American Journal of Plant Physiology

ISSN 1557-4539

Academic Journals Inc.

www.academicjournals.com

American Journal of Plant Physiology 7 (5): 200-211, 2012
ISSN 1557-4539 / DOI: 10.3923/ajpp.2012.200.211

Cassava Mosaic Disease Transmission by Whiteflies (*Bemisia tabaci* Genn.) and its Development on Some Plots of Cassava (*Manihot esculenta* Crantz) Clones Planted at Different Dates in Togo

[1]K.D. Adjata, [2]T. Tchacondo, [1]K. Tchansi, [1]E. Banla and [1]Y.M.D. Gumedzoe
[1]Laboratory of Plant Virology and Biotechnology, High School of Agriculture, University of Lomé, B.P. 1515, Lomé, Togo
[2]High School of Biological and Food Techniques, University of Lomé (ESTBA-UL), B.P. 1515, Lomé, Togo

Corresponding Author: K.D. Adjata, Laboratory of Plant Virology and Biotechnology, High School of Agriculture, University of Lomé, B.P. 1515, Lomé, Togo

ABSTRACT

A study was carried out to determine the effect of planting date on Cassava Mosaic Disease (CMD) transmission by white flies (*Bemisia tabaci*) and its development in a population of cassava clones selected at Lomé Agricultural Experimental Station (LAES) of the High School of Agriculture, University of Lomé in order to contribute in the search of a strategy of effective control of CMD in Togo. To achieve this goal, cassava clones resulting from seeds of the third generation (F_3) were planted at different dates on plots P_1, P_2 and P_3 with the interval of 21 days. Three weeks after the establishment of the planted seedlings, data assessment was initiated weekly during twenty weeks. And the measured parameters were: (i) weekly counting of whitefly population on seedlings per plot of 114 m^2 and (ii) weekly visual observation to quantify the diseased seedlings according to an assessing note on the severity of the disease ranging from 1 to 5. The results obtained from the visual observations made during this study, revealed that the propagation of the disease on each plot of the evaluated clones is proportional to the size of the population of vectors in presence. Thus, three months after plantation, it was numbered 53% diseased individuals ($p<0.05$) among the population of cassava clones; at the same time, the population of whiteflies reached an average 1.49±5.23 to 7.83±12.81 individuals by cassava seedlings under the conditions of this work. It was observed that the most significant number of whiteflies was noted on the plots P_2 and P_3. It was noticed that the plot P_3 which was installed six weeks after plot P_1, 41% of the seedlings died ($p<0.05$) due to the infestations of eggs and the larvae of whiteflies.

Key words: *Bemisia tabaci*, clones, disease, mosaic, propagation, transmission

INTRODUCTION

Cassava (*Manihot esculenta* Crantz) figures among the main starchy root plants in Africa and in Asia (Legg and Fauquet, 2004; Saunders *et al*., 2002). Cassava is by order of importance, the fourth staple food in the world, with a production estimated at 242 millions of tones in 2009 (FAO, 2009). At the same time, Africa alone produces 121.5 million tones (FAO, 2009). It is a food crop for nearly billions of people in the world where it provides the third of daily calories. Its potential is enormous, at the present time, the average yields of cassava are barely 20% of those obtained under optimum conditions (FAO, 2008). In Togo, the yields have decreased from 2004 till 2007,

respectively to 10.13; 9.277; 9.277 and 8,119 t ha^{-1} (FAO, 2003). That is to say, in four years, there was a decrease of 2.019 t ha^{-1}. Apart the abiotic factors, these falls of outputs are ascribable to the negative effects of devastating insects and the viral diseases. Among the devastating insects, whiteflies (*Bemisia tabaci* Gen.), both nymph (juvenile stages) and adult whitefly cause direct damage when they suck plant juices, resulting in a reduction in the strength of the attacked plants. During heavy feeding, both whitefly adult and nymph stages feed by sucking plant juices noticeable by sticky honeydew excreted by these insects which glazes both the upper and lower leaf surfaces, permitting the development of black sooty mold fungus (Martin, 1999). Also whiteflies inject saliva which contains toxins disturbing the physiological activity of the plant and consequently reducing the yield (Adjata *et al*., 2011). Besides the direct damage which is not the least, is added indirect damage which is even more damaging; this indirect damage occurs when sticky honeydew secretions grow sooty moulds that block photosynthesis (Martin, 1999). The indirect damage is of two types: development of the honeydew and mycelium of fungus and the transmission of viral diseases. The secretion of the honeydew during sap sucking triggers the growth of black colored mycelia covering all surfaces of the leaves, causing a negative impact on photosynthesis and might cause a yield loss. The whiteflies transmit *Begomovirus* which is the most alarming disease at present in Togo, as in the case of the ACMV (African Cassava Mosaic Virus), EACMV (East African Cassava Mosaic Virus) and UgV/Tg (Uganda Variant of East African Cassava Mosaic Virus) (Adjata *et al*., 2009). Disease plant manifests simple discolorations of the leaves until completely modified (Adjata *et al*., 2008). Studies on the causes of reduced cassava production revealed that the losses inherent in the damage caused by cassava *Begomovirus* mosaic disease (CBMD) occupy a very significant part and can cause a loss ranging from 20 to 100% (Brown and Bird, 1992). It was shown that the diffusion of cassava mosaic disease in space and in time is due to whiteflies (*B. tabaci*) which are the natural vectors of cassava *Begomovirus* (Fauquet and Fargette, 1990). The knowledge on whitefly-related crop production problems has significantly increased in the past two decades and young plants are more susceptible to damage by whiteflies and whitefly-transmitted viruses. In a standpoint of searching for an effective strategy to fight CMD, whiteflies could be used to screen resistant clones in a selection program. This study was therefore, undertaken to determine the effect of different planting dates of cassava seedlings on the development of cassava mosaic disease epidemics under the variation of *B. tabaci* population with the goal of acquiring data that may facilitate the screening of cassava selected clones resistant to CMD in field conditions.

MATERIALS AND METHODS

Plant material: The plant materials used in this study were cassava clones resulting from cassava seeds (F_3) under the program of selection with respect to resistance to Cassava Mosaic Disease (CMD) at Lomé Agricultural Experimental Station (LAES), High School of Agriculture, University of Lomé.

Animal material: It is stated that *B. tabaci* is the only known vector of begomoviruses worldwide (Bird and Maramorosh, 1978; Bedford *et al*., 1994). So, to determine the effect of different planting dates of cassava seedlings on the development of cassava mosaic disease epidemics under the variation of *B. tabaci* population with the goal of acquiring data that may facilitate the screening of cassava selected clones resistant to CMD in field conditions, *B. tabaci* was the only animal material we considered in our evaluation of its effect on the field.

Some other materials used in the implementation of this work are in particular a magnifying glass to observe the various larval stages of the whiteflies and cages to maintain cassava seedlings free from any contact with *B. tabaci*.

Experimentation: To determine the effect of different planting dates of cassava seedlings on the development of cassava mosaic disease epidemics under the variation of *B. tabaci* population with the goal of acquiring data that may facilitate the screening of cassava selected clones resistant to CMD in field conditions, field experiments were composed of three blocks planted at three different planting dates at 21 days interval of cassava seedlings of 21 days old, resulting from seeds. Thus, cassava seedlings of 21 days old were successively planted at 01/06/09; 22/06/09 and 13/07/2009 on plots P_1, P_2 and P_3 at Lomé Agricultural Experimental Station (LAES) of the High School of Agriculture, University of Lomé. The seedlings were spaced from each other of 1×1 m. Each plot corresponds to a block of 20 on 8 m and separate from each other by an alley of 1.5 m. The operations of plow and maintenance were made according to the usual technology recommended for cassava production (Cock *et al*., 1977; IITA, 1990). In this study, the main-plot treatments were three planting dates and sub-plot treatments were cassava susceptibility to CMD. Some seedlings also resulting from seeds were put in cages under impregnated mosquito nets in order to preserve them from *B. tabaci* attacks (Fig. 1) were used as controls.

Measurements and observations: Three weeks after the establishment of the planted seedlings, data assessment was initiated weekly during twenty weeks. The parameters measured were related to the visual observations of viral disease symptoms on the planted cassava seedlings and the measures which were made during (20) weeks of the experimentation were in particular (a) the marking of all the sprouted seedlings on each plot, in order to identify them during future observations; (b) the weekly evaluation of the progression of the disease within the plots according to the date of plantation of the plots; (c) the weekly measurement of the severity of the symptoms of the viral diseases on the seedlings (it should be noted that all the seedlings are considered on each plot) and (d) the weekly numbering of the whiteflies on each plant on the plots according to the period of the plantation of each plot.

Evaluation of the incidence of CMD within the plots: The weekly evaluation of the incidence of the disease on the installed cassava plants was carried out in order to measure the spreading out of the disease on each plot and this, three weeks after the establishment of the planted seedlings.

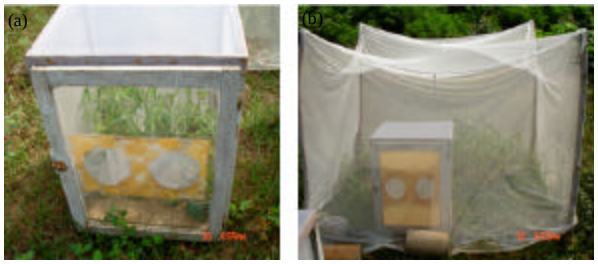

Fig. 1(a-b): Healthy cassava seedling controls in cages under mosquito nets

This follow-up consisted in observing visually and the marking of obviously diseased plants in order to have an idea on the evolution of the symptoms of the viral diseases within the population of clones used in this study. The expression of the incidence of cassava mosaic disease within a given plot is the proportion of seedlings presenting the symptoms of the disease at the time of the observation.

Evaluation of the progression of diseased plants on the plots: The evaluation of the development of the disease was made according to a visual diagnosis (Fargette *et al*., 1990; Hillocks *et al*., 1999) based on the observation of the characteristic mosaic, leaf deformation, yellowing and stunting symptoms appearing on the leaves. The degree of the infection for each cassava seedling was done by the attribution of an accessing note according to the presence of mosaic, leaf deformation, yellowing and stunting symptoms on the surface of the leaves. Disease severity was scored on a scale of 1-5 (Ikotun and Hahn, 1991) (Fig. 2):

- **1:** No visible symptoms on the plant (resistant)
- **2:** 25% of the leaves of the plant observed are infected
- **3:** 50% of the leaves of the plant observed are infected
- **4:** 75% of the leaves of the plant observed are infected
- **5:** 75 to 100% of the leaves of the plant observed present very severe symptoms

The intensity of the infection (severity of the attack) within each plot was calculated according to the formula established by Tchoumakov and Zaharova (1990):

$$I = \sum ab/N$$

where, I is average score, indicating the intensity of the infection or severity of the attack; it also can be express in percentage; $\sum ab$ is sum of the multiplications of the number of diseased individuals on the plots (a) by the degree of the corresponding infection (b) and N, the total number of diseased plants by plot. Data on CMD attacks were collected every week during the entire period of observations from the third week of planting after the establishment of the planted seedlings.

Fig. 2: Reference of disease severity evaluation/Scoring scale of 1-5, 1: No visible symptoms on the plant (resistant), 2: 25% of the leaves of the plant observed are infected, 3: 50% of the leaves of the plant observed are infected, 4: 75% of the leaves of the plant observed are infected, 5: 75 to 100% of the leaves of the plant observed present very severe symptoms

Assessment of the evolution of the viral epidemic within the plots: The assessment of the evolution of cassava mosaic disease epidemic within the plots P_1, P_2 and P_3 was determined from the data of the incidence of the disease within the populations of clones in study following the formula (Tchoumakov and Zaharova, 1990):

$$\text{Evolution of the epidemic} = \text{Log } (x/1-x)$$

where, x is the amount of the viral disease within a plot. The speed of the propagation expressed in rate of spread (r) is calculated by the formula (Tchoumakov and Zaharova, 1990):

$$r = (1/t_2-t_1)*[\text{Log } (x_2/1-x_2)-\text{Log } (x_1/1-x_1)]$$

where, x is amount of viral disease infection at a given time in a plot.

Evaluation of changes in the population of whiteflies in plots: Given that the spread of cassava mosaic disease in space and time is done by whiteflies, which are the natural vectors of cassava *Begomovirus*, three weeks after the establishment of the planted seedlings, a counting of whiteflies on every cassava plant on every plot was initiated weekly during twenty weeks.

All the data collected for scab disease incidence and severity were subjected to an Analysis of Variance (ANOVA) as described by Snedecor and Cochran (1967), using the statistical soft ware, SAS (1998). Mean separations were performed with the Student Newman Keuls (SNK) Test to determine planting dates effects.

RESULTS AND DISCUSSION

Evaluation of the incidence and the evolution of the disease within the plots: Weekly assessment of the number of diseased plants allowed the estimation of the progress of the disease within the plots according to the date of plantation. In fact, the percentages of diseased plants displaying mosaic, leaf deformation, yellowing and stunting characteristic symptoms evolved from 6 to 19% on plot P_1, from 2 to 27% on plot P_2 and from 0 to 53% plot P_3 during the whole period of assessment. The analysis of variance of these results ($p<0.05$) revealed that there are no significant differences between the three plots. The analysis of the incidence of the disease within the plots allowed to appreciating the evolution of the viral epidemic within the plots (Table 1). The analysis of the obtained results showed that the distribution of the disease within the plots during the twenty weeks of observation is polycyclic; infected individuals becoming in turn, sources of inoculums (Fig. 3).

Speed of the epidemic propagation (r) according to the date of plantation within the plots: The results obtained from the speed of the disease propagation (r) within the plots (Table 1), revealed that the disease has evolved differently at the level of the plots according to the date of plantation of each plot; for instance seven weeks after plantation, the speed of progression of the disease at the level of plot P_1 was 0.17; at the same period, the speed of progression of the disease at the level of P_2 was 0.2 whereas at the level of plot P_3, the speed of progression of the disease was 0.69. This means that the speed of the distribution is very fast at the level of plot P_3 ($r = 0.69$), fast

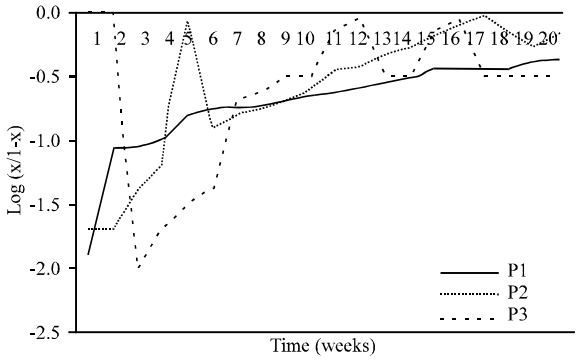

Fig. 3: Evolution of the viral disease epidemic within the plots P_1, P_2 and P_3

Table 1: Analysis of the evolution of the viral epidemic within the plots

	Plot P_1			Plot P_2			Plot P_3		
Weeks	x (%)	Log (x/1-x)	R	x (%)	Log (x/1-x)	R	x (%)	Log (x/1-x)	R
1	6	-1.19	-	2	-1.69	-	0	-	-
2	8	-1.06	0.13	2	-1.69	0.00	0	-	-
3	8	-1.06	0.00	4	-1.38	0.31	1	-2.00	-
4	9	-1.00	0.06	6	-1.19	0.19	2	-1.69	0.31
5	13	-0.82	0.18	8	-1.06	0.13	3	-1.51	0.18
6	13	-0.75	0.00	11	-0.91	0.15	4	-1.38	0.13
7	15	-0.75	0.07	14	-0.79	0.12	17	-0.69	0.69
8	15	-0.75	0.00	15	-0.75	0.04	19	-0.63	0.06
9	15	-0.69	0.00	17	-0.69	0.06	24	-0.50	0.13
10	17	-0.66	0.06	20	-0.60	0.09	31	-0.50	0.20
11	18	-0.63	0.03	26	-0.45	0.15	42	-0.14	0.21
12	19	-0.60	0.03	27	-0.43	0.02	53	-0.05	0.09
13	20	-0.55	0.03	32	-0.33	0.10	24	-0.50	0.13
14	22	-0.52	0.05	35	-0.27	0.06	31	-0.50	0.20
15	23	-0.45	0.03	40	-0.18	0.09	42	-0.14	0.21
16	26	-0.45	0.07	44	-0.10	0.08	53	-0.05	0.09
17	26	-0.45	0.00	48	-0.03	0.07	24	-0.50	0.13
18	26	-0.45	0.00	60	0.17	0.20	31	-0.50	0.20
19	29	-0.39	0.06	32	-0.27	0.10	24	-0.50	0.13
20	30	-0.37	0.02	35	-0.18	0.06	31	-0.50	0.20

at the level of the plot P_2 ($r = 0.2$) and less fast at the level of the plot P_1 ($r = 0.17$). The analysis of variance ($p<0.05$) confirmed these results and showed a significant difference between the plot P_1, P_2 and P_3.

The hypothesis of this work was that *B. tabaci* being the privileged vector of the CMD, a possible variation within its population, could have an incidence on the development of cassava mosaic disease epidemics and could be used as a pattern to screen cassava clones in field conditions.

Evaluation of *B. tabaci* population within the plots: The results obtained from the weekly assessment of *B. tabaci* population within the plots, is recorded in Table 2. These results show that, three months after the plantation, the population of *B. tabaci* was approximately 3.11±2.44; 13.45 and 11.43 by cassava seedling within plots P_1, P_2 and P_3, respectively, while the number of these

Table 2: Average of *B. tabaci* population by cassava plant at the level of each plot

Time (weeks)	Plot P_1	Standard error	Plot P_2	Standard error	Plot P_3	Standard error
1	0.32	0.43	0.31	0.42	0.07	0.18
2	0.12	1.01	0.30	0.42	0.21	0.27
3	0.22	1.47	0.48	0.65	0.36	0.46
4	0.68	1.66	0.28	0.69	0.76	1.13
5	0.58	2.25	0.37	0.94	1.70	2.71
6	0.73	2.67	0.47	1.10	2.09	3.35
7	0.84	3.13	0.70	1.25	3.58	5.97
8	0.59	3.92	1.01	1.58	6.68	11.43
9	1.15	3.97	1.32	1.75	9.20	15.92
10	1.35	4.36	2.39	3.06	11.43	19.44
11	1.30	4.94	3.68	5.00	9.42	15.10
12	1.49	5.33	2.70	3.41	7.83	12.81
13	2.26	5.37	4.52	6.31	9.20	14.23
14	1.69	6.25	6.00	8.63	11.43	17.43
15	1.75	6.75	8.27	12.45	9.42	12.87
16	2.91	6.56	6.68	9.71	7.83	10.84
17	2.30	7.41	13.45	21.45	6.68	9.16
18	2.08	8.12	4.52	5.79	9.20	14.41
19	2.44	8.38	6.00	8.10	9.20	13.65
20	3.11	2.44	8.27	5.41	11.43	6.44

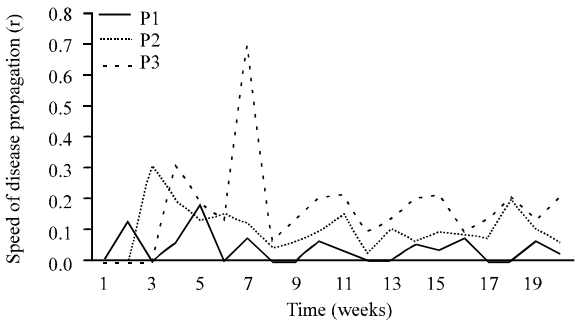

Fig. 4: Speed of propagation of the CMD epidemic within the plots P_1, P_2 and P_3

whiteflies by plant were 0.32±0.43 within plot P_1, 0.31±0.42 within plot P_2 and 0.07±0.18 within plot P_3 in the first week of the of the plantation. These results show that the population of vectors evolved in the time according to the date of plantation. The number of whiteflies by plant is low at the level of the plot P_1, high at the level of plot P_2 and very high at the level of plot P_3. The comparative analysis of this result is represented by Fig. 4. This observation was confirmed by an analysis of variance ($p<5\%$) which shows a significant difference between the various plots. It has been often noticed during this study that the temperature is positively related to *B. tabaci* populations and disease incidence.

Effect of *B. tabaci* population on the propagation of cassava mosaic disease: A comparison of the evolution of the disease in contrast with the evolution of *B. tabaci* population within the plots revealed that, when the population of vectors increases, the propagation of the mosaic disease epidemic is increased and the most susceptible seedlings are severely attached.

Evolution of the disease within the plots: The analysis of the results obtained of the evolution of cassava mosaic disease within the plots reveals that the propagation of the disease was slow, fast and very rapid according to the time of installation of the plots. Thus within the plot P_1, the evolution of the disease is slow and weak during the first three weeks (with R = 0.17). This is explained on one hand, by the fact that the seedlings set up are healthy, without any disease and on the other hand, the inoculum brought outside and transmitted by the vector, took time to settle, multiply and to be propagated. This fact was remarkable within plots P_2 and P_3 where it was noticed starting from the twelfth week, a fast development (R = 0.2) and very rapid (R = 0.7) of the disease. Thus, 27% of the clones of plot P_2 were infected. This rate was 19% for the clones of the plot P_1 and 53% for those of plot P_3. The ANOVA analysis ($p<5\%$) of the results of the rate of the disease propagation speed within the plots shows a significant difference between the plots (P_1 and P_2); (P_1 and P_3) and (P_2 and P_3); what justifies the fact that the propagation of the disease is accelerated within the plot P_3 than within the other plots. It is important to notice that this plot P_3 was the last plot to be installed. It is obvious that although the rate of the disease increase within the plots is influenced by the date of installation of the seedlings, the incidence of the disease itself was not influenced by this date of plantation because of the simple fact that the clones are the same on the three plots. That is to say, in a strategy of search for resistant clones, the resistant individuals would remain resistant whatever the activity of the vector. In other words, *B. tabaci* could be used in field conditions to screen resistant clones in a strategy of search for cassava resistant clones.

Evolution of the population of *B. tabaci*: The analysis of the results of the numbering of *Bemisia* within the plots according to the time of plantation, showed an evolution of the population of *B. tabaci* in the course of time. Thus, two months after sprouting, the level of the population of *Bemisia* within the plots P_1, P_2 and P_3, were 1.49±5.33; 2.70±3.41 and 7.83±12.81 by cassava plant. After three months, this level was 3.11±2.44; 13.45±21.45 and 11.43±17.43 by cassava plant within plots P_1, P_2 and P_3. The analysis of the evolution of the level of *Bemisia* population in the course of time within the individual plots P_1, P_2 and P_3, reveals that the level of *Bemisia* population could vary according to the conditions of the environment (Fig. 5-7). This increase in the population of *B. tabaci* is due to their very fast reproduction when the conditions of the environment become favorable. The falls of the density of population of vector observed per moment are explained by the frequency of precipitation which would have decimated the populations of insects as Fig. 5 shows it. This same observation was made by Dengel (1980), Fargette *et al.* (1985) and Greathead (1986), who showed that the variety of cassava, their date of plantation and the environment (temperature, light and precipitations) exert an influence on the density of population of *B. tabaci*. The results of the evolution of *B. tabaci* population observed within the framework of this study, confirm those observed by Adjata and collaborators in 2011.

Evolution of the disease compared to the level of *Bemisia* population increase according to the date of plantation: The analysis of the compared results of the rates of the disease increase within the different clones on the different plots and the level of *Bemisia* population according to the date of plantation, revealed that the propagation of the disease on the plants displaying mosaic, leaf deformation, yellowing and stunting characteristic symptoms, is related to the level of *Bemisia* population within the individuals plots in the time. Thus, the results showed that the more the populations of the vectors increased, the more the proportion of the contaminated

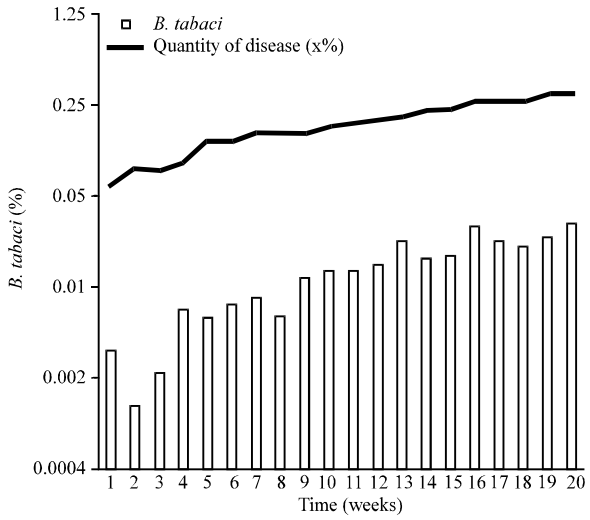

Fig. 5: Relation between the increase of *B. tabaci* population and the speed of the disease propagation within plot P_1

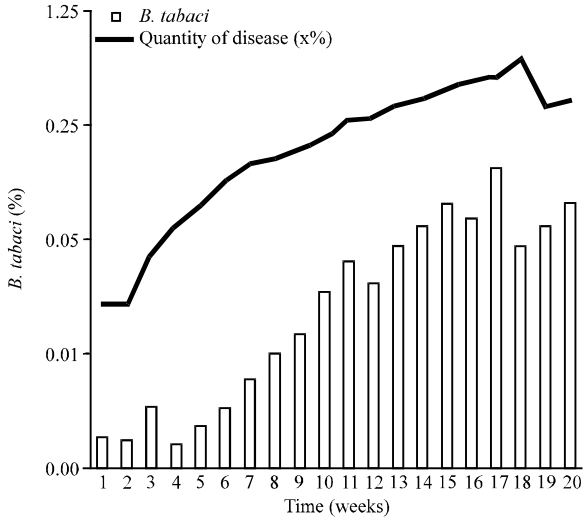

Fig. 6: Relation between the increase of *B. tabaci* population and the speed of the disease propagation within plot P_2

plants is increased and the more severely the disease is felt by the susceptible clones. These same observations were made by Dengel (1980), Fargette *et al.* (1985) and Greathead (1986). This could be explained by the fact that when the population of vectors increases, the quantity of inoculated viral particles becomes significant and the repeated punctures of the seedlings for the taking away of the sap, stress these cassava seedlings and could increase their level of sensibility to the disease. But, it is important to point out that the increase in the population of vectors does not have any effect on resistance of the clones with respect to the disease; the resistant individuals remain resistant and the most susceptible individuals remain susceptible and the severity of symptoms are consequent. The observations made during this study revealed that the level of the population of

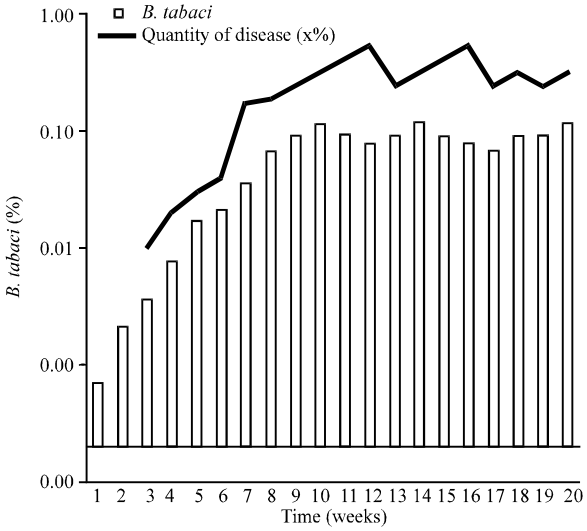

Fig. 7: Relation between the increase of *B. tabaci* population and the speed of the disease propagation within plot P_3

Fig. 8(a-e): Damages to *B. tabaci*

Bemisia within the plots had a direct incidence on cassava young seedlings in the time. In fact, apart from the development of honeydew and mycelium of fungus on the leaves of the plants, it was observed that *B. tabaci,* damaged cassava seedlings, by its eggs which cover the totality of the lower face of the leaves and by ricochet, the larvae, when nourishing themselves, weaken the seedlings, which would result in the death of the young seedlings which do not have yet enough reserves to survive (Fig. 8). This observation was made by Martin (1999) who stated that heavy feeding by whitefly can eventually kill plants. It is to be noticed that the more the populations of *B. tabaci* increases, the more mechanical damages are significant. These same observations were made by Dengel (1980), Fargette *et al.* (1985) and Greathead (1986) who pointed out that the environment, the variety of cassava, their date of plantation and the environment (temperature, light and precipitations) exert an influence on the density of population of *B. tabaci*. The results of the evolution of *B. tabaci* population observed within the framework of this study, confirm those observed by Adjata and collaborators in 2011.

Transmission of cassava mosaic disease by *B. tabaci* in the population of selected cassava clones within the plots: The results obtained from the study of the transmission of cassava mosaic disease by *B. tabaci* and its development in plots of selected cassava clones planted at various dates in Togo, showed that the spreading out of the disease on plants displaying mosaic, leaf deformation, yellowing and stunting characteristic symptoms in the plots depend not only of the transmissibility of the disease by *Bemisia*, but also increases its damage on cassava seedlings. This is remarkable with the cassava seedlings maintained in cages under mosquito nets where they were free of any cassava mosaic disease attack (Fig. 1). The results obtained of this study, showed also that for the same individuals, the reaction with respect to the disease was the same whatever the date of installation of the plots; but the degree of sensitivity was different for the clones very susceptible to the disease. This observation could explain the results of the analysis of variance ($p<5\%$) which revealed that there are no significant differences between the three plots with regard to the incidence of the disease within the plots compared to the dates of installation of the plots. The interest of this study is that the spreading out of the disease in the plots could start an extremely strong inoculation, causing itself a significant and fast infection, which could allow detecting with certainty, the resistance of each clone. It is known that cassava age plays a major role in the progress of the disease (Thresh *et al*., 1983). So, by taking seedlings resulting directly from seeds is a very important strategy to detect easily the susceptible clones to CMD.

CONCLUSION

From the results obtained from this study, it arises that the whiteflies (*B. tabaci*) are not only vectors of Cassava Mosaic Disease (CMD), but also a significant destructive agent of young cassava seedlings. The propagation of the disease is largely influenced by the date of plantation; this information is significant to be taken into account in the screening of selected cassava clones. Given that the installation of the plots in the time could start an extremely strong inoculation, causing itself a significant and fast infection, which could allow detecting the resistance of the clones submitted to the screen, *Bemisia* could be used in a scenario of cassava clone screening under field conditions.

ACKNOWLEDGMENTS

The authors would like to express all their gratitude to the head office of the High School of Agriculture of the University of Lomé for its moral assistance during this study. Their thanks are also addressed to the personnel of Lomé Agricultural Experimental Station (LAES) for their technical assistance during this study.

REFERENCES

Adjata, K.D., E. Muller, M. Aziadekey, Y.M.D. Gumedzoe and M. Peterschmitt, 2008. Incidence of cassava viral diseases and first identification of *East African cassava mosaic virus* and *Indian cassava mosaic virus* by PCR in Cassava (*Manihot esculenta* Crantz) fields in Togo. Am. J. Plant Physiol., 3: 73-80.

Adjata, K.D., E. Muller, M. Peterschmitt, M. Aziadekey and O. Traore *et al*., 2011. Strategies of effective control of cassava mosaic disease by genetic selection in Togo. Int. J. Plant Breed. Genet., 5: 150-158.

Adjata, K.D., E. Muller, M. Peterschmitt, O. Traore and Y.M.D. Gumedzoe, 2009. Molecular evidence for the association of a strain of Uganda variant of east African cassava mosaic virus to symptom severity in cassava (*Manihot esculenta* Crantz) fields in togo. Am. J. Biochem. Biotechnol., 5: 196-201.

Bedford, I.D., P.J. Markham, J.K. Brown and R.C. Rosell, 1994. Geminivirus transmission and biological characterization of whitefly (*Bemisia tabaci*) types from different world regions. Ann. Applied Biol., 125: 311-325.

Bird, J. and K. Maramorosh, 1978. Viruses ad virus diseases associated with whiteflies. Adv. Virus Res., 22: 55-110.

Brown, J.K. and J. Bird, 1992. Whitefly-transmitted begomoviruses and associated disorders in the Americas and the Caribbean Basin. Plant Dis., 76: 220-225.

Cock, J.H., D. Wholey and O. Guitierrez de las Casa, 1977. Effects of spacing on cassava (*Manihot escukena* Crant). Exp. Agric., 13: 289-299.

Dengel, H.J., 1980. Investigation on the Disease Intensity, Crop Loss-relationship of Cassava Mosaic in Togo. Recherches at Observations, GTZ, GmbH-Germany, pp : 59-65.

FAO, 2003. Production Yearbook: 2003. Food Agriculture Orgainzation, Rome.

FAO, 2008. African Press Organization (APO). ROME, Italy, July 2008, http://www.fao.org

FAO, 2009. FAO corporate document repository. ROME, Italy, December 2009/http://www.fao.org

Fargette, D., C. Fauquet and J.C. Thouvenel, 1985. Field studies on the spread of African cassava mosaic. Annals Appl. Biol., 106: 285-294.

Fargette, D., C. Fauquet, E. Grenier and J.M. Thresh, 1990. The spread of African Cassava Mosaic virus in to and within cassava fields. J. Phytopathology, 130: 289-302.

Fauquet, C. and D. Fargette, 1990. African cassava mosaic virus: Etiology, epidemiology and control. Plant Dis., 74: 404-411.

Greathead, D.J., 1986. Parasitoids in Classical Biological Control. In: Insect Parasitoids, Waage, J.K. and D. Greathead (Eds.). Academic Press, London, pp: 290-318.

Hillocks, R.J., M.D. Raya and J.M. Thresh, 1999. Distribution and symptom expression of cassava brown streak disease in southern Tanzania. Afr. J. Root Tuber Crops, 3: 57-62.

IITA, 1990. Impact of IITA Cassava Varieties. Annual and Ressearch Highlights.

Ikotun, T. and S.K. Hahn, 1991. Screening cassava cultivars for resistance to anthracnose disease. Proceedings of the 9th Symposium of International Society of Tropical Root Crops, October 20-26, 1991, Accra, Ghana, pp: 178-183.

Legg, J.P. and C.M. Fauquet, 2004. Cassava mosaic geminiviruses in Africa. Plant Mol. Biol., 56: 585-599.

Martin, N.A., 1999. Whitefly: Biology, identification and life cycle. Crop Food Res. Broadsheet, 91: 1-8.

SAS, 1998. SAS User's Guide: Statistics. SAS Institute Inc., Cary, NC.

Saunders, K., N. Salim, V.R. Mali, V.G. Malathi, R. Briddon, P.G. Markham and J. Stanley, 2002. Characterisation of Sri Lankan cassava mosaic virus and Indian cassava mosaic virus: Evidence for acquisition of a DNA B component by a monopartite Begomovirus. Virology, 293: 63-74.

Snedecor, G.W. and W.G. Cochran, 1967. Statistical Methods. 6th Edn., Oxford and IBH Publishing Co. Pvt. Ltd., New Delhi, India, Pages: 593.

Tchoumakov, A.E. and I.I. Zaharova, 1990. Statistics of Disease Development: Disease Damages Caused in Crop Production. Agroprom-Izdat, Moscou, Pages: 53.

Thresh, J.M., R.S. Scorer, R. Harrington, D.E. Pedgley, P.A. Nuttall and R.F. Sellers, 1983. The long-rage dispersal of plant viruses by arthropod vectors. Philos. Trans. R. Soc. London B, 302: 497-528.