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Cocoa Research Unit The University of the West Indies St. Augustine, Trinidad and Tobago Tel. +1 868 662 8788 +1 868 662 2002 Ext. 2115 Fax +1 868 662 8788 E-mail cru@sta.uw.edu

Cover photograph. Field trial planted in 2001 with enhanced germplasm for Black Pod disease resistance

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Pre-breeding of cacao for resistance to Witches' Broom and Black Pod diseases

A. Holder, P. Deberdt, V. Jadoo and J-M. Thévenin

Introduction

A pre-breeding programme for resistance to Witches' Broom disease (WB) was initiated in July 2004 as an activity in the CFC/ICCO/BI Cocoa Productivity Project. Pollinations at UCRS were completed using an incomplete diallele Kempthorne and Curnow (1961) model in year one and a combination of incomplete factorial experimental designs and bi-parental crosses in years two and three. A total of 5,300 seedlings from 50 crosses were screened for WB resistance between 2005 and 2008.

Methodology

Screening

Witches' Broom disease

Analysis of variance of the measures; MBD (maximum broom diameter), TFS (time to first symptoms) and TBI (time to broom initiation) for year two progeny was prepared with the General Linear Model using Statistical System Analysis (SAS). Classification of WB resistance was based on TFS and MBD values (Table1). Depending on the time first symptoms (TFS <20 or TFS \geq 20) the MDB values were submitted to GLM statistical analysis and classified into 3 resistance groups (resistant, moderately resistant or susceptible). This classification took into account the fact that some plants took a very long time to show symptoms (TFS \geq 20), but eventually developed large brooms. It is possible that these individuals showed partial resistance. Surujdeo-Maharaj *et al.*, (2004) highlighted the importance of time to first symptoms as a measure of resistance and this was also taken into account when selecting individual plants.

Table 1. Classification scale of resistance to Witches' Broom disease based on time to first symptoms and maximum broom diameter.

Time to first symptoms (days)	Maximum broom diameter (mm)			
	Resistant	Moderately resistant	Susceptible	
< 20	≤ 7.8	> 7.8 ≤ 9.7	> 9.7	
≥ 20	≤ 8.5	> 8.5 ≤ 12.0	>12.0	

Progeny from year three crosses between the ages of 6-7 months together with their parents (seedlings from open pollinated pods) were screened in four batches (June, August, September and October 2007) using the agar droplet technique (Surujdeo-Maharaj *et al.*, 2003). Percentage of plants infected (incidence), MBD (severity) as well as TFS and TBI were observed. Plants which were determined to have low incidence or severity will be tested for black pod resistance together with a few WB susceptible crosses.

Utilisation

Black Pod disease

Selected crosses from the first pollination year together with the controls ICS 46, CAS 1, IMC 57 and PA 124 [PER] were screened for resistance to Black pod using the leaf disc test (Nyassé *et al.*, 1995). Results were analysed via ANOVA (General Linear Model of SAS) and plants were classified according to their score (degree of necrosis scale developed by Nyassé *et al.*, 1995). Resistant plants scored ≤ 2.5 , moderately resistant plants 2.51 – 3.0 and susceptible plants scored > 3.0. Plants classified as resistant or moderately resistant to WB and BP were planted at a 1.8×1.8 m spacing in Field 3A, La Reunion Estate, Centeno in October 2007.

Results and Discussion

Witches' Broom disease screening

Out of 1,373 seedlings screened for WB resistance from the year two crosses, 469 genotypes from 20 families were selected with resistance (Table 2).

Screening for WB resistance of 1,238 seedlings of year three crosses is complete, but analysis of data and selections for screening for BP resistance is still to be completed.

	Total	No. of resistant		TFS	MBD
Cross	plants	plants	% plants	(days)	(mm)
CC 71 × NA 33	28	12	42.9	15	10.1
TRD 45 × NA 471	58	24	41.4	15	9.7
PA 171 [PER] × TRD 109	132	42	31.8	14	9.9
PA 126 [PER] × AMAZ 6/3 [CHA]	72	42	58.3	15	9.8
CRU 80 × MATINA 1/7	50	22	44.0	16	9.3
MO 9 × PA 150 [PER]	83	29	34.9	14	9.5
CL 10/15 × [ICS 84 × TSH 1077(T64)]	75	21	28.0	15	9.8
IMC 47 × [NA 45 × B 7/21 [POU] (T83)]	89	27	30.3	16	9.8
NA 399 × [SCA 6 × IMC 67 (T12)]	104	39	37.5	15	8.9
TRD 32 × NA 471	26	17	65.4	13	9.5
B 9/10-25 [POU] × CL 10/5	92	29	31.5	14	9.2
LP 3/15 [POU] × CL 10/5	10	3	30.0	13	11.9
PA 195 [PER] × [ICS 1 × GU 175/P(T28)]	25	13	52.0	13	10.3
CRU 89 × [ICS 1 × GU 175/P(T28)]	36	20	55.6	14	9.6
CRU 89 × SJ 1/40 [POU]	66	22	33.3	13	9.7
AM 2/19 [POU] × SJ 1/40 [POU]	20	15	75.0	14	8.6
AM 2/19 [POU] × NA 232	101	26	25.7	14	9.9
MOQ 6/95 × NA 232	20	5	25.0	14	11.3
MOQ 6/95 × [IMC 67 × GU 353/L (T64)]	35	21	60.0	15	8.7
B 9/10-25 [POU] × [IMC 67 × GU 353/L (T64)]	78	40	51.2	14	8.7

Table 2. Number and percentage of seedlings selected as resistant to Witches' Broomdisease from each family of year two crosses and the mean time to first symptoms(TFS) and maximum broom diameter (MBD) for each family.

Black Pod disease screening and field planting

One hundred and thirty-four (134) plants from 26 families of the year 1 crosses were selected as resistant / moderately resistant to BP and WB from 355 WB resistant plants screened for BP

resistance (Table 3). These plants together with 55 WB susceptible seedlings showing varying levels of resistance to BP, grafted parents (29) and WB resistant and susceptible controls (IMC 57 (6) and UF 29 (6)) controls were planted in the field. Screening of year 2 WB resistant progeny for BP resistance is approximately 20 % completed.

Table 3. Seedlings from year one crosses	selected as resistant and moderately resistant to
Witches' Broom and Black Pod	diseases.

	Resistant	Resistant to
Cross	to WB	WB & BP
PLAYA ALTA 2 [VEN] × RB 29 [BRA]	1	0
ICS 46 \times CATONGO	2	1
JA 3/4 [POU] × SLC 4	5	1
CRUZ 7/8 × RB 29 [BRA]	5	2
GU 114/P \times SLC 4	6	2
LP 1/45 [POU] × CATONGO	8	2
SLC 4 × GU 114/P	14	2
GU 114/P × CRUZ 7/8	4	3
ICS 46 × LP 1/45 [POU]	21	3
PLAYA ALTA 2 [VEN] × CATONGO	8	3
JA 3/4 [POU] × SPA 9 [COL]	6	4
RB 29 [BRA] × PLAYA ALTA 2 [VEN]	5	4
PLAYA ALTA 2 [VEN] × LCTEEN 90/S-7	9	5
PA 303 [PER] × LP 1/45 [POU]	14	5
RB 29 [BRA] × CRUZ 7/8	8	6
RB 29 [BRA] × CATONGO	10	7
SPA 9 [COL] × PA 303 [PER]	15	8
LP 1/45 [POU] × ICS 46	17	9
SPA 9 [COL] × JA 3/4 [POU]	23	10
SPA 9 [COL] × CATONGO	16	10
CRUZ 7/8 × CATONGO	13	11
GU 114/P × CATONGO	19	11
IMC 57 × CATONGO	12	11
PA 303 [PER] × CATONGO	16	11
LP 1/45 [POU] × PA303 [PER]	28	14
PA303 [PER] × SPA 9 [COL]	25	14
CRUZ 7/8 × GU114/P	35	21

Conclusion

Field planting of 134 seedlings showing resistance to WB and BP from year one crosses was completed in October 2007. Several other seedlings from different families were kept to replace any which may die during establishment. A proposal to replicate those seedlings in the field by micro-grafting is also being planned to ensure that this important germplasm is not lost.

Witches' Broom disease screening of seedlings from years two and three is virtually complete and next year the focus will be on screening for Black Pod disease resistance.

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