequently, seeds were moistened and treated with Rhodiauran®, a contact fungicide classified as a dithiocarbamate and subjected to constant 25°C temperature and alternations of 25/20°C, 30/20°C and 35/25°C (day/night, respectively).

The seeds were sown in germination boxes (11 x 11 x 3.5 cm, 250 mL volume), using synthetic foam moistened with distilled water. All boxes were placed in a germinator pre-programmed to provide a 14 hours photoperiod with 20 µmol m^{-2} s^{-1} light intensity. Treatments followed a completely randomized design in a factorial scheme of 4x3, with four temperature regimes, three progenies with four replicates of 75 seeds each.

Germination percentage evaluations were performed twice a week, every three or four days and were carried out up to 60 days after sowing. Radicle protrusion (length ≥ 1.0 mm) was the criterion for seed germination. Variables registered consisted of mean germination time, mean germination rate and germination synchrony. Mathematical expressions, authors and interpretations of these germination measures are described in Ranal and Santana (2006).

All data were submitted to Lilliefors test to verify normality of residuals and Bartllet test to confirm homogeneity of variances. With all presuppositions attended, analysis of variance was performed and Tukey’s test at 5% probability applied using SISVAR program (FERREIRA, 2011).

Results and Discussion

Practically no seed germination occurred for all treatments and progenies up to 20 days after sowing (DAS), and germination percentages tended to stabilize from 50 DAS (Figure 1).

Significant interaction was observed between progenies and temperature regimes for germination percentage at 32 DAS for mean germination time and mean germination rate. No significant interaction was confirmed between progenies and temperature regimes for the variables percentage of germination at 60 DAS and synchrony of germination. Both progenies and temperature regimes were jointly assessed for variables with significant interaction and separately for those with no significant interaction. For progenies, only germination percentage at 32 DAS and synchrony of germination were not significant. Temperature regimes were highly significant for all variables (Table I).

Seed germination was slow and was longer than four weeks (from 27.8 to 40.1 days) (Table II). The best mean germination time (from 27.8 to 30.0 days) for all progenies was obtained at 25°C and the worst (40.1 days) was for the progeny (SC x SC-60) x SC at 35/25°C (Table II). Mean germination rate, which measures the speed of germination, was higher at 25°C for PE x PRI and (PE x SC-60) x SC progenies, but was not significantly affected by temperature for the progeny BRS Imperial x SC. Similar to what occurred to mean germination time, the lowest mean germination rate was for (SC x SC-60) x SC progeny at 35/25°C (Table II). For *Ananas ananassoides* seeds, Anastácio and Santana (2010) also observed slow germination, between 21 and 26.8 days. The slow germination process occurs because of the undeveloped embryo. According to the classification proposed by Nikolaeva (1977), morphological dormancy can be caused by poorly developed or lack of differentiation of embryos at collection.

Germination percentage at 32 DAS verified for 25°C constant temperature was significantly higher for the PE x PRI and (SC x SC-60) x SC progenies. For BRS Imperial x SC progeny, the best temperatures were 25°C and 25/20°C (Table III). 32 DAS, percentage of germination was the only variable with difference in alternating temperature 35/25°C between the BRS Imperial x SC and (PE x SC-60) x SC progenies (Table III).

Figure 1 - Germinability curves of three progenies of pineapple seeds submitted to different temperature conditions over 60 days.

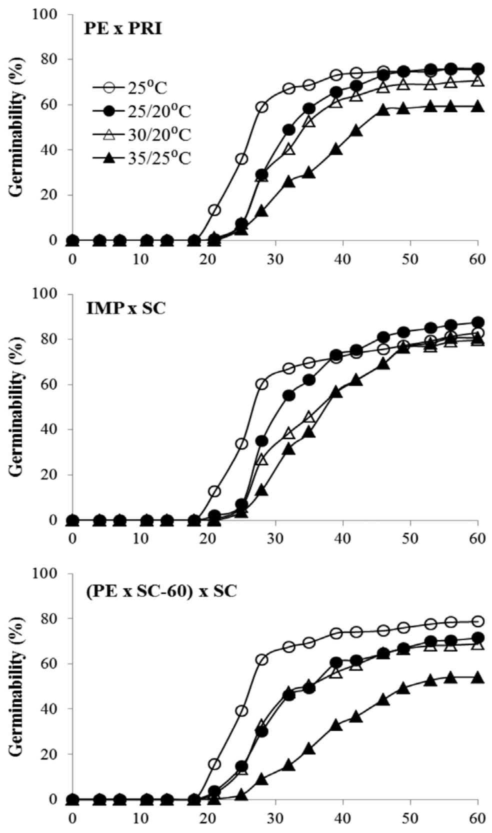

Table I - Summary of analysis of variance for the effects of the progenies and temperature regimes, and interactions between progenies and temperature regimes in the germination percentage at 32 and 60 days after sowing (DAS), in the mean germination time, in the mean germination rate and in the synchrony of germination of pineapple.

Variable	Progeny (P)	Temperature (T)	P x T	CV (%)
Germ. 32 DAS (%)	0.42ns	0.00**	0.05*	18.4
Germ. 60 DAS (%)	0.00**	0.00**	0.08ns	12.1
Mean germination time	0.02*	0.00**	0.02*	4.4
Mean germination rate	0.02*	0.00**	0.01**	9.4
Synchrony	0.31ns	0.00**	0.13ns	17.8

**Significant by F test at 1% probability; *Significant by F test at 5% probability; nsNot significant by F test at 5% probability.

Table II - Mean germination time and mean germination rate of three progenies of pineapple seeds submitted to different temperature conditions.

Temp.	Mean germination time (days)			Mean germination rate		
	PE x PRI	IMP x SC	60 x SC	PE x PRI	IMP x SC	60 x SC
25ºC	27.8 aA[1]	30.0 aA	28.1 aA	0.0375 aA	0.0325 aB	0.0375 aA
25/20ºC	33.2 bA	34.0 bA	33.4 bA	0.0300 bA	0.0300 aA	0.0300 bA
30/20ºC	33.6 bcAB	35.5 bcB	32.5 bA	0.0300 bA	0.0300 aA	0.0300 bA
35/25ºC	36.4 cA	37.7 cAB	40.1 cB	0.0300 bA	0.0300 aA	0.0225 cB

(1)Mean values followed by the same letter, lowercase in a column (temperature values) and uppercase in a row (progeny values), do not differ between themselves by the Tukey test at 5% significance.

Highest percentage of germination was observed at 60 DAS for the BRS Imperial x SC progeny (Table IV). In contrast, at 60 DAS, there was no difference between the constant temperature of 25ºC and alternating temperatures of 25/20ºC and 30/20ºC in germination percentages. Nevertheless, constant temperature of 25ºC provided best synchrony of germination (Table V).

Table III - Germinability of three progenies of pineapple seeds submitted to different temperature conditions at 32 days after sowing.

	PE x PRI	IMP x SC	60 x SC
25ºC	67.0 aA[1]	67.0 aA	66.7 aA
25/20ºC	49.0 bA	55.3 aA	48.0 bA
30/20ºC	40.3 bcA	38.7 bA	49.7 bA
35/25ºC	26.0 cAB	31.7 bA	12.7 cB

(1)Mean values followed by the same letter, lowercase in a column (temperature values) and uppercase in a row (progeny values), do not differ between themselves by the Tukey test at 5% significance.

Table IV - Germinability of three progenies of pineapple seeds at 60 days after sowing (DAS).

Progeny	Germ. 60 DAS (%)
PE x PRI	70.7 b
IMP x SC	82.0 a
60 x SC	67.4 b
31.7 bA	12.7 cB

(1)Mean values followed by the same lowercase letter in a column do not differ between themselves by the Tukey test at 5% significance.

Results indicate an optimum temperature for these progenies (25ºC), which resulted in best germinability, average time, speed and synchrony of germination. Similar results were obtained with *Pseudananas sagenarius* (currently *Ananas macrodontes*), for which optimum temperature was 25ºC, and temperatures of 15, 20, 30 and 35ºC, were also tested (VIEIRA & SILVEIRA, 2010).

Table V - Germinability and synchrony of pineapple seeds submitted to different temperature conditions at 60 days after sowing.

Temperature	Germ. 60 DAS (%)	Synchrony
25ºC	79.1 a[1]	0.23 a
25/20ºC	79.2 a	0.19 b
30/20ºC	72.4 a	0.18 b
35/25ºC	62.7 b	0.16 b

(1)Mean values followed by the same letter, lowercase in a column (temperature values) and uppercase in a row (progeny values), do not differ between themselves by the Tukey test at 5% significance.

Conclusions

Ananas comosus var. *comosus* progenies behave differently in terms of germination percentage and germination rate.

The BRS Imperial x SC progeny has higher germination percentage at 60 days after sowing at constant temperature of 25ºC.

Optimum temperature for germination of pineapple seeds is 25ºC.

Acknowledgements

Thanks to Cláudia Fortes Ferreira and Herminio Souza Rocha for technical advice.

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