A search for anthracnose resistant cashew cultivars in Mozambique

A. Uaciquete [a,*] , L. Korsten [b] , J.E. Van der Waals [b]

[a] *Instituto de Investigação Agrária de Moçambique, Centro Zonal Nordeste, C.P. 152 Nampula, Moçambique*

[b] *Department of Microbiology and Plant Pathology, University of Pretoria, Pretoria 0002, South Africa*

* Corresponding author. *E-mail address:* amuaciquete@gmail.com (A. Uaciquete)

ABSTRACT

Dwarf and common cashew (*Anacardium occidentale*) genotypes were screened separately for resistance against anthracnose (*Colletotrichum gloeosporioides*). Disease incidence was assessed on emerging leaves over three consecutive crop seasons in Mocuba, Meconta and Pebane districts of northern Mozambique. Evaluation the disease using leaf incidence is presented as a new field method for screening cashew genotypes resistant to anthracnose. It is fast, precise and consistent in ranking cultivars over several tree seasons. Seasonal, cultivar and disease incidence means were compared using Fishers' LSD test. The method enabled the differentiation of highly infected cultivars from those consistently tolerant across seasons and locations. No a single clone with a high level of resistance was identified out of 229 entries. However, hierarchical tables of clonal sensitivity ranked clones 1.12PA, 12.8PA and 1.18PA as tolerant and 11.9PA and 2.3BG as susceptible among the dwarfs. Among the common genotypes, clones NA7, MB77, 1.5R and MCH-2 ranked tolerant and IM1 and MU3 susceptible. Tolerant clones were therefore recommended to be used in the national cashew breeding program for further development of cashew cultivars with durable resistance to anthracnose. Further, clones such as 2.5VM, 1EM, MB75 and others that revealed incidence consistency over seasons can be used as susceptibility or tolerance standards in screening trials .

Keywords: *Anacardium occidentale*; Cashew resistance; Disease incidence; Anthracnose

1. Introduction

Cashew, *Anacardium occidentale* L., is a crop with demonstrated potential for foreign exchange and job creation throughout the world (Cardoso et al., 1999; Freire et al., 2002). In Mozambique, cashew supports more than one million small holder farmers, in excess of six thousand employees and it earns over 20 million US dollars per year (Anonymous, 2007).

It was during the 16th century that European travellers introduced cashew from Brazil in the form of seed (Milheiro & Evaristo, 1994; Behrens, 1996). In Mozambique, later introductions were recorded from the 1970's and 90's, as seed of Brazilian cultivars CCP09, CCP76, CCP1001 and Matriz 96 genotypes. Seed introductions were also made from India and Zambia (Prasad *et al*., 2000) and most recently, from Tanzania. Continuous seeding returned heterozygous orchards throughout Asia, Africa and Latin America (Araujo & Silva, 1995) with heterogeneous sensitivity to diseases.

Anthracnose disease has become seriously damaging in Mozambique (Dhindsa & Monjana, 1984). Tolerant genotypes have been identified in Brazil (Cardoso *et al .,* 1999), Guinea Bissau and Cameroon (Anonymous, 1999) and Tanzania (Intini, 1987). But importation of tolerant clones is subjected to international regulations on trans-boundary movement of germplasm. In addition, variation on pathotypes and environmental conditions between regions would expose risk to the tolerance of the imported material Therefore, the objective of this study was to identify anthracnose tolerant cashew clones among locally available germplasm.

2. Material and methods

2.1. Locations and experimental design

Cashew orchards used for this study consisted of a range of cloned dwarf and common cashew types located at different trial sites as indicated in Fig. 1. At the Mocuba and Pebane sites, the trials on common and dwarf types were established parallel to one another with only a six-meter wide road between the two types. At Nassuruma in the Meconta district, only one trial

consisting of dwarf progenies was used in this study.

All trials were laid out in randomized complete block designs (Gomez and Gomez, 1994) with cultivar as treatment. Each trial consisted of three replications of three plants each. Other details on the orchards are provided in Table 1.

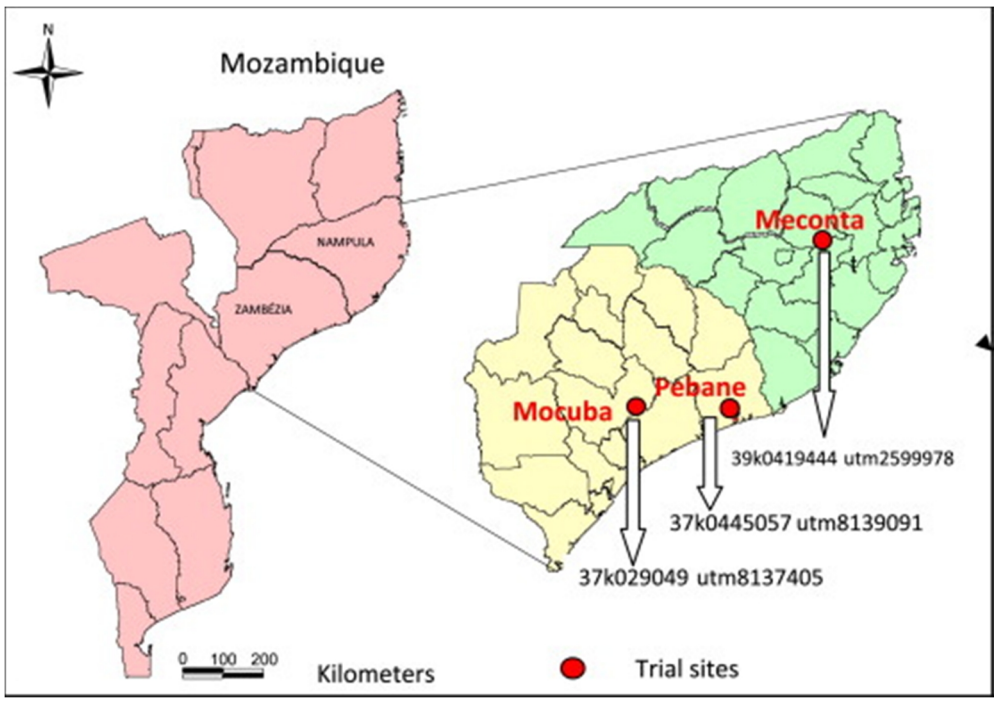

Fig. 1. Map of Mozambique, with inset showing anthracnose cashew genotypes screening trial sites, 2006–2008.

Table 1. Germplasm screening trial sites and related data in randomized complete block design, Mozambique, 2006–2008.

Trial site	Distance from Nassuruma (km)	Type of grafted cashew progenies	Number of cultivars	Plant spacing (m)	Plant age (years)	Owned by
Nassuruma	0	Dwarf	10	8 × 6	9	IIAM [a]
Mocuba	460	Dwarf	39	10 × 10	7	NGO [b]
Mocuba	460	Common	33	10 × 10	7	NGO
Pebane	512	Dwarf	67	10 × 10	8	INCAJU [c]
Pebane	512	Common	80	10 × 10	8	INCAJU

[a] Agriculture Research Institute of Mozambique.
[b] Non-governmental organization.
[c] National Institute for Cashew Development.

2.2. Field data collection and statistical treatment

For each growing season, five shoots from each cultivar located on the northern and southern sides of individual trees, were tagged with a sisal cord. This was intended to mark the shoots under investigation and facilitate repeated scoring (Masawe et al., 1997). Disease assessments were made for three consecutive crop seasons from 2006 (beginning in May or June and ending in September) as per the development and maturation of new flushes. Weekly or fortnightly intervals for observations were considered depending on the size of the trial. From individual shoots, all emerging leaves from the same crop season were counted and each assessed for the presence or absence of anthracnose necrotic lesions. Readings were made up to the tenth leaf whenever shoots grew beyond this level. Therefore, in this trial disease incidence reflected the proportion of visually diseased leaves (percentage) (McRoberts et al., 2003). Leaf severity scores were recorded from the Nassuruma trial based on the scale developed by Nathaniels (1996) for powdery mildew which has been further detailed by Sijaona et al., (2001) and was found practical also for anthracnose necrosis evaluation.

Disease scores were initially processed to return plant mean scores as detailed by Masawe et al., (1997). For individual cropping seasons, incidence data were tabulated in excel spreadsheets according to location, date of observation, replicate, cultivar and plant. Data were analyzed using the statistical program GenStat (2003). Analysis of variance (ANOVA) was used to test differences between the disease incidence responses of cultivars per cropping season. The data were acceptably normal with heterogeneous treatment variances. Thus, Fishers' protected t-test of least significant difference (LSD) at 1 or 5% levels of significance could be used to separate incidence means (Snedecor and Cochram, 1980) with respect to each year during the study. At Nampula, data were

log transformed before mean separation. Annual means were ranked by giving numbers from the smallest to the largest values in the range of means obtained. An overall mean was calculated as the sum of cultivar ranks divided by the number of seasons (3). Final ranking of cultivars was made on cultivar overall means.

3. Results

3.1. Cloned dwarf progenies

Table 2. Comparison of cashew anthracnose leaf incidence (%) and severity (%) on dwarf genotype progenies at Nassuruma, Mozambique, 2006–2008.

	Incidence							Severity						
Year	**2006**		**2007**		**2008**		**Overall rank**	**2006**		**2007**		**2008**		**Overall rank**
Clone	**Mean**	**Rank**	**Mean**	**Rank**	**Mean**	**Rank**		**Mean**	**Rank**	**Mean**	**Rank**	**Mean**	**Rank**	
11.8PA	21.59 (58.9)	2	4.77 (3.73)	1	8.30 (4.09)	2	1.7	1.447	2	0.313	1	0.947	2	1.7
1.12PA	20.92 (29.2)	1	11.79 (8.21)	4	3.83 (5.68)	1	2	1.403	1	1.237	3	0.817	1	1.7
1.3PA	34.38 (87.1)	4	8.74 (16.16)	2	9.66 (111.08)	3	3	4.347	6	0.907	2	1.017	3	3.7
2.3A	34.26 (301.4	3	9.43 (10.55)	3	12.17 (26.70)	4	3.3	3.480	3	1.450	4	1.813	5	4
5.12PA	35.46 (71.8)	5	16.71 (29.74)	6	13.92 (60.96)	6	5.7	4.117	4	1.583	5	1.890	6	5
2.4PA	42.98 (9.9)	7	25.23 (51.21)	8	13.84 (53.98)	5	6.7	5.420	8	3.580	8	1.165	4	6.7
2.5VM	43.28 (379.7)	8	15.37 (82.30)	5	22.75 (216.22)	8	7	4.717	7	1.890	6	4.643	8	7
11.7PA	47.00 (252.6)	9	21.36 (106.16)	7	18.82 (97.74)	7	7.7	4.143	5	2.367	7	4.043	7	6.3
7.10PA	41.38 (291.3)	6	39.48 (70.14)	10	33.99 (127.42)	9	8.3	8.240	9	5.703	10	4.910	9	9.3
11.9PA	50.07 (441.5)	10	35.24 (53.56)	9	66.40 (119.35)	10	9.7	12.807	10	4.833	9	18.410	10	9.7
SEM	**8.59**		**3.82**		**5.22**			**2.659**		**0.687**		**2.422**		
LSD	**NS**		**15.66**		**21.39**			**NS**		**2.814**		**9.928**		
CV (%)	**39.9**		**35.2**		**44.4**			**83**		**50.1**		**106.1**		
Fishers' level (%)			**1**		**1**									

At Nassuruma, cashew genotype reactions to anthracnose infection were variable over the three years and between clones (Table 2). Overall ranks obtained indicated that

clone 11.8PA expressed consistently the lowest levels of anthracnose incidence on leaves varying from 4.77 to 21.59% over the three years under the study period while clone11.9PA ranked the highest with anthracnose incidence levels on leaves varying from 35.24 to 66.40% (Table 2).

Incidence and severity relationships of leaf anthracnose over crop seasons, germplasm variation, locations and fungicide spray systems have been established (subject for specific publication). Field data proved to be robust for the use of disease incidence as a valuable parameter for screening germplasm instead of severity which is difficult to assess. Table 2 illustrates the similarity between outputs for clonal ranking and disease severity and anthracnose incidence data.

At Mocuba, the overall ranking of cloned cashew dwarf genotypes indicated that clone 12.8PA expressed the lowest level of anthracnose leaf incidence ranging from 22.45 to 33.93% over the three years under study while clones 2.3BG ranked the highest with incidence levels varying from 48.76 to 78.72% (Table 3).

Table 3. Comparison of cashew anthracnose leaf incidence (%) on dwarf cashew genotypes at Mocuba, Mozambique.

Year	2006		2007		2008		Overall rank
Clone	Mean	Rank	Mean	Rank	Mean	Rank	
12.8PA	32.87	8	33.93	5	22.45	2	5.0
6.7NASS	22.46	2	40.71	12	44.04	10	8.0
4.1AD	24.87	3	34.80	6	60.66	21	10.0
11.7PA	24.90	4	55.42	24	23.46	3	10.3
1.20VM	22.41	1	55.26	23	37.80	7	10.3
3.2VM	28.73	6	30.22	2	64.57	24	10.7
12.1PA	42.90	18	38.75	11	27.45	4	11.0
35EM	43.90	19	36.04	9	51.73	16	14.7
2.7NASS	33.90	11	54.59	21	45.01	12	14.7
7EM	33.13	9	22.11	1	77.99	35	15.0
12.3PA	26.43	5	59.47	32	38.21	8	15.0
11.8PA	44.23	20	54.94	22	30.27	5	15.7
2.3PA	46.60	22	35.33	8	56.79	18	16.0

Year	2006		2007		2008		Overall rank
Clone	**Mean**	**Rank**	**Mean**	**Rank**	**Mean**	**Rank**	
5.12PA	42.47	17	31.68	4	72.91	32	17.7
2EM	52.30	27	49.93	20	32.12	6	17.7
12.9PA	39.31	15	34.80	7	71.69	31	17.7
2.5VM	35.47	13	48.15	19	62.45	22	18.0
10.1NASS	48.07	24	59.96	33	10.03	1	19.3
12.2PA	33.37	10	71.91	38	44.49	11	19.7
11.2PA	32.63	7	64.82	36	55.80	17	20.0
1.20VM	40.07	16	55.90	25	59.08	19	20.0
1.18VM	55.61	29	30.33	3	69.85	30	20.7
12.6PA	53.70	28	56.11	26	40.74	9	21.0
16.1BG	64.04	36	47.11	18	50.09	15	23.0
5EM	57.67	30	40.86	14	68.22	27	23.7
32EM	47.80	23	38.51	10	79.84	38	23.7
12.9PA	37.50	14	58.36	29	68.49	28	23.7
8EM	61.37	34	40.78	13	66.78	25	24.0
2.8VM	60.36	33	42.79	15	66.91	26	24.7
3.1NASS	49.30	26	56.58	27	64.39	23	25.3
2.3VM	34.90	12	58.63	31	79.17	37	26.7
9.3NASS	65.30	37	58.44	30	48.13	14	27.0
12.1PA	59.13	32	73.06	39	48.09	13	28.0
9.1PA	57.90	31	43.61	16	80.83	39	28.7
2.4PA	44.40	21	60.72	34	73.37	33	29.3
3.3VM	73.93	39	46.03	17	74.46	34	30.0
2.11BG	63.90	35	57.30	28	69.62	29	30.7
8.5PA	73.41	38	67.26	37	59.96	20	31.7
2.3BG	48.76	25	62.09	35	78.72	36	32.0
SEM	**9.10**		**8.02**		**8.30**		
LSD	**34.10**		**30.04**		**31.01**		
CV (%)	**34.9**		**28.4**		**25.7**		
Fishers' level (%)	**1**		**1**		**1**		

SEM = Standard error mean; LSD = Least significant difference; CV (%) = Percentage coefficient of variance.

In the cases of dwarf and cloned genotypes at Pebane, anthracnose disease incidence was also variable from year to year within each clone. However, overall ranking indicated that clone 29EM was the least infected, in contrast to clone 9EM on which anthracnose incidence ranked the highest (Table 4).

Table 4. Comparison of cashew anthracnose leaf incidence (%) on dwarf genotype progenies at Pebane, Mozambique.

Year	2006		2007		2008		Overall rank
Clone	Mean	Rank	Mean	Rank	Mean	Rank	
22.3PA	*		*		*		
29EM	37.33	12	9.60	1	3.21	1	4.7
40EM	47	22	34.77	2	4.82	2	8.7
1.12PA	37.93	14	3.17	10	12.42	10	11.3
11.8PA	35.57	11	8.93	12	15.06	14	12.3
12.6PA	63.23	41	49.40	5	6.85	5	17.0
3.2VM	62.3	38	10.92	7	11.19	7	17.3
6.7NASS	22.4	1	6.00	26	21.73	26	17.7
2.5VM	43.8	18	5.50	18	19.19	18	18.0
55 EM	69.17	48	2.87	3	5.75	3	18.0
1.20VM	57	33	55.60	11	13.97	11	18.3
31EM	44.47	19	0.43	19	19.62	19	19.0
30EM	25.73	4	5.83	15	18.55	39	19.3
19EM	37.87	13	2.47	23	21.3	23	19.7
9.4Nass	53.6	28	11.27	16	18.61	16	20.0
47EM	69.93	51	7.73	8	11.33	8	22.3
4.1AD	25.57	3	25.43	38	29.48	31	24.0
2.7Nass	77.77	59	28.07	9	12.40	4	24.0
12.1PA	31.5	7	8.73	4	6.60	62	24.3
41EM	54.77	29	28.57	22	21.04	22	24.3
37EM	33.87	9	9.93	32	25.62	32	24.3
2.3BG	69.77	49	30.53	13	16.13	13	25.0
2.3VM	83.93	63	16.20	6	7.93	6	25.0
48EM	55.43	30	11.10	24	21.58	24	26.0
1.18VM	34.87	10	0.00	25	21.72	48	27.7
1.4Nass	76.63	57	29.70	14	17.17	14	28.3
3.1Nass	57.37	34	44.43	34	25.87	18	28.7
7.10PA	71.73	53	13.23	17	18.74	17	29.0
53EM	68.47	46	30.20	21	20.90	21	29.3
20EM	23.7	2	0.00	45	37.02	45	30.7
38EM	33.57	8	16.47	36	28.83	50	31.3
2.4PA	39.3	15	27.70	40	31.11	40	31.7
25EM	45.17	21	16.83	37	29.15	37	31.7
3.11PA	72.8	56	8.73	20	20.08	20	32.0
42EM	57.77	35	0.80	43	34.93	18	32.0
57EM	31.03	6	4.40	47	27.60	47	33.3

Year	2006		2007		2008		Overall rank
Clone	**Mean**	**Rank**	**Mean**	**Rank**	**Mean**	**Rank**	
60EM	58.23	36	12.13	33	25.75	33	34.0
12.9PA	43	17	6.63	44	36.61	44	35.0
1.3Nass	69.83	50	33.80	28	24.47	28	35.3
2.3PA	53	27	9.50	42	33.59	42	37.0
2.11BG	80.07	60	60.07	27	23.06	27	38.0
24EM	71.3	52	7.40	31	25.24	31	38.0
16.1BG	62.93	39	31.97	41	31.31	41	40.3
11.2PA	65.1	43	7.67	39	30.58	39	40.3
3.3VM	56	31	7.50	46	37.35	46	41.0
11.9PA	85.87	64	41.33	30	24.82	30	41.3
10.1Nass	77.1	58	43.97	35	28.58	35	42.7
6.7Nass	42.1	16	15.97	57	43.32	57	43.3
8.5PA	52.87	26	3.27	52	40.11	52	43.3
12.8PA	30.38	5	8.63	63	55.32	63	43.7
18EM	52.13	24	18.60	54	42.54	54	44.0
2.8VM	56.33	32	0.67	50	38.78	50	44.0
1.7VM	45.03	20	16.23	59	47.07	59	46.0
9.1 PA	63.17	40	13.93	51	39.54	51	47.3
12.3PA	68.73	47	16.13	48	37.77	48	47.7
52EM	72	54	21.70	29	24.49	63	48.7
5.12PA	48.1	23	3.30	62	54.84	62	49.0
50EM	59.2	37	4.40	56	42.80	56	49.7
9.3Nass	72.5	55	29.50	49	38.60	49	51.0
39EM	65.17	44	17.92	55	42.58	55	51.3
43EM	67.37	45	56.10	58	44.05	58	53.7
12.2PA	64.27	42	33.30	61	49.45	61	54.7
11.7PA	*	66	9.50	53	40.59	53	57.3
5.9PA	83.2	61	26.80	60	47.81	60	60.3
16.1PA	52.33	25	*		*	*	
6.2PA	*		*		*	*	
9EM	83.47	62	23.70		8.27	*	
SEM	**13.85**		**9.23**		**30.58**		
LSD	**38,75**		**25.84**		**30.58**		
CV (%)	**43.2**		**89.2**		**52.5**		
Fishers' level (%)	**5.0**		**5.0**		**1.0**		

SEM = Standard error mean; LSD = Least significant difference; CV (%) = Percentage coefficient of variance; *Plants died due to stem borer.

3.2. Cloned common progenies

On common genotypes of cashew investigated at Mocuba, the anthracnose disease incidence was also variable from year to year within each clone. Overall ranking positioned two of the clones (clones NA7 and MB77) with the least leaf anthracnose incidence. In contrast, Clone IM1 was ranked the highest with incidence between 65.05 and 84.58% over the three years under the study (Table 5).

Table 5. Comparison of cashew anthracnose leaf incidence (%) on common genotype progenies at Mocuba, Mozambique.

Year	2006		2007		2008		Overall rank
Clone	Mean	Rank	Mean	Rank	Mean	Rank	
NA7	26.56	8	6.06	1	22.52	1	3.3
MB77	27.57	10	14.78	3	24.49	3	3.3
MU2	24.86	6	18.96	5	45.74	12	5.3
103,82	20.83	4	34.68	14	45.60	11	7.7
103,81	9.80	1	19.72	7	65.83	23	9.7
Na100	40.43	21	17.28	4	38.52	6	10.3
MB76	40.40	20	27.12	9	30.15	4	10.3
1.5R	31.00	15	49.94	22	23.77	2	11.0
MU63	29.87	13	40.91	17	44.22	9	13.0
MS-2	23.13	5	42.39	18	57.13	18	13.0
02NASS	29.80	12	13.34	2	75.29	28	13.7
EBA70	37.77	17	21.60	8	55.71	17	14.0
MU106	41.67	22	28.78	12	42.94	8	14.0
NA96	33.03	16	34.61	13	45.94	13	14.0
NA98	29.43	11	35.40	15	52.93	16	14.0
PPE13	34.13	18	28.63	11	50.00	15	14.0
103,79	55.07	30	27.86	10	39.74	7	14.7
MU45	24.87	7	43.57	19	63.52	22	15.7
IM5	52.30	28	38.21	16	32.79	5	16.0
103,68	45.37	24	51.13	24	45.03	10	16.3
MU18	17.40	2	58.02	29	73.10	27	19.3
MU42	37.63	19	54.17	25	46.05	14	19.3
103,85	27.07	9	60.51	30	59.37	21	19.3
NA5	18.00	3	54.69	26	76.65	31	20.0
MU32	49.06	27	19.44	6	75.36	29	20.0
NC3	30.97	14	50.61	23	68.92	25	20.7
NC1	48.67	26	47.32	20	58.71	20	20.7

Year	2006		2007		2008		Overall rank
Clone	**Mean**	**Rank**	**Mean**	**Rank**	**Mean**	**Rank**	
MB83	47.53	25	56.48	27	57.46	19	22.0
NA1001	55.40	31	48.20	21	68.52	24	23.7
MU1	42.40	23	69.28	33	75.50	30	25.3
MU3	72.33	33	57.55	28	69.74	26	28.7
MB75	54.76	29	65.01	32	78.82	32	29.0
IM1	65.06	32	61.35	31	84.58	33	31.0
SEM	**7.63**		**8.34**		**3.75**		
LSD	**28.72**		**23.61**		**14.07**		
CV (%)	**35.7**		**36.7**		**11.9**		
Fishers' level (%)	**1.0**		**5.0**		**1.0**		

SEM = Standard error mean; LSD = Least significant difference; CV (%) = Percentage coefficient of variance.

At Pebane, the overall ranking of cloned cashew common genotypes indicated that clone 1.5R and clone MCH-2 expressed the lowest levels of anthracnose leaf incidence varying from 1.99 to 16.43% and 0 to 37.33%, respectively (Table 6). The highest scores of anthracnose incidence were recorded from clone MU3, with incidence values ranging from 52.64 to 67.99% (Table 6).

Table 6. Comparison of cashew anthracnose leaf incidence (%) on common genotype progenies at Pebane, Mozambique.

Year	2006		2007		2008		Overall rank
Clone	**Mean**	**Rank**	**Mean**	**Rank**	**Mean**	**Rank**	
1.5R	16.43	4	1.99	14	13.18	8	8.67
MCH-2	37.33	8	0	2	18.47	16	8.67
NA-7	50.94	3	5.72	18	13.6	10	10.33
NH-3	0	1	15.06	29	12.99	7	12.33
MS-6	63.64	30	1.85	13	6	2	15.00
MH-1	24.54	36	4.67	16	4.78	1	17.67
MS-5	25.28	32	1.58	12	20.42	18	20.67
MR-6	56.51	12	16.67	32	20.85	19	21.00
IN-4	47.57	11	8.66	20	24.36	33	21.33
MR-2	22.81	52	0	5	13.59	9	22.00
EBA-70	55.59	14	12.79	24	23.69	30	22.67
IN-1	19.02	29	2.91	15	23.15	26	23.33
MS-1	58.04	20	18.26	35	16.83	15	23.33
NNB-6	37.48	61	0	9	10.83	4	24.67

Year	2006		2007		2008		Overall rank
Clone	Mean	Rank	Mean	Rank	Mean	Rank	
IM-5	16.67	7	50.77	66	10.12	3	25.33
MMC-4	4.11	47	0	4	23.2	27	26.00
IN-3	9.73	10	10.67	22	29.56	46	26.00
MB-76	0	43	5.57	17	21.63	20	26.67
NC-3	81.48	22	13.64	26	4.8	35	27.67
IN-2	48.65	25	21.98	39	21.72	21	28.33
02Nass	69.93	26	29.17	44	19.72	17	29.00
MMR-4	44.44	2	17.62	34	31.44	52	29.33
MMJ-3	55.21	15	16.67	33	28.35	42	30.00
MS-4	86.05	50	0	6	24.51	34	30.00
NC-1	39.03	24	31.3	45	22.36	22	30.33
IM-3	52.33	19	16.53	31	27.4	41	30.33
IM-2	19.33	79	0	1	14.84	12	30.67
NNT-4	93.85	21	0	10	36.06	62	31.00
NNT-2	29.53	37	18.81	36	24.24	28	33.67
NH-2	71.53	49	10.23	21	25.24	36	35.33
NH-4	42.2	76	0	8	22.38	23	35.67
MSC-1	48.9	73	0	7	24.19	31	37.00
NC-2	19.43	78	10.95	23	14.62	11	37.33
MMJ-2	41.5	17	25.29	42	32.18	53	37.33
MMR-6	58.86	16	33.33	48	30.15	49	37.67
103,85	91.6	28	60.9	73	16.12	14	38.33
NNT-6	32.08	66	7.78	19	24.33	32	39.00
MS-2	55.84	75	20.26	37	11.88	5	39.00
MO-1	89.72	38	16.46	30	30.26	50	39.33
NNB-1	3.85	51	14.83	27	28.88	43	40.33
ME-1	45.61	64	0	3	35.97	61	42.67
MMC-1	65.1	46	22.02	40	29.02	44	43.33
MH-2	80.31	9	55.05	68	32.7	54	43.67
MMR-5	25.52	48	40.37	60	22.57	24	44.00
NNB-2	42.6	42	33.63	51	26.63	39	44.00
IM1	6.48	13	37.86	55	39.38	66	44.67
PSP-2	86.06	33	33.33	50	30.63	51	44.67
MCR-5	40.37	60	59.46	71	11.9	6	45.67
MH-3	57.18	57	52.19	67	15.38	13	45.67
NNB-3	67.09	5	57.1	69	38.92	65	46.33
MCH-1	69.59	45	38.89	57	27.39	40	47.33
PPE-4	68.4	35	24.35	41	40.34	68	48.00
NC-4	51.68	23	39.79	59	38.58	63	48.33
NNB-5	81.47	27	65.33	76	29.09	45	49.33
PPE-15	61.94	18	38.04	56	46.43	75	49.67

Year	2006		2007		2008		Overall rank
Clone	**Mean**	**Rank**	**Mean**	**Rank**	**Mean**	**Rank**	
MR-9	90.45	6	50	64	70.2	80	50.00
MSC-2	96.44	69	13.27	25	33.73	57	50.33
IM-4	29.28	77	31.1	46	23.6	29	50.67
QM-1	87.57	40	61.22	74	25.73	38	50.67
MCL	97.03	34	33.33	47	45.66	73	51.33
NNT-3	44.06	68	14.96	28	34.33	59	51.67
MMR-3	5.48	63	39.49	58	25.34	37	52.67
NNT-5	55.98	80	0	11	39.59	67	52.67
MMP-2	75.47	53	21.67	38	40.67	69	53.33
PPE-13	57.12	59	37.33	54	29.98	48	53.67
MMJ-1	87.09	55	37.13	53	32.83	55	54.33
NM-2	78.93	44	47	62	35.26	60	55.33
PPE-18	27.85	65	27.66	43	38.9	64	57.33
PSP-1	67.48	72	79.75	77	23.04	25	58.00
CA13	81.18	39	50	65	45.88	74	59.33
MS-3	80.92	58	33.33	49	47.42	76	61.00
MR-1	26.13	41	62.25	75	43.3	70	62.00
PPE-14	39.88	70	41.79	61	33.17	56	62.33
MMP-1	69.61	56	49.16	63	44.3	71	63.33
NNT-1	92.41	31	100	80	65.44	79	63.33
MMR-2	63.11	67	35.85	52	44.36	72	63.67
PPE-16	65.38	62	60.28	72	33.79	58	64.00
QM-2	81.84	71	86.52	79	29.96	47	65.67
NM-2	98.16	54	84.77	78	59.42	78	70.00
MU-3	67.99	74	58.51	70	52.64	77	73.67
SEM	**14.44**		**16.57**		**8.08**		
LSD	**40.33**		**61.13**		**29.78**		
CV (%)	**45.9**		**101.3**		**48.6**		
Fishers' level (%)	**5**		**1**		**1**		

SEM = Standard error mean; LSD = Least significant difference; CV (%) = Percentage coefficient of variance.

At Pebane and Nassuruma, among the dwarf progenies, clones 2.5VM, 1EM, 1.12PA and 11.8PA were the most consistently tolerant clones. In contrast, clones 5.9PA, 17PA, 12PA, 7.10PA and 11.9PA were consistently susceptible over the experimental period. With all other clones, the incidence of the disease differed significantly among seasons (Table 4). Among the common type clones, consistency in anthracnose incidence was

observed only in the susceptible clones, NA1001, MU1, MU3, MB75 and IM1 in the Mocuba trial (Table 5).

.Some clones were integrated in two of the three trial sites. Overall anthracnose _ incidence ranks have characterized most of these clones consistently either as tolerant or susceptible. Clones 1.12PA and 11.8PA in the Nassuruma trial ranked tolerant (Table 2). Similarly in the Pebane trial, these two clones ranked third tolerant (Table 4). At Mocuba, the same clones were intermediate (Table 3). Clones 5.12PA and 11.7PA were intermediate at Nassuruma (Table 2) and Mocuba (Table 3) and susceptible at Pebane _ (Table 4). The rank changes for a particular cultivar can be explained by means of the LSD value as compared to the most susceptible or the most tolerant clones in the trial. Therefore, using this approach, a given clone could be categorized as "tolerant", if not statistically different from the top reference, "susceptible" if not different from the bottom reference and "intermediate" if different from either of the above references.

4. Discussion

For small holder farmers, anthracnose tolerant cultivars are still the best option for integrated crop management (Cardoso et al, 1999). Unlike other methods, they provide suitable and environmentally safe, economical and practical options for control of the anthracnose disease in cashew. In addition, resistance to anthracnose disease has often been shown to be of polygenic and durable nature (Waller, 1992). In this study, 229 cultivars among dwarfs and common genotypes of cashew were hierarchically ranked as

per their relative susceptibility to anthracnose disease. Less susceptible clones could be considered for analytic selection in conjunction with yield performance and powdery mildew disease responses.

Substantial variability in the responses of cashew cultivars to anthracnose disease development was observed during the present study. This is in conformity with previous findings where variability in cashew reactions to the anthracnose pathogen was demonstrated both in vitro (Muniz et al., 1997; Anonymous, 1999) and in the field

(Cardoso et al., 1999). The disease is known to vary in severity and aggressiveness with the prevailing environmental conditions (Cardoso et al., 2000; Topper et al., 2003). Annual variations were also evident during the course of the present study. In addition, pathotypes have revealed differential aggressiveness (Muniz et al., 1997; Anonymous, 1999). The results of the current investigations are the first to be obtained in Mozambique.

Cashew germplasm screening generally uses severity data and this has been previously achieved in field (Cardoso et al., 1999) and in vitro (Muniz et al., 1997; Anonimous, 1999) studies. This is because the relationship between incidence and severity had not been established at the time that these previous studies were being carried out. In fact, the idea of having it established in most crops is to reduce labor cost and improve accuracy (McRoberts et al., 2003). More importantly, the whole plant scores currently used in cashew anthracnose assessment (Cardoso et al., 2000) can lead to misleading conclusions because under severe attack, highly susceptible clones become defoliated (Freire et al., 2002) and therefore there is an increasing risk that such a defoliated clone could be underscored. Tolerant clones, however, can be scored taking

into account multiple seasons' damage caused by the pathogen. Using the incidence approach, anthracnose incidence values can be used to assess two epidemics within a single calendar year: cashew vegetative growth epidemic and cashew generative growth epidemic and thus correlate them for possible disease forecast models.

In Mozambique, there has been an empirical perception that dwarf genotypes are highly susceptible to anthracnose as compared to the common ones. At Mocuba and Pebane, dwarf and common genotypes were established in parallel to one another and the incidence data did not support such a perception. The height and diameter of common types could well be obscuring the damage caused by anthracnose to casual observers.

Most of the germplasm used in the present study are among the genetically elite material for the northern region of Mozambique. They are composed of recent introductions from Brazil (the EM-collection); selections from Nampula Agronomic Research Station (PA-Collection);

selections from Nassuruma Cashew Research Station (The Nass-collection) and farmers' field collections referred to by the names of location sources and numbers, e.g. NC4 is the fourth elite mother tree from Naburi-Calima. From all of these germplasm sources, no evidence of source related tolerance/resistance was noted. This supports the concept of genetically controlled cashew reactions to anthracnose infection (Waller, 1992).

Dwarf clones 1.12PA and 11.8PA and common clones NA7, MB77, 1.5R and MCH-2 were identified as the most tolerant to anthracnose disease. Likely, heritability of anthracnose resistance has been highlighted from recent studies carried out in Tanzania (Sijaona et al, 2001). Therefore these clones are potentially relevant for future cashew breeding programs in Mozambique (Freire et al, 2004). However, clones 11.9PA (dwarf type), MU3 and IM1 (common type) were identified as the most susceptible an therefore, can be used as positive controls in future trials. Clones such as 2.5VM, 1EM NA1001, MU1, MU3 and others have shown seasonal consistency and therefore can b used as tolerant or susceptible standards in future screening trials.

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