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RESEARCH ARTICLE

ASSESSMENT OF THREE CASSAVA VARIETIES RESPONSES TO CASSAVA BACTERIAL BLIGHT (CBB) IN THE SEVEN AGRO-ECOLOGICAL ZONES OF CÔTE D'IVOIRE DURING A SURVEY IN 2017.

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Abstract

Several cassava varieties are grown in Côte d'Ivoire. Some of them are more widespread than others. Their dissemination depends on characteristics such as yield, taste and dry matter content. Cassava bacterial blight pressure constitutes a threat in all cassava agro-ecological zones. This study aims to survey the widely used varieties and point out the zones where they were more susceptible. The survey took into account the seven agro-ecological zones, the frequency of the varieties presence, the severity index of the disease and the disease incidence. The results showed that three varieties were predominately recorded and are locally known as Akama, Yace and Yavo. Yace was found in all agro-ecological zones. Akama and Yace were abundantly found in the agro-ecological zone 1 and then the agro-ecological zone 4 whereas Yavo was abundantly cropped in the agro-ecological zone 4 and then in the agro-ecological zone 1. Yavo was found more susceptible than Akama and Akama more susceptible than Yace to the disease. The higher rates of severity index and disease incidence were found in the agro-ecological zone 5 and agro-ecological zone 1 for Yavo, the agro-ecological zone 6 and agro-ecological zone 4 for Akama and the agro-ecological zone 6 and agro-ecological zone 1 for Yace, Yace was disease free in the agro-ecological zone 4 and agro-ecological zone 5. Based on these results, it would be necessary to investigate for an efficient control management in order to reduce yield losses due to the high prevalence of Cassava bacterial blight.

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Introduction:-

The Ivorian economy is largely driven by agriculture which contributes up to 22.3 % of the gross domestic product (GDP) and 47% of the country's total exportations (MAAF, 2015 cited by N'Guessan, 2016). Although dependent of coffee and cocoa since 1960s (Ducroquet *et al.*, 2017), the GDP has incremented from 14.1% in 2000 to 15% in

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2001 mainly due to the increase of cassava production (BAFD/OCDE, 2003). The growing interest in cassava cultivation lead to an increase ploughed area from 271,000 hectares in 2000 to 353,000 hectares in 2011. With an increase of 8.5% from 2005 to 2015, its current production was estimated at 4.54 million of tons in 2016 (Minagri, 2012; Mendez del Villar *et al.*, 2018; DPSA/MINADRI/DR cited by APA, 2017). Cassava constitutes an important source of income for producers with a value chain representing almost 12% of the agricultural GDP and 2.8% of the national GDP (N'Zue *et al.*, 2013a; Mendez del Villar *et al.*, 2017). Although cassava cultivation is mainly characterized by small-scale, it is widespread all over the country with its high yields recorded in the forest zone (Mendez del Villar *et al.*, 2018; N'Zue *et al.*, 2013a; N'Zue *et al.*, 2014).

Cassava is naturally drought tolerant, has a greater adaptability to climate and soil, thrives in different texture of soil and can even grow on poor and acid soils, which are often detrimental to other crops such as maize, millet and sorghum. It is also useful for the prevention of hunger through the gradual harvesting of tuberous roots and leaving the surplus in the soil. It is also available throughout the year for households and in times of agricultural and social instability (Burns *et al.*, 2010; PACIR, 2013; Bodnar, 2012; Yao *et al.*, 2013).

The cassava cultivars can be divided into two major groups, the sweet ones and the bitter ones according to the content of hydrocyanic acid which is very high in bitter varieties (Akpingny *et al.*, 2017). This characteristic plays a role in their adaptive resilience to environmental conditions. For instance, according to Perrin *et al.* (2015), some bitter varieties can be grown in some places of the northern part of Côte d'Ivoire whereas the sweet ones cannot. Different cassava varieties, local and improved cultivars are grown in Côte d'Ivoire. Examples of locally well-known varieties Akama (also called 'Six mois' or Kaman), Yace, Tambou and Bonoua (Dje Bi *et al.*, 2018; Perrin *et al.*, 2015). The improved ones are Yavo or TME07, Bocou 1, IM8 and TMS4(2)14254 (Akpingny *et al.*, 2017; Mendez del Villar *et al.*, 2017; N'Zue *et al.*, 2013b). The adoption of these varieties by the growers depend on factors such as yield, taste and semi-industrial processing aspects. The most adopted and cultivated varieties are Yace, Akama, Bonoua and Yavo (Kouassi *et al.*, 2018; Mendez del Villar *et al.*, 2017).

Cassava cultivation is threaten by Cassava bacterial blight (CBB), one of the major worldwide threat to cassava production (Ogunjobi *et al.*, 2010). CBB is responsible for high economic losses up to 100 % of the total production (Restrepo *et al.*, 2000; Mamba-Mbayi *et al.*, 2014). The disease is caused by *Xanthomonas phaseoli* *pv.* *manihotis* (*Xpm*), (Constantin *et al.* 2016). Losses of fresh roots, planting material, low accumulation of starch in edible roots and leaves which affect the availability of leafy vegetables for humans and reduces cash income in communities where cassava leaves are sold, have also been observed and can be high under favourable environmental conditions (Fanou *et al.*, 2018). CBB is present in countries where cassava is produced, but its incidence and severity are variable (Fanou *et al.*, 2017; Fanou *et al.*, 2018). The characteristic symptoms of the disease are the wilting of leaves, blighting, angular leaf lesions and stem cankers, stem and leaf exudates production and dieback of stems (Jorge *et al.*, 2001). Its occurrence depends on the interaction between a susceptible plant, a virulent pathogen and a conducive environment (Ghini *et al.*, 2008; Rana and Randhawa, 2014).

The geographical distribution, incidence and severity of the disease have been studied in some countries like Colombia, Togo and Guinea (Verdier and Restrepo, 1997; Banito *et al.*, 2007; Bamfeka *et al.*, 2011). In Côte d'Ivoire, CBB constitutes a threat in the agro-ecological zones (AEZ), (Affery *et al.*, 2016) with various severities and incidences. Since cassava is an important staple food crop as well as for the producers and for consumers, and the susceptibility of the varieties in the different agro-ecological zones has not yet been assessed, it seemed necessary to identify the most grown varieties and to establish their distribution maps, to highlight their behavior regarding the disease in the different AEZ. It also appears important to classify them according to their level of susceptibility by taking into account their repartition.

Material and methods:-

Survey

Surveys were carried out in 2017 during the rainy seasons from July to the beginning of November in different cassava producing areas of the seven Ivorian agro-ecological zones. These zones (Fig 1A) were identified by Halle and Bruzon (2006) as shown in the Table 1. They were defined according to the edapho-climatic conditions in Côte d'Ivoire. In each AEZ, three fields/area were considered for the high cassava production areas. For areas with very low cassava production, one to two fields were considered. They were chosen at the entrance, in and outside of the locality and their geographical coordinates were recorded using a GPS GARMIN OREGON 550.

Observations:-

Each field was assessed for CBB presence/absence taking into account thirty cassava plants. The meeting point of two diagonal lines was taken as a reference point for the plants assessment. The severity and incidence were evaluated based on assessment sheets. Ten samples of leaves, stems and leafstalks per field showing CBB symptoms were collected. The rating scale of CBB severity described by Wydra and Msikita (1995) was used. The ratings ranged from 1 to 5 and describe as followed: 1: no symptom, 2: only angular leaf spot, 3: angular leaf spots, wilting, blighting, defoliation, and some exudates on stems/leafstalks, 4: blighting of leaves, wilting, defoliation, exudates, and tip die-back, 5: blighting of leaves, wilting, defoliation, exudates, tip die-back, and plant stunting (Figure 5). The severity index (SI) and disease incidence (DI) were calculated for each parcel using following formulas below, used by Mamba-Mbayi *et al.* (2014).

$$SI = \frac{\sum \text{Number of affected plants per scale} \times \text{the scale}}{\text{Total number of observed plants} \times \text{the high scale}} \times 100$$

$$DI = \frac{\text{Number of affected plants}}{\text{Total number of observed plants}} \times 100$$

Data analyses

Statistical analyses were done with the software Rstudio version 3.3 in order to classify the varieties according to their level of susceptibility to CBB, the zones where they more susceptible. The Kruskal-Wallis test with a threshold of 5 % was performed for the comparison of the SI and DI means according to the varieties. These parameters were compared for each field and each AEZ where the varieties were encountered.

Maps have been built by using the software QGIS version 2.18.4 based on the longitudes and latitudes of each field recorded during the survey. A georeferenced map of Côte d'Ivoire was used for the projection of the points.

Results:-

The results of the surveys highlighted that three cassava varieties, Akama, Yace and Yavo were the most grown.

Geographical distribution of the cassava varieties

A total of 249 fields was recorded for the presence of the three varieties during the surveys. The variety Akama was the most encountered with a frequency of 46.59 % (116 fields), followed by Yace with a frequency of 38.55 % (96 fields) and by Yavo with a frequency of 14.86 % (37 fields).

The distribution of these varieties according to the AEZ was not the same. While Yace and Akama were mostly found in the AEZ1 respectively with 55.21 % and 36.21 %, Yavo was more present in the AEZ4 with 48.65 %. Yace was the only variety found in the AEZ7 with 1.04 % considered as the lower rate of presence of the variety. The AEZ3 and 7 were characterized by the absence of Yavo. The lower presence of Akama with 4.31 % was in the AEZ3; while the AEZ6 was characterized by the lower presence of Yavo (5.41 %) (Fig. 1 B, C and D).

Disease repartition on the varieties in the agro-ecological zones

Akama

On the 116 fields where Akama is grown, 67 fields (57.76%) were healthy while 49 fields (42.24%) were affected by CBB. The AEZ4 recorded the most diseased fields followed by the AEZ1 while in the AEZ3, there was no diseased field (Table 2).

Yace

Out of the total of the 96 fields obtained, 62 fields (64.58 %) where Yace is grown were healthy and 34 fields (35.42%) were affected by CBB. The AEZ1 recorded the most diseased fields followed by the AEZ2 whereas the AEZ4 and AEZ5 fields where CBB free (Table 3).

Yavo

Out of the 37 Yavo fields sampled, 15 fields (40.54 %) were healthy while 22 fields (59.46 %) were affected by CBB. The AEZ4 recorded the most diseased fields followed by the AEZ1. However in the AEZ3, there was no diseased field (Table 4).

Varieties behavior

From the agro-ecological zones perspective

The varieties displayed the higher mean of SI and DI in the AEZ6, respectively 17.61 ± 17.34 and 20.74 ± 22.1 . AEZ4 came in the second place with an SI of 17.40 ± 22.35 and DI of 18.43 ± 24.53 . The AEZ5 was the third with 15.28 ± 22.88 for SI, 16.89 ± 27.3 for DI. The Kruskal-Wallis test showed a significant difference for SI and DI in the AEZ with a $p = 0.02$ for both.

Akama

The overall means of Akama for SI and DI were respectively 10.78 ± 17.75 and 11.98 ± 20.34 .

CBB expression on Akama was higher in the AEZ6 and AEZ4. In the AEZ6, the mean of SI was 19.48 ± 19.97 and DI was 21.67 ± 24.88 . In the AEZ4, the means were of 17.78 ± 22.98 for SI and 18.78 ± 25.41 for DI. In the AEZ5, the means of SI and DI were respectively 9.08 ± 13.67 and 9.67 ± 15.35 . In the AEZ2, SI was estimated at 8.12 ± 14.85 and DI at 9.24 ± 17.67 . In the AEZ3, Akama did not showed a susceptibility to CBB (Fig 2 A and B). SI and DI showed a significant difference between the AEZ with $p_{SI} = 0.03$ and $p_{DI} = 0.04$.

Yace

The average SI and DI of Yace was respectively 9.5 ± 19.66 , 10.25 ± 21.06 .

While Yace didn't show any susceptibility to Cassava Bacterial Blight in both AEZ4 and AEZ5, it was more susceptible in AEZ6 with SI and DI respectively equals to 16.6 ± 16.79 and 20.83 ± 22.3 . In AEZ1, SI was of 12.15 ± 23.92 and 12.77 ± 25.08 for DI. SI and DI in AEZ2 were respectively 5.28 ± 13.09 and 5.37 ± 13.24 . It was less susceptible in the AEZ3 and AEZ7. In the AEZ7, the relative SI and DI were both 3.33. In the AEZ3, Yace presented the lower rate of susceptibility with SI of 2.78 ± 3.93 and DI of 3 ± 4.29 (Fig 3 A and B). There was no significant differences between the susceptibility of Yace in the AEZ with $p_{SI} = 0.45$, DI with $p_{DI} = 0.41$.

Yavo

Yavo presented overall means of SI and DI respectively equal to 19.61 ± 21.82 and 21.23 ± 24.67 . SI and DI were the higher ones in the AEZ5 with respective averages of 46.11 ± 31.2 and 52.22 ± 41.68 . In the AEZ4, SI and DI were respectively estimated at 18.99 ± 22.14 and 20.18 ± 24.07 . SI was estimated at 16.39 ± 24.11 in the AEZ1 whereas DI was 18.15 ± 26.83 . In the AEZ6, the means of SI and DI were respectively 13.89 ± 2.55 and 15.56 ± 1.93 . In the AEZ2, the relative SI and DI were both equal to 12.78 ± 10.63 (Fig 4 A and B). There was no significant differences between the susceptibility of Yavo in the AEZ with $p_{SI} = 0.45$, DI with $p_{DI} = 0.44$.

SI and DI of the varieties were significantly different with respectively $p_{SI} = 0.007$, $p_{DI} = 0.009$.

Discussion:-

According to Kouassi *et al.* (2018) and Mendez del Villar *et al.* (2017) Yace, Akama, Yavo and Bonoua are the more disseminated cassava varieties in Côte d'Ivoire. The findings of this study indicated that the first three varieties were more disseminated than Bonoua. The dissemination of these varieties could be related to their yield, the taste, the processing aspects and the dry matter yield as mentioned by Kouassi *et al.* (2018), Mendez del Villar *et al.* (2017) and Perrin *et al.* (2015). Even though Perrin *et al.* (2015) stated that Yavo was largely disseminated, the results of this study showed that it was less disseminated than Akama and Yace.

Although Akama was more widespread than the others, it was not found in the AEZ7 while Yace was found in all the AEZ and Yavo was not found in both AEZ3 and 7. Yace has been described as a bitter variety while Yavo has been described as a sweet variety by Akpingny *et al.* (2017). Akama was described as a sweet variety by the farmers surveyed. These facts could explain their distribution. Indeed, Perrin *et al.* (2015) stated that the varieties' ability to adapt themselves to the climatic conditions was also related to their bitterness feature. According to these authors, some bitter varieties can be cultivated in some northern parts of Côte d'Ivoire while the sweet ones cannot be grown there. This fact could explained the presence of Yace, a bitter variety in the AEZ6 and 7 and the absence of Akama and Yavo, sweet varieties in the AEZ7. However, unlike to what they said, Akama and Yavo were grown in the AEZ6 even if it was at lower rates. This finding could be explained by the fact that Akama and Yavo are in a process of adaptation to a new and hostile environment as said by Coakley *et al.* (1999). According to these authors, the repartition and development of the plants were going to change under climate change.

Akama was mostly found in the AEZ1 followed by the AEZ4 and the AEZ2. Its lower occurrence was in the AEZ3 followed by the AEZ6. Yace distribution was mostly concentrated in the AEZ1, followed by AEZ2 and the AEZ3. Its lower rates were found respectively in the AEZ7, AEZ5 and AEZ4. Yavo was more widespread in the AEZ4 then

in the AEZ1 and AEZ2. It was less widespread in the AEZ6 and AEZ5. Akpingny *et al.* (2017) mentioned that Yace has high production zones were in the southern (predominantly) and the central parts of Côte d'Ivoire; however, in this study, Yace was more widespread in the western part than in the central part. Yavo distribution is consistent with Akpingny *et al.* (2017); it was more present in the central, eastern and southern parts.

Concerning the susceptibility of the varieties, Yavo described as resistant to cassava mosaic virus (Perrin *et al.*, 2015; Akpingny *et al.*, 2017) was the most susceptible to CBB. Akama was the second susceptible variety while Yace showed a lower susceptibility.

The higher rates of Yace and Yavo diseased fields were found in AEZ where they mostly occurred: AEZ1, AEZ2 and AEZ3 for Yace and AEZ4, AEZ1 and AEZ2 for Yavo. This findings are consistent with the statements of Coakley *et al.* (1999) who stated that the distribution of the pathogen would followed those of the host. However, the AEZ6 and AEZ3 displayed the same rate of Yace diseased fields whereas the AEZ5 and AEZ2 showed the same rate of Yavo diseased fields. These results could be explained by the rapid change in *Xpm* strains distribution as highlighted by Shaw and Osborne (2011). Although Akama was mostly found in the AEZ1 and then in the AEZ4, the majority of diseased fields were found in the AEZ4, then secondly in the AEZ1 and lastly followed by the AEZ2. The AEZ5 and AEZ6 had the same rate of diseased fields. This may be due to the fact that the pathogen was able to be quickly widespread in the AEZ4 than the AEZ1 leading to a higher rate of diseased fields in the AEZ4.

By considering all the AEZ, the AEZ6 recorded the higher rates of varieties susceptibility in term of SI and DI. It could be explained by the fact that the pathogen achieved its complete cycle. In fact, according to Fanou *et al.* (2018), *Xpm* goes through a survival stage during the dry season for the establishment of the primary inoculum and a parasitic stage during the rainy season where the disease symptoms occur. In Côte d'Ivoire, the AEZ6 has two seasons, a six months dry season and a six months rainy season. The pathogen could have hence had conducive environmental conditions to cause the infection on non-resistant varieties. In the AEZ4 which got the higher SI and DI rates after the AEZ6, there are two dry and two rainy seasons, corresponding to a set of conditions less favourable for the pathogen survival. However, the pathogen was able to cause disease. This finding could be attributed to a reduction of the incubation time as mentioned by Ahanger *et al.* (2013). The rates of CBB on the varieties in the AEZ5 could be justified by the stressful environmental conditions on both the varieties and the pathogen. According to Yáñez-López *et al.* (2012), the incidence and severity of a plant disease depend on the deviation of the climatic parameters taken separately into the best conditions for the disease occurrence. According to Shaw and Osborne (2011), the persistence of plant pathogens can be infrequent or regular with a low severity in regions without being a threat for producers in these zones. This fact could explained the low impact of CBB on the varieties in the AEZ3 but also the adverse climatic conditions that prevailed there. This AEZ is characterized by a long rainy season and a short dry season that would have reduced the survival and the quantity of primary inoculum, hence the expression of the disease.

Akama and Yace were mostly susceptible in the AEZ6 but Akama was more susceptible than Yace in this AEZ. Although Yavo was also susceptible in the AEZ6, its SI and DI were lower than those of the two other varieties. Nevertheless, it was mostly susceptible to the disease in the AEZ5. It could be explained by the compatible host interaction where the bacteria strains penetrate into cassava and overcome host defense barriers causing the characteristic symptoms of the disease (Hamza, 2010). It seemed in this AEZ that this interaction was strong to cause hence a high CBB severity on the variety. In fact, Yavo susceptibility reached the higher levels of susceptibility while Yace didn't show a susceptibility to CBB. The absence of Yace susceptibility to CBB in the AEZ4 and AEZ5 could be due to the incompatible host interaction where bacteria strains would have been unable to overcome cassava varieties defense reactions (Fargier, 2007; Hamza, 2010). Yavo and Akama susceptibility to CBB was secondarily higher in the AEZ4 with the high rates recorded in Yavo fields. While Yace was secondarily susceptible in the AEZ1, Yavo was thirdly susceptible in the same AEZ with higher rates. The level of each variety susceptibility varied according to the AEZ. This behaviour regarding the disease in each AEZ could be explained by the interaction between the environment and the genotype as described by Zinsou *et al.* (2005). In fact, according to Elad and Pertot (2012), plants proceed to the regulation of their genes due to the modifications of their environment patterns. Though in the AEZ6, Yace and Akama had the higher susceptibility rates than those of Yavo, its susceptibility was very high than the two other varieties in the AEZ where they were all together. This is in contradiction to what Tindo *et al.* (2016) found in their study which showed that local varieties were most attacked and susceptible to CBB than improved varieties.

Conclusion:-

This study showed the geographical repartition of the three cassava varieties assessed and also the most widespread in Côte d'Ivoire. It also showed that the local ones (Akama and Yace) were still very much accepted than the improved one (Yavo). The presence of Akama and Yavo considered as sweet varieties in the AEZ6 help to understand that the geographical distribution of the varieties is changing. The varieties are in a process of adaptation in a new environment previously defined as unfavourable for their growth. Except Yace which didn't show a susceptibility to CBB in the AEZ4 and AEZ5, the others were susceptible in all the AEZ where they were found at different rates. Yavo was the most susceptible in all AEZ excluding in the AEZ6 where it was less susceptible than Akama and Yace; however, the varieties susceptibility differed from one AEZ to another. The AEZ6 was characterized by the high level of Akama and Yace susceptibility while the AEZ5 was characterized by those of Yavo susceptibility. These zones were followed by the AEZ4 for Akama and Yavo and the AEZ1 for Yace. This behaviour in the AEZ pointed out an interaction between the varieties, the pathogen and the environment. Since these factors seems to affect the relationship between the disease and the varieties, it would be important to test these varieties for other control strategies in order to prevent yield losses due to the strong pressure of CBB.

Ethics approval and consent to participate'Not applicable' for this section.

Availability of data and materials

All data generated or analysed during this study are included in this published article

Competing interests

The authors declare that they have no competing interests.

Authors' contributions

Howele Michaëlle Andree Celestine Toure and Daouda Kone conceptualised the work. Howele Michaëlle Andree Celestine Toure and Kouadio Jean Nestor Ehui realised the study. Kouamenan Abo, Arthur Marthurin Affery and Daouda Kone read and approved the final manuscript.

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Table 1:-Description of the season in Côte d'Ivoire (EDSCI-II, 1999; FAO, 2005) and Characteristics of the seven agroecological zones by Halle and Bruzon (2006) where VZ= Vegetative zones; F= Forest, T= Transition; S=Savannah; AEZ= Agro-Ecological Zones; SDS= Short Dry Season; LRS= Long Rainy Season; LDS= Long Dry season; SRS= Short Rainy Season.

AE Z	V Z	Characteristics	Altitude (m)	Rainfall (mm)	Annual Temperature (°C)	SDS	LRS	LDS	SRS
1	F	Southern humid dense forest area	0-200	1400-2500	29 (5.6)	July-August	April-July	December-March	September - November
2	F	Wet dense forest area of the west	~1000 (Daloa)	1300-1750	23.5 (13.4)	July-August	April-July	December-March	September - November
3	F	Semi-mountainous forest area of West	> 1000 (Man)	1300-2300	24.5 (7.7)	November-February	March-October		
4	F	Semi humid dense forest zone deciduous	0-200	1300-1750	23.5 (13.4)	July-August	April-July	December-March	September - November
5	T	Transitional forest area	300-600	1300-1750	23.5 (13.4)	July-August	March-June	November - February	September - October

6	S	Tropical humid savanna zone	300-500	1150-1350	26.7 (1.1)		May-October	November-April	
7	S	Dry tropical savanna zone	300-500	1150-1350	26.7 (1.1)		May-October	November-April	

AEZ	Number of Healthy Fields	Relative Frequency (%)	Number of Diseased fields	Relative Frequency (%)
1	29	43.28	13	26.53
2	13	19.4	7	14.29
3	5	7.46	0	0
4	14	20.9	17	34.69
5	4	5.97	6	12.24
6	2	2.99	6	12.24

Table 2:-Sanitary characteristics of the fields where Akama is grown

Table 3:-Sanitary characteristics of the fields where Yace is grown

AEZ	Number of Healthy Fields	Relative Frequency (%)	Number of Diseased fields	Relative Frequency (%)
1	33	53.23	20	26.53
2	14	22.58	5	14.29
3	7	11.29	4	11.76
4	3	4.84	0	0
5	2	3.22	0	0
6	3	4.84	4	11.76
7	0	0	1	3

Table 4:-Sanitary characteristics of the fields where Yavo is grown

AEZ	Number of Healthy Fields	Relative Frequency (%)	Number of Diseased fields	Relative Frequency (%)
1	5	33.33	4	18.11
2	2	13.34	3	13.64
3	0	0	0	0
4	8	53.33	10	45.45
5	0	0	3	13.64
6	0	0	2	9.1

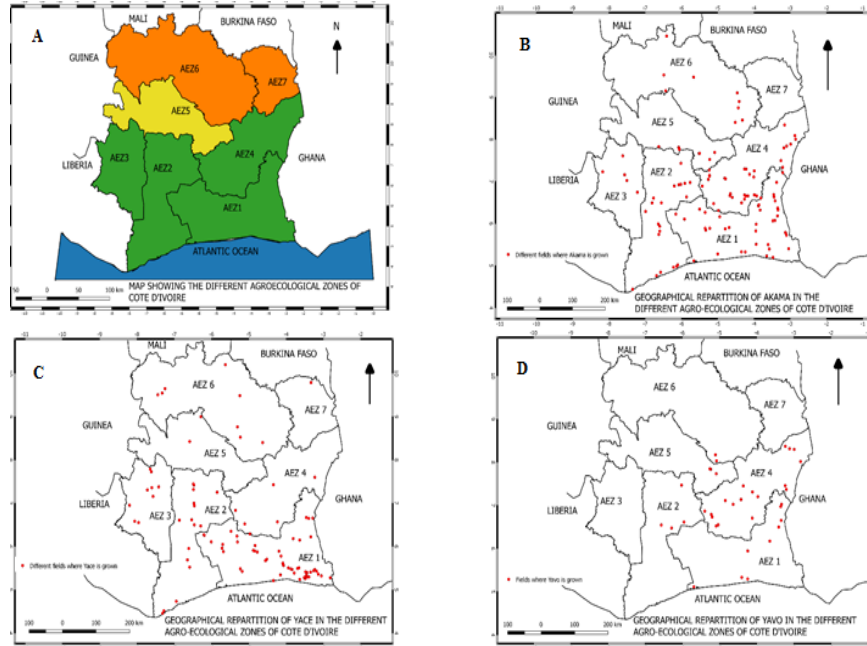


Fig 1:- A: Agro-ecological zones of Côte d'Ivoire based on Bruzon and Halle description. B, C and D: Respective geographical distributions of Akama, Yace and Yavo in the seven Agro-ecological zones of Côte d'Ivoire

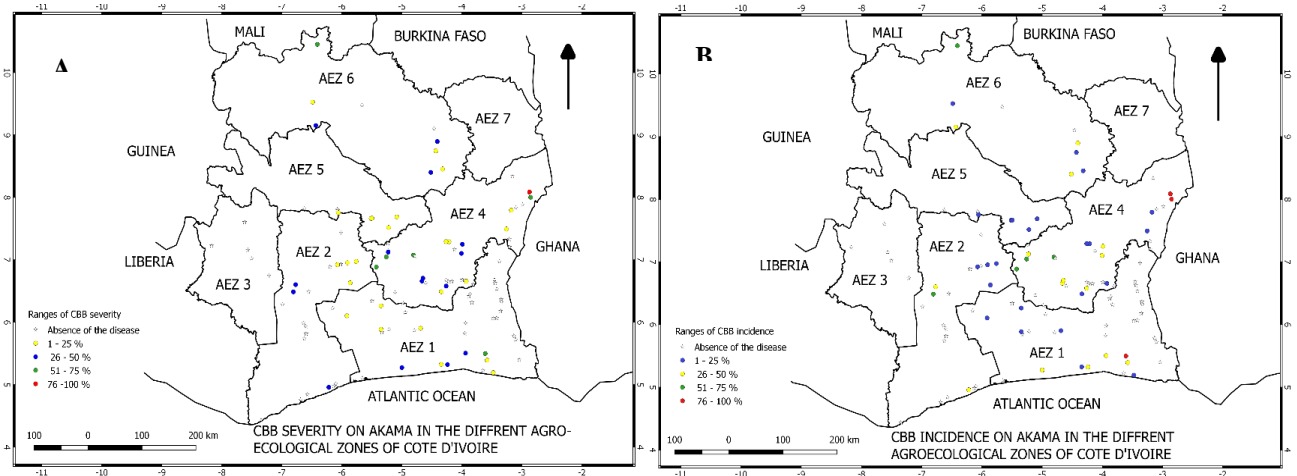


Fig 2. A :-Repartition of cassava bacterial blight severity in the fields where Akama is grown. **B :** Repartition of cassava bacterial blight incidence in the fields where Akama is grown

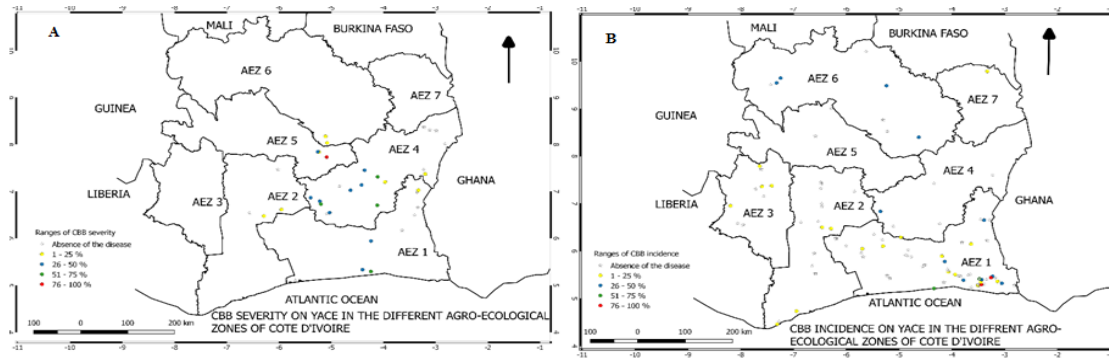


Fig 3. A :-Repartition of cassava bacterial blight severity in the fields where Yace is grown. **B :** Repartition of cassava bacterial blight incidence in the fields where Yace is grown

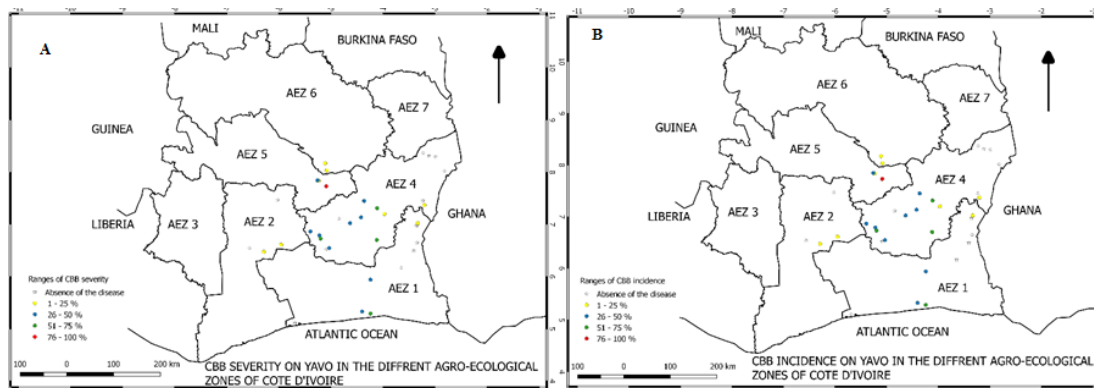


Fig 4:-A : Repartition of cassava bacterial blight severity in the fields where Yavo is grown. **B :** Repartition of cassava bacterial blight incidence in the fields where Yavo is grown

References:-

1. Affery, A.M., Abo, K., Tuo, S., N'Zue, B. and Kone, D. (2016): Geographical Distribution and Incidence of Cassava Bacterial Blight (*Manihot esculenta* Crantz) Caused by *Xanthomonas axonopodis* pv. *manihotis* in Two Agro-ecological Zones of Côte d'Ivoire. *Plant Pathol. J.*, 16 (1): 1-11.
2. Ahanger, R.A., Bhat, H.A., Bhat, T.A., Ganie, S.A., Lone, A.A., Wani, I.A., Ganai, S.A., Haq, S., Khan, O.A., Junaid, J.M. and Bhat, T.A. (2013): Impact of Climate Change on Plant Diseases. *Int J Modern Plant Anim. Sci.*, 1(3): 105-115.
3. Akpingny, K.L.D., Koulou, N.Y. and Okou, W.C.A. (2017): Fiche technicoéconomique du MANIOC. Agence Nationale d'Appui au Développement Rural (ANADER). Direction d'Appui aux Filières Agricoles., 2 :8.
4. APA (Agence Presse Africaine). (2017): Production du manioc en Côte d'Ivoire., <http://apanews.net/fr>.
5. BAFD/OCDE. (2003): «Côte d'Ivoire», Perspectives économiques en Afrique. Certificat d'aptitude aux fonctions de directeur des réceptions collectives de mineurs/Organisation de coopération et de développement économiques, 4, 6:14.
6. Bamkefa, B.A., Bah, E.S. and Dixon A.G.O. (2011): Survey of the current distribution and status of bacterial blight and fungal diseases of cassava in Guinea. *Afr. J. Root and Tuber Crops.*, 1-5.
7. Banito, A., Verdier, V., Kpémoua, K.E. and Wydra, K (2007): Assessment of major cassava diseases in Togo in relation to agronomic and environmental characteristics in a systems approach. *Afr. J. Agric. Res.*, 418-428.
8. Bodnar, A.M. (2012): Function of cassava bacterial blight in TALE1 *Xam*: A transcriptomic approach. Universidad Nacional de Colombia. Facultad de ciencia, Biología Departamento de Bogotá, Colombia., 18, 24: 178.
9. Coakley, S.M., Scherm, H. and Chakraborty, S. (1999): Climate change and plant disease management. *Annu. Rev. Phytopathol.*, 399-426.

10. Constantin, E.C., Cleenwerck, I., Maes, M., Baeyen, S., Van Malderghem, C. and De Vos, P. (2016): Genetic characterization of strains named as *Xanthomonas axonopodis* pv. *dieffenbachiae* leads to a taxonomic revision of the *X. axonopodis* species complex. *Plant pathol.*, 65, 792–806.
11. Dje Bi, I.R., Kouassi, K.I., Koffi, K.K., Kouakou, K.L., Baudoin, J.P. and Zoro Bi, I.A. (2018): Evaluation of cassava varieties for weed tolerance ability, *Experimental Agriculture*. Cambridge University., 443–451.
12. DPSA/MINADRI/DR (Direction de la Production et de la Sécurité Alimentaire du Ministère Ivoirien de l'Agriculture et du Développement Rural). (2017): *Annuaire des Statistiques Agricoles*.
13. Ducroquet, H., Tillie, P., Louhichi, K. and Gomez-Y-Paloma, S. (2017) *L'agriculture de la Côte d'Ivoire à la loupe: Etat des lieux des filières de production végétales et animales et revue des politiques agricoles*. EUR 28754 FR. 2017, 1-244.
14. Elad, Y. and Pertot, I. (2014): *Climate Change Impacts on Plant Pathogens and Plant Diseases*. *J. Crop Improv.*, 28:99–139.
15. Fanou, A.A., Zinsou, V.A. and Wydra K. (2017): Survival of *Xanthomonas axonopodis* pv. *manihotis* in weed species and in cassava debris: Implication in the epidemiology of cassava bacterial blight. *Int. J. Adv. Res.*, 5(4), 2098-2112.
16. Fanou, A.A., Zinsou, V.A. and Wydra, K. (2018): *Cassava Bacterial Blight: A Devastating Disease of Cassava*. IntechOpen., 1-25.
17. Fargier, E. (2007) *The study of the pathology of Xanthomonas campestris and the nature of the genetic structure of its pathovars allowed the improvement of pathogen detection in seeds of Brassicaceae*, Doctoral School of ANGERS., 65, 66-67: 236.
18. Ghini, R., Hamada, E. and Bettiol, W. (2008): *Climate change and plant diseases*. *Sci. Agric. (Piracicaba, Braz.)*, 98-107.
19. Halle, B. and Bruzon, V. (2006): *Profil Environnemental de la Côte d'Ivoire*. Commission Européenne, Offre de service dans le secteur de la coopération relatif au: Contrat Cadre Europe Aid/119860/C/SV/Multi, Consortium AGRIFOR Consult. Rapport final., 133.
20. Hamza, A.A. (2010): *Taxonomy and diagnosis of Xanthomonas species associated with scabies of tomato and Capsicum spp.: situation in the South West Islands of the Ocean Indian*. University of Reunion, Faculty of Science and Technology, UMR Peuplements Plants and Bio-agresseurs in Tropical Environment CIRAD - University of Reunion., 33, 34: 234.
21. Kouassi, K.M., Mahyao, A., N'zue, B., Koffi, E. and Koffi, C. (2018): *Status of Cassava (Manihot Esculenta Crantz) in Côte d'Ivoire: From Production to Consumption and Evaluation of Technology Adoption*. *Eur. Sci. J.*, 1-15.
22. MAAF (Ministère de l'Agriculture, l'Agroalimentaire et de la Forêt Agricolaire). (2015): *Les politiques agricoles à travers le monde: quelques exemples*. Côte d'Ivoire., 1-10.
23. Mamba-Mbayi, G., Tshilenge-Djim, P., Nkongolo, K.K. and Kalonji-Mbuyi, A. (2014): *Characterization of Congolese Strains of Xanthomonas axonopodis pv. manihotis associated with Cassava Bacterial Blight*. *Am. J. Plant Sci.*, 5, 1191-1201.
24. Mendez del Villar, P., Adaye, A., Tran, T., Allagba, K. and Bancal, V. (2017): *Analyse de la chaîne de Manioc en Côte d'Ivoire*. Rapport pour l'Union Européenne, DG-DEVCO. Value Chain Analysis for Development Project (VCA4D CTR 2016/375-804), 157p + annexes.
25. Mendez del Villar, P., Adaye, A., Tran, T., Allagba, K. and Bancal, V. (2018): *Analyse de la chaîne de Manioc en Côte d'Ivoire*. Rapport pour l'Union Européenne, DG-DEVCO. Value Chain Analysis for Development Project (VCA4D) N°3 – Janvier., 4:6.
26. Minagri (Ministère de l'Agriculture de la Côte d'Ivoire). (2012): *Annuaire des statistiques agricoles*.
27. N'Guessan, M.S.A. (2016): *Projet de création d'une société industrielle de transformation du manioc en produits dérivés en Côte d'Ivoire: Elohim Transformation, Centre Africain d'études Supérieures en Gestion (CESAG)*. Master en Banque et Finance (MBF) Option : Gestion Bancaire et Maitrise des risques, *Projet Professionnel.*, 7:55.
28. N'Zue, B., Bouan, B., Dibi, K.E.B., Kouakou, A.M., Djedji, C., Kouassi, K.F., Zohouri, G.P., and Ehounou, E. (2013a): *Activity Report Q1 2013. PSTAD (DONATA)*. CNRA, www.cnra.ci, Côte d'Ivoire., 7.
29. N'Zue, B., Zohouri, G.P., Djedji, C., Tahouo, O., Keli, J. and Beninga, M.B. (2013b): *Bien cultiver le manioc en Côte d'Ivoire*. Direction des programmes de recherche et de l'appui au développement - Direction des systèmes d'information, Centre national de recherche agronomique (CNRA)., 1:4.
30. N'Zue, B., Okoma, M.P., Kouakou, A.M., Dibi, K.E.B., Zohouri, G.P., Essis, B.S. and Dansi, A.A. (2014): *Morphological Characterization of Cassava (Manihot esculenta Crantz) Accessions Collected in the Centre-west, South-west and West of Côte d'Ivoire*. *Greener J. Agric. Sci.*, 4(6):220-231.

31. Ogunjobi, A.A., Fagade, O.E., Dixon, A.G.O. and Bandyopadhyay, R. (2010): Assessment of large population of cassava accessions for resistant to cassava bacterial blight infection in the screen house environment. *J. Agric. Biotech. Sustain. Dev.*, 50:132-138.
32. Perrin, A., Ricau, P. and Rongead, C.R. (2015): Study of the sector Cassava in Côte d'Ivoire. Project "Promotion and Marketing of Plantain Banana and Cassava in Côte d'Ivoire » funded by the French Committee for Solidarity International (CFSI)., 84.
33. Rana, I. and Randhawa, S.S. (2014): Impact of Climate variations on Plant Diseases. State Centre on Climate Change (H.P State Council for Science Technology & Environment) Block-34. SDA Complex, Kusumpti, Shimla (H.P)-71009., 1-20.
34. Restrepo, S., Vélez, C.M., and Verdier, V. (2000): Measuring the Genetic Diversity of *Xanthomonas axonopodis* pv. *manihotis* in Different Fields in Colombia. *Phytopathol.*, 90, 683: 683-690.
35. Shaw, M.W. and Osborne, T.M. (2011): Geographic distribution of plant pathogens in response to climate change. *Plant Pathol.*, 60, 31–43.
36. Tindo, M., Njukwe, E., Mbairanodji, A. and Tenkouano, A. (2016): Survey on the current diseases status of local versus improved cassava varieties and their management strategies in Cameroon. *Sciences, Technologies et Développement.*; <http://www.univ-douala.com/std/>.
37. Verdier, V. and Restrepo, S. (1997): Répartition géographique de la bactériose vasculaire du manioc en Colombie et variabilité de l'agent pathogène. Dossier : racines, tubercules et plantains n°2. *Les cahiers de le Recherche Développement* n°44, 1-11.
38. Wydra, K. and Msikita, W. (1995): An overview of the present situation of cassava diseases in West Africa. In: *Proceedings of the 6th ISTRC-AB Symposium, Lilongwe, Malawi. October 22–28 1995 (in press)*, 198-206.
39. Yáñez-López, R., Torres-Pacheco, I., Guevara-González, R.G., Hernández-Zul, M.I., Quijano-Carranza, J.A. and Rico-García, E. (2012): The effect of climate change on plant diseases. *Afric. J. Biotech.*, 2417-2428.
40. Yao, N.R., Oule, A.F. and N'Goran, K.D. (2013): Study of the Vulnerability of the Agricultural Sector to Climate Change in Côte d'Ivoire. *Final Report.*, 53: 105.
41. Zinsou, V., Wydra, K., Ahohuendo, B. and Hau, B. (2005): Genotype environment interactions in symptom development and yield of cassava genotypes with artificial and natural cassava bacterial blight infections. *Eur. J. Plant Pathol.*, 111: 217–233.