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Full Length Research Paper

Prevalence and severity of bacterial blight and anthracnose diseases of cassava in different agro-ecological zones of Nigeria

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Geo-referenced surveys were conducted in 2001 and 2003 to assess the prevalence and severity of cassava bacterial blight (CBB) and cassava anthracnose disease (CAD) in different agro-ecological zones of Nigeria. A total of 132 fields were visited in 2001 as follow: humid forest (HF) 42, derived savannah (DS) 38, southern guinea savannah (SGS) 16, northern guinea savannah (NGS) 16 and Sudan savannah (SS) 20. In 2003, 277 fields were visited: HF (83), DS (143), SGS (22), NGS (11), and SS (18). CBB prevalence was greater than 70% in all ecozones in 2001; 33.7% in HF, 65.7% in DS and greater than 90% in others in 2003. CAD prevalence was greater than 90% in HF for the two surveys, 44.7% and 61.5% for 2001 and 2003 respectively in DS, while it was not observed in the other zones. In both surveys, more than 80% of CBB infected fields in all ecozones were moderately severe, except in SS where 47% of fields in 2003 were highly severe. In both HF and DS, more than 30% of fields in 2001, and less than 20% in 2003, had highly severe CAD symptoms. Prevalence of CBB was negatively correlated with annual precipitation and positively correlated with maximum temperature of the ecozones, while prevalence of CAD had strong positive relationship with the annual precipitation and negative association with maximum temperature. The distribution patterns of the diseases found in this study provide a baseline for disease management programme in the rapidly expanding cassava industry in Nigeria, and implications of the results for cassava industry were discussed.

Key words: anthracnose, bacterial blight, cassava, *Colletotrichum gloeosporioides* prevalence, severity, *Xanthomonas axonopodis.*

INTRODUCTION

Cassava is a major food crop in many tropical countries across the globe where it constitutes an essential part of the diet of more than half a billion people (Hahn et al., 1989). In recent times, cassava is gradually gaining a strategic position in the world trade as a result of the effort by various governments and the private sector, in developing novel value- added cassava-based products for human consumption and industrial uses. Africa produces more than 50% of the world's annual output of 184 million tonnes, and Nigeria accounts for more than 33% of the total production in African, with estimated increaseing annual production of 33.6 million tonnes as at 2003 (FAO, 2003). The increasing cultivation of cassava in Nigeria has resulted in expansion of the crop into marginal environment, with increasing production constraints among which the activities of various disease agents are of principal concern.

Cassava diseases affect plant establishment and vigour, inhibit photosynthetic efficacy and in some cases cause pre-harvest or post-harvest deterioration (Lozano et al., 1981; IITA, 1990). Diseases can lead to total crop failure with losses in tuber yield as high as 90% under

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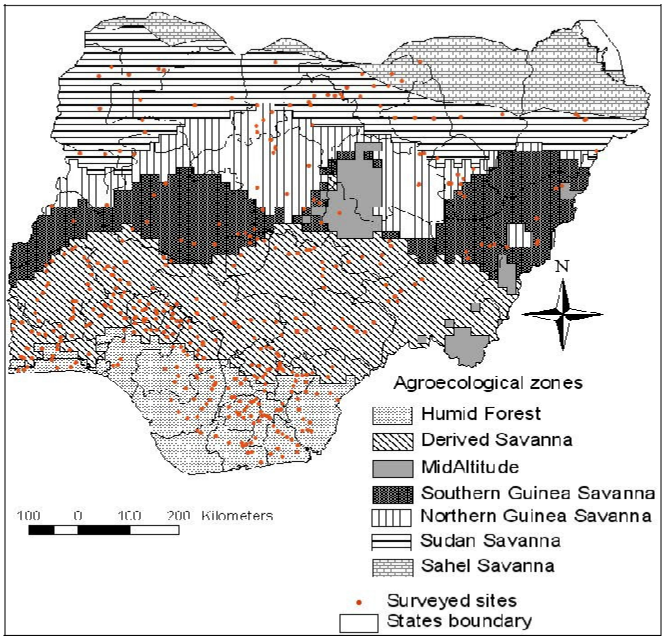

Figure 1. Map of Nigeria showing the locations in different agro-ecological zones where cassava disease survey were conducted in 2001 and 2003

favourable conditions (Wydra and Msikita, 1998). The need to protect cassava against diseases is therefore, a crucial aspect of enhancing the production of the crop. Some diseases are distributed world-wide, appearing endemically in almost all cassava cultivating regions, whilst others are limited to certain geographical areas. Consequently, the importance of a particular disease could vary from one geographical area or ecological zone to another. Therefore, information from detailed farm survey data obtained from evenly distributed fields across geographical regions or ecological zones are prerequisite to effective disease management. Such surveys can reveal the effectiveness of existing disease management practices, and the desirability and conditions required for introduction of new methods (Ngugi et al., 2002).

The major diseases of cassava in Nigeria include cas-sava mosaic disease, cassava bacterial blight, cas-sava anthracnose disease, and cassava root rot. While recent surveys in the country focused on cassava mosaic disease (Ogbe et al., 2003; 2006), and the distribution of root rot disease and its associated pathogens (Onyeka, 2002; Onyeka et al., 2004; Bandyopadhyay et al., 2006), there are no report on the current status of cassava bacterial blight (CBB) and cassava anthracnose disease (CAD) in Nigeria. Therefore, the objectives of the surveys reported here are to determine the prevalence and seve-rity of CBB and CAD in farmers' fields across different agro-ecological zones of Nigeria; assess relationship between disease prevalence and the two major climatic variables (temperature and rainfall) in different ecozones; and identify potential sites for disease screening trials and establishment of commercial production of planting materials.

MATERIALS AND METHODS

Survey area

Cassava disease survey was conducted first in 2001 and again in 2003, across five ecological zones of Nigeria (Figure 1). The survey routes were determined using the road maps of Nigeria, which included highways, secondary roads, and feeder roads. As much as possible, the routes were chosen to intersect the main cassava-growing areas and to ensure that sufficient cassava fields were available for sampling. Along the routes, cassava fields were visited at intervals of 10 to 15 km in humid forest, derived savannah and southern Guinea savannah where cassava fields were common. In the northern Guinea savannah and Sudan savannah, the sampling interval was about 20 to 30 km because cassava fields were sparsely spaced. The coordinates of each field visited, were recorded using a global positioning system (GPS; Magellan GPS 315, San Dimas, CA).

A total of 132 fields were assessed in 2001 across humid forest zone (n = 42), derived savannah (n = 38), southern guinea sava-nnah (n = 16), northern guinea savannah (n = 16) and Sudan savannah (n = 20). In 2003, a total of 277 fields were assessed across the different ecozones, with 83 in the humid forest, 143 in the derived savannah, 22 in the southern guinea savannah, 11 in the northern guinea savannah and 18 in the Sudan savannah.

Sampling and data collection

At each survey site, 30 plants were selected at random on two diagonals across the field, and assessed for both CAD and CBB. The severity of each disease was scored on a scale of 1 – 5 following the scoring system described by Wydra and Msikita (1998) as follow: *CBB*: 1 = no symptom; 2 = only angular leaf spots; 3 = angular leaf spots, wilting, blighting, defoliation, and some exudates on stem/petioles; 4 = blighting of leaves, wilting, defoliation, exudates, and tip dieback; 5 = blighting of leaves, wilting, defoliation, exudates, tip dieback, and plant stunting. *CAD*: 1 = no symptom; 2 = cankers only on lower parts of the stem; 3 = cankers spread from lower to mid-parts of the stem; 4 = cankers spread from lower to green parts of the stem and stem wilting; 5 = severe leaf wilting, leaf and stem distortions. Weather data for the various ecozones for the survey years were obtained from the geographical information service (GIS) unit of IITA, Ibadan.

Isolation and identification of associated pathogens in the laboratory

Cassava stems with CAD cankers, and young stems and leaves showing CBB symptoms were collected from each site where the diseases were observed during the survey for the detection of the associated pathogen in the laboratory.

Detection of CAD pathogen was conducted by potato dextrose agar (PDA) culture of symptomatic stems. Small stem pieces of diseased samples were surface sterilized for 3 min in 10% sodium hypochlorite solution, rinsed in 5 changes of sterile distilled water and dried on sterilized filter paper before inoculating on acidified PDA. The inoculated plates were incubated at 27^{o}C for 5 - 7 days during which pure cultures of microbial growth were established for identification. Confirmation of *C. gloeosporioides*, the causal patho-gen of CAD was carried out based on the morphological and cultural characteristics on PDA, and microscopic observation following the fungi identification key of Barnett and Hunter (1972).

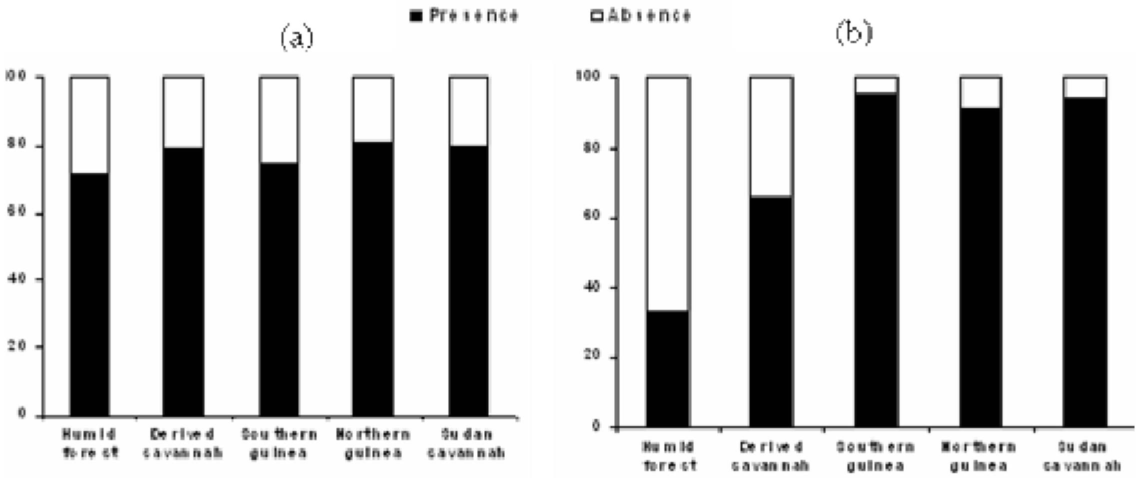

Figure 2. Prevalence of cassava bacterial blight in five agro-ecological zones of Nigeria in 2001 (a) and 2003 (b)

For the microscopic observation, small amounts of mycelia and fruiting structures were mounted, teased in lactophenol cotton blue on a slide. The samples were observed under Sterobinocular microscope (Wild M5) at 12 – 60 x magnification for presence of *C. gloeosporioides* based on the type of mycelium, fruiting structure, shape and size of conidia following the descriptions of Barnett and Hunter (1972).

Isolation of CBB pathogen was carried out on potato yeast glucose agar (PYGA) using the method described by Bradbury (1978). Symptomatic leaves and stems were cut into 2 - 3 mm pieces, sterilized for 3 min in 10% sodium hypochlorite and rinsed in sterile distilled water. The treated plant materials were aseptically transferred with a pair of forceps to a few drops of distilled water. The tissues were triturated and the suspension was allowed to stand for up to 5 min. Loopfuls of the suspension were streaked on freshly prepared PYGA, incubated at 28^{o}C for 72 h. The presence of *Xanthomonas axonopodis* was confirmed based on morphological and biochemical tests (Fahy and Hayward, 1983; Ogunjobi et al., 2007). *X. axonopodis* is gram-negative, usually motile and aerobic, fluorescent in King's medium B, and gray with characteristic mucoidal colonies on sucrose containing media. *X. axonopodis* pv *manihotis* produced grayish-white, smooth, glistening mucilaginous convex colonies on glucose yeast extract calcium carbonate agar.

Data analysis

Prevalence of each disease within an agro-ecological zone was summarized as the percentage of surveyed fields in the zone with disease symptoms. The number of fields within each severity category was expressed as percentage of total field with disease to obtain severity frequency distributions. Based on the 2003 survey, the mean disease severity for each state of the country was used to compare variation in disease severity within ecozone and to determine the pattern of changes from one ecozone to another. Pearson correlation coefficients were used to determine association between disease prevalence and climatic variables in different agro-ecological zones. The minimum and maximum mean annual precipitation (P_{min} and P_{max}), and minimum and maximum mean temperature of the coldest (T_{min}) and warmest (T_{max}) month respectively, were considered as climatic variables because of their strong correlations with other environmental variables.

RESULTS

Prevalence and severity of cassava bacterial blight (CBB)

Cassava bacterial blight was observed in all the agro-ecological zones in both 2001 and 2003 surveys. The prevalence of the diseases in different ecozones varied slightly between the two surveys. In the first survey, CBB prevalence was greater than 70% in all the zones (Figure 2a). In the second survey however, CBB prevalence was 33.7% in the humid forest, 65.7% in the derived savannah and greater than 90% in the southern guinea savannah, northern guinea savannah, and Sudan savannah zones (Figure 2b).

In both 2001 and 2003 surveys, more than 80% of CBB infected fields in all the ecozones except Sudan savannah, had moderately severe symptoms (mean scores less than 4), and less than 20% showed highly severe symptoms (mean disease score ≥4). In the Sudan savannah, highly severe symptoms were observed from 47% of fields visited in 2003. At the ecozone level, the mean severity score was generally 3, ranging from 2.5 in derived savannah to 2.7 in humid forest for 2001, and 1.9 in humid forest to 3.0 in Sudan for 2003 surveys (Table 1).

Prevalence and severity of cassava anthracnose disease (CAD)

Anthracnose disease was recorded only in humid forest and derived savannah ecozones during the two surveys. In humid forest, CAD prevalence was greater than 90% in both 2001 and 2003, while in the derived savannah zone CAD prevalence was 44.7% and 61.5% in 2001 and 2003 respectively (Figure 3a-b).

In 2001, 65.9% and 64.7% of fields in humid forest and

Table 1. Severity[a] of cassava bacterial blight in five agro-ecological zones of Nigeria in 2001 and 2003

	2001				2003			
Ecozones	N	Mean	MS (%)	HS (%)	N	mean	MS (%)	HS (%)
Humid forest	30	2.74	90.00	10.00	28	1.78	100.00	0.00
Derived savannah	30	2.50	93.33	6.67	94	2.24	82.98	17.02
Southern guinea savannah	12	2.68	83.33	16.67	21	2.35	85.71	14.29
Northern guinea savannah	13	2.62	84.62	15.38	10	2.55	90.00	10.00
Sudan savannah	16	2.62	81.25	18.75	17	2.97	52.94	47.06

[a]N is the total number of fields with disease symptoms in each ecozone, moderately severe (MS) 1< mean scores < 4; highly severe (HS) mean scores ≥ 4.
[b]Difference of means, [c] probability of difference of means

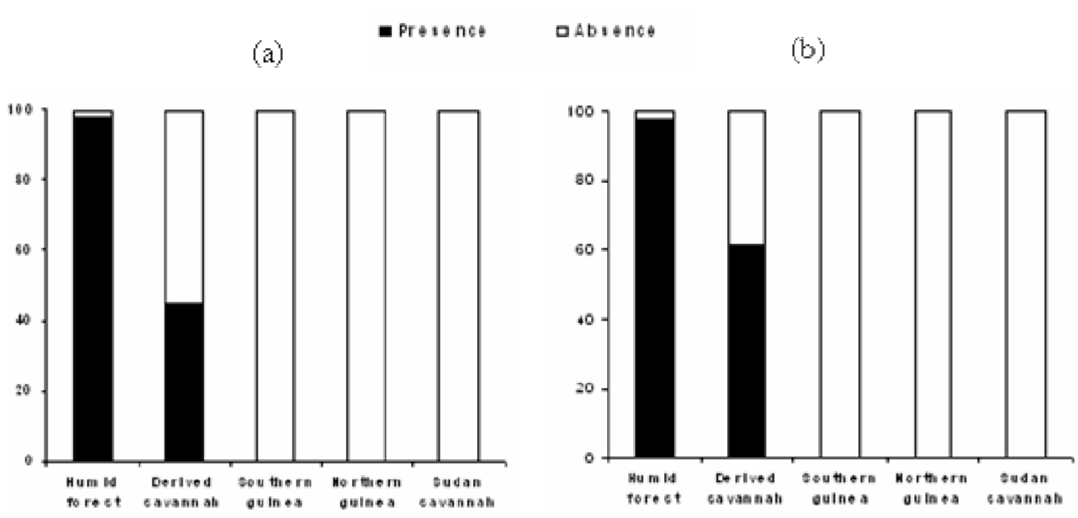

Figure 3. Prevalence of cassava anthracnose disease in five agro-ecological zones of Nigeria in 2001 (a) and 2003 (b)

derived savannah zones respectively had moderately severe CAD symptoms, while 34.1% and 35.3% in the respective zones, had highly severe symptoms. However, during the second survey in 2003, less than 20% of fields visited in both ecozones had highly severe CAD symptoms (Table 2).

Variation in CBB and CAD severities within and across different ecozones in 2003

The distributions of mean severities of both diseases across different states within each ecozone are shown in Figure 4. In humid forest zone, CAD was observed in all states with generally moderately severe symptoms (mean scores 2 - 3) with slight variation across states. CBB was recorded in only six (Rivers, Cross River, Akwa Ibom, Delta, Edo and Ondo) of the twelve states in humid forest with generally low mean severity scores was less than 2.

In derived savannah zone, both CAD and CBB were observed in most of the states with variable mean severities across states. While CBB was not recorded from two states (Enugu and Ebonyi) which are partly derived savannah and partly humid forest, CAD was not recorded from three states (Nasarawa, Plateau and Taraba) which share boundary with southern guinea savannah ecozone. These three states with Kogi state generally had mean disease severities scores less than 2 for both diseases.
States in the three dry savannah zones (southern guinea, northern guinea and Sudan savannas) where only CBB was observed had varying mean CBB severity scores. States in the southern guinea savannah zone generally had mean scores below 3, while states in the northern guinea and Sudan savannah had scores ≥ 3.

Relationship between disease prevalence and climatic variables

The minimum and maximum precipitation for the ecozones ranged from 566.8 – 1327.3 and 1052.0 – 2911 respectively, while the minimum and maximum temperature

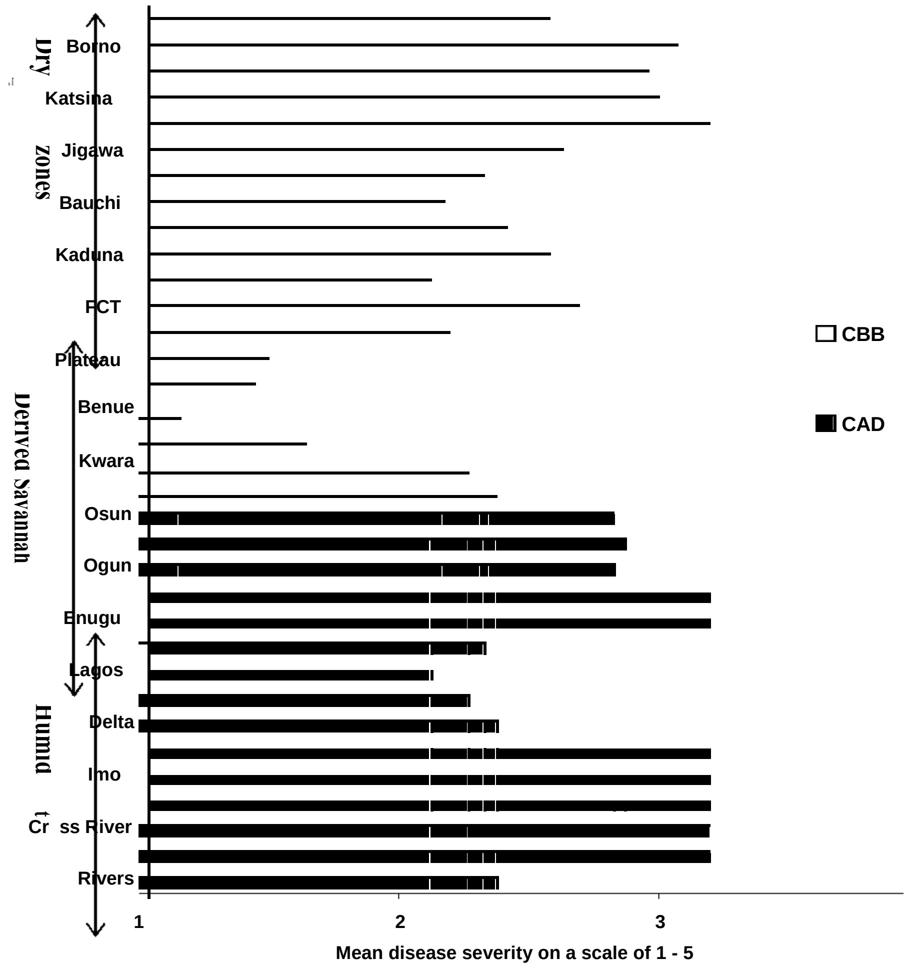

Figure 4. Severity distribution of cassava anthracnose disease (CAD) and cassava bacterial blight (CBB) across different states in different agro-ecological zones of Nigeria in 2003

Table 2. Severity[a] of cassava anthracnose disease in five agro-ecological zones of Nigeria in 2001 and 2003

	2001				2003			
Ecozones	N	Mean	MS(%)	HS(%)	N	Mean	MS(%)	HS(%)
Humid forest	41	3.01	65.85	34.15	81	2.61	86.42	13.58
Derived savannah	17	3.10	64.71	35.29	88	2.54	80.68	19.32
Southern guinea savannah	-	-	-	-	-	-	-	-
Northern guinea savannah	-	-	-	-	-	-	-	-
Sudan savannah	-	-	-	-	-	-	-	-

[a]N is the total number of fields with disease symptoms in each ecozone, moderately severe (MS) 1< mean scores < 4; highly severe (HS) mean scores ≥ 4.
[b]Difference of means, [c] probability of difference of means

ranged from 15 – 18.7 and 31.9 – 35.9 °C respectively (Table 3).

The prevalence of CBB within ecozone was negatively correlated with the mean annual precipitation of the ecozones, while the prevalence of CAD had a strong positive relationship with the annual precipitation (Table 4). There was no significant association between the minimum temperature in the ecozones and the preva-

Table 3. Climatic variables in different agro-ecological zones surveyed for cassava diseases in 2001 and 2003 in Nigeria

	Annual rainfall (mm)		Temperature (°C)	
Zone	Min[b]	Max[c]	Min	Max
Humid forest	1327.3	2911.0	18.7	31.9
Derived savannah	1041.2	2619.9	15.0	34.2
Southern guinea savannah	726.9	1365.5	16.4	35.0
Northern guinea savannah	710.4	1225.2	18.2	35.0
Sudan savannah	566.8	1052.0	18.5	35.9

[a] Number of field surveyed in each ecozone.
[b] Minimum precipitation and temperature,
[c] Maximum precipitation and temperature

Table 4. Person correlation coefficients between climatic characteristics of different agro-ecological zones and prevalence of cassava diseases 2001 and 2003 surveys in Nigeria

	Bacterial blight		Anthracnose	
Climatic Characteristic	2001	2003	2001	2003
Temperature (min)	0.19[ns]	-0.08[ns]	-0.13[ns]	-0.04[ns]
Temperature (max)	0.93*	0.96**	-0.91*	-0.93*
Rainfall (min)	-0.95**	-0.98**	0.98**	0.98**
Rainfall (max)	-0.92*	-0.95*	0.99**	0.98**

** Significant at P = 0.01, * significant at P = 0.05

prevalence of any of the two diseases. However, the mean maximum temperature had a positive correlation with the prevalence of CBB and a negative correlation with the prevalence of CAD.

DISCUSSION

The diagnostic surveys reported in this paper revealed the prevalence and variations in severities of bacterial blight and anthracnose disease of cassava in different ecozones of Nigeria. Prevalence of CBB in the humid forest and derived savannah was significantly lower in the 2003 than in the 2001, which tends to agree with the reported variation in the incidence and severity of CBB across years within a country or an ecozone (Akle and Gnouhoue, 1979; Wydra and Verdier, 2002). This dynamic in CBB occurrence often makes prediction of disease severity and potential yield loss very difficult (Wydra et al., 2001). The two surveys reported in this study however, consistently showed higher prevalence of CBB in the savannah ecozones in comparison to the prevalence of the disease in the humid forest ecozone. This is an indication that CBB is of greater importance in the savannah ecozones of Nigeria. And this is in agreement with the observed distribution of the disease in other African countries (Boher and Agbobli, 1992; Banito et al., 2001; Wydra and Verdier, 2002).

The strong negative correlation of CBB with annual precipitation in different ecozones, and the positive correlation with the maximum temperature also explain the persistence of the disease in the drier savannah than in the humid forest zone. Persley (1979) and Fanou et al. (2001) attributed the prevalence of CBB in the savannah zones to the survival of the causal organism (*X. axonopodis* pv. *manihotis*) in plant debris during the dry season. This situation is better favoured by the dry climatic conditions in the savannah than the humid and moist conditions in the forest zones. Consequently, as cassava cultivation expands to the marginal regions of the savannah ecozones in Nigeria, the severity of CBB is likely to become an increasing constraint.

Another factor that could have contributed to the high incidence of CBB in the savannah zones of Nigeria is the cultivation of a single and often susceptible but popular local cultivar by the farmers in these zones. The only practicable means of controlling CBB is the use of resistant cultivars, and this may have contributed to the suppression of CBB between the 2001 and 2003 surveys, in the humid forest zone where there have been increasing adoption of new cassava hybrids by the farmers in recent time and where an average farm visited had up to 3 cultivar mixture

Cassava anthracnose disease was prevalent in the humid forest and derived savannah zones of Nigeria, while the disease was not recorded in cassava fields in the drier savannah zones. This observation is in accord with the optimal conditions for the development of the pathogen. According to Bruggen et al. (1990), the causal organism of CAD (*Colletotrichum gloeosporioides* f.sp. *manihotis*) requires high humidity of 85 – 90% and optimal temperature of 20 – 28 °C for survival. Such conditions are not common in the drier savannah ecozones of Nigeria. Takatsu and Fukuda (1990) observed that CAD usually appears after a long period of rain and tends to disappear with the approach of the dry season. This is confirmed by the strong negative association between maximum temperature and CAD in this study as well as the observed positive correlation of CAD prevalence with annual precipitation.

Although, Lamptey et al. (2001) reported high incidence and severity of CAD in two locations from the drier ecological zone of Ghana, which are not typical zones for CAD infection. Wydra and Msikita (1998) however, observed that it is possible to confuse stem symptoms caused by CBB with anthracnose cankers. Our observations from the surveys support results obtained from multi-location trials with selected cassava genotypes (Dixon et al., 2002), which showed that CAD was more severe in trial sites located in the humid forest and derived savannah zones, while CBB was more severe in trial sites located in the drier ecozones.

The distribution patterns of the two diseases found in this study provides a baseline for disease management programme in the rapidly expanding cassava industry in Nigeria. These surveys showed that CBB is likely to become an increasing problem as cassava production is rapidly expanding to drier savannah ecozones. Since the use of disease resistant cultivars remains the most economical approach to control of cassava diseases, there is urgent need to intensify the introduction of new improved CBB resistant cultivars to these ecozones where local landraces which are more susceptible to disease were predominant in the surveyed fields. However, the presence of both CAD and CBB in humid forest and derived savannah ecozones, which are the major cassava growing areas in Nigeria, requires multiple disease resistant varieties for the growing cassava industry in Nigeria. The savannah ecozones provide good environment for CBB resistance screening since disease expression is optimal in these zones, while the humid forest zone provides optimal conditions for CAD resistance screening.

Since all major diseases of cassava can be transmitted by planting of infected stems, the availability of disease free stem cuttings is crucial to reducing disease risks in cassava production. The four derived savannah states of Kogi, Benue, Nasarawa and Plateau with very low disease pressures as identified in these surveys provide potential locations for establishment of commercial production of disease free planting materials.

Although, the observed distribution patterns of the diseases in these surveys have been shown to correlate with the variations in climatic conditions of different ecozones, other factors such as cultivars used in different zones, and variation in pathogen isolates from different ecozones (Restrepo and Verdier, 1997) could partly account for the observed variations. Further study is required to elucidate the pathogenic and genetic diversity of pathogen isolates from different ecozones of Nigeria for the two diseases, which will facilitate adequate selection of sources of resistance for cassava breeding.

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