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ASIAN JOURNAL OF SCIENCE AND TECHNOLOGY

ISSN: 0976-3376

Asian Journal of Science and Technology
Vol. 09, Issue, 08, pp.8530-8534, August, 2018

RESEARCH ARTICLE

EFFECT OF SOME CULTURAL PRACTICES ON THE DEVELOPMENT OF COTTON VIRESCENCE DISEASE IN THE AREAS OF BOUANDOUGOU, NIANKARAMANDOUGOU AND SÉGUÉLA (CÔTE D'IVOIRE)

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ARTICLE INFO

Article History:
Received 14th May, 2018
Received in revised form
19th June, 2018
Accepted 15th July, 2018
Published online 30th August, 2018

Key words:

Floral virescence disease,
Seed disinfection,
Genetic control,
Cotton cultural calendar.

ABSTRACT

Cotton virescence disease development has been studied according to genotypes mainly used by farmers, sowing dates and seed treatment in order to develop an integrated control strategy and thereby reduce cotton losses in the northern part of Côte d'Ivoire. Genotypes and sowing dates were carried on three improved cotton varieties sown at 6 dates. 27% of the farms received batches of seeds disinfected by Cotomence 45WP (Thiram + Imidacloprid). The 3 cotton genotypes expressed different levels of floral virescence disease attack. Variety Y301AR4 showed sensitivity to the disease with relatively high attack severities (18.44%). In contrast, cultivars Y301 AR3 and Y 331BR4 showed low attack severities of 3.45% and 8.20%, respectively. Disinfection of seeds before planting had no impact on the occurrence of cotton plant disease. Early sowing, carried out in June, has favored the development of the disease mainly due to the decrease of the rainfall regime and its poor distribution during the vegetative stage of the cotton plant. In contrast, subsequent sowing, those of July, would reduce the risk of attack by floral virescence. These results argue in favor of the genetic control of floral virescence disease and the shift of cotton cultivation calendar in Côte d'Ivoire.

INTRODUCTION

Floral virescence is the most feared disease in the entire cotton-growing area of the sub-region. In Côte d'Ivoire, it is prevalent in the northern parts where it is particularly monitored (O. Traoré, 2008; A. Renou, 2000). The disease is associated with the presence of mycoplasma-like organisms and might be transmitted by *Orosius cellulosus* (Homoptera, Cicadellidae). The term floral virescence refers to the pathological transformation of petals into persistent green organs. This phenomenon is often accompanied by morphological abnormalities and can lead to the formation of leaf structures in all floral organs. It is actually a typical phyllody (Cauquil et J.C. Follin, 1983). The first symptoms appear when the cotton plant is 10 to 50 days old and begins with a general yellowing of the foliage, sometimes accompanied by stunting; later, flower buds and floral pieces are transformed. If the attack occurs at end-of-cycle, the part of the plants formed before the onset of the disease can yield.

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The damage due to virescence is very unevenly distributed and some farms can be destroyed almost completely (M. Desmidts *et al*., 1973; J. C. Follin, 1982). The development dynamism experienced by cotton cultivation in Côte d'Ivoire in the 1970s has favored the appearance of floral virescence disease in the main cotton belts of the north (M. Desmidts *et al*., 1973). Very serious epidemic situations with total destruction of certain farms were reported in the Kani-Odienne region (J. C. Follin, 1982). In the search for control methods, conclusive results were obtained in the past, especially in the control of the insect vector, Orosius cellulosus, by application of furandan in the hill, by treatment of seeds with 2% Frumin AL or by foliar treatment at 10 and 20 days with dimethoate (Cauquil et Folin, 1983). But the adoption of this control method is problematic today because of the ban of certain pesticides due to their high toxicity on humans and the environment but also because of their high cost for farmers (H. Höhn *et al*, 2012; Nibouche *et al*., 1998). Moreover, resistance to such insecticides by pests is commonly reported in cotton cultivation. According to kone *et al*. (2017) a large number of Ivorian producers complain about the persistence of jassid attacks despite insecticide treatments. As a result, there is an emergence and proliferation of pest

populations and their extension made easier by the climatic and environmental conditions that have become favorable in recent years (C. Cilas *et al*, 2015). Thus, floral virescence of cotton plant confined for a long time to the northern part of the cotton-growing area has started extending to the southern part especially the region of Séguéla (D. C. Tonessia *et al.*, 2018b). Faced with this situation, research advises the use of varieties with high pilosity and/or the uprooting of cotton plants affected by the disease (M. Bruno *et al*, 2000). Thanks to genetic progress, promising varieties for the control of the disease exist. However the other methods are not to be neglected, especially agronomic control methods. Indeed, when genetic control relies on the use of specific resistances, agronomic control is a precious ally for maintaining the effectiveness of such resistances over time (E. Mestries *et al*, 2011). However, to date, few studies have been conducted on the ways in which farming practices can influence the sensitivity of cotton to floral virescence. Thus, this work aims at studying some cultivated cotton genotypes, the effect of fungicidal seed treatment and the date of sowing on the development of floral virescence of cotton plant in 3 cotton producing areas in northern Côte d'Ivoire. The results of this work will be of great importance in the development of an integrated pest management strategy against this disease.

MATERIAL AND METHODS

***Sites of study*:** This study was conducted in the Regional Directorate of the Cotton Company Olam (SECO-SA) of Bouaké and Séguéla. The areas of Niakaramadougou and Bouandougou were selected concerning the northern part of the cotton-growing area (8° North Latitude and 5° West Longitude) and the area of Séguéla concerning the southern part (7° North Latitude and 6° West Longitude). In these three zones, the rainy season extends over 7 months from April to October with peaks reaching on average 250, 150 and 300 mm for the months of May, August and September respectively (L. Soro, 2018).

***Plant material*:** The plant material used was composed of seeds of 3 cotton varieties (*Gossipium Hirsutum*) from the National Center for Agronomic Research (CNRA). They included varieties Y 301AR3, Y 301AR4 and Y 331 BR4. They were certified seeds cultivated mainly in northern and west central Côte d'Ivoire (Tonessia *et al*. 2018a). They were characterized by a high yield potential of up to 4 t/ha of seed cotton, a better fiber quality, a good yield precocity and a very high ginning fiber yield.

***Sampling*:** 30 cotton producers were randomly selected and monitored throughout the 2016-2017 cotton crop year, that is, 10 farmers per area of study. Seeds of the 3 cotton varieties from early harvest and early sowing were made available to farmers. Thus, farmers from the village of Niankaramandougou and Boandougougou located in the same agro-ecological zone received the seeds of variety Y 331 BR4 and Y 301AR4, respectively while those of Séguéla received varieties Y 331 BR4 and Y 301AR3. Over the 30 plots under study, eight plots (27%) were sown with seed batches disinfected by Cotomence 45WP (Thiram + Imidacloprid). Sowing in the 30 farms was carried out in the wet period just after a rain with 6 different sowing dates (Table 1).

Table 1. Locality of study and features of the farms studied

Area of study	Farmers	Varieties	Seed quality	sowing dates
Niakaramadougou	P1	Y331BR4	NT	D2
	P2		NT	D2
	P3		T	D2
	P4		T	D3
	P5		T	D3
	P6		NT	D3
	P7		T	D3
	P8		NT	D3
	P9		NT	D4
	P10		NT	D5
Bouandougou	P1	Y301AR4	NT	D1
	P2		T	D2
	P3		T	D2
	P4		NT	D3
	P5		NT	D3
	P6		T	D3
	P7		NT	D4
	P8		NT	D4
	P9		T	D4
	P10		NT	D5
Séguela	P1	Y331BR4	NT	D5
	P2	Y331BR4		D2
	P3	Y301AR3		D3
	P4	Y301AR3		D2
	P5	Y331BR4		D3
	P6	Y331BR4		D3
	P7	Y331BR4		D4
	P8	Y331BR4		D4
	P9	Y331BR4		D5
	P10	Y301AR3		D6

***Experimental design of the field trial*:** The sowing was carried out flat in hills and in rows. The distance between 2 rows of seedlings was 80 cm and the spacing between hills was 30 cm. The sowing rate was 25 to 35 kg/ha of seed, by putting 4 to 6 seeds per closed hill. The recommended sowing density was 83 500 plants/ha. The cultural maintenance and phytosanitary treatments were those recommended by research.

***Experimental design for phytosanitary surveys*:** The experimental design set up after the establishment of crops so as to make observations and measurements was made on a plot of 1 ha. The number of plants with floral virescence was counted on the rows of the 1-ha plot. The rows differed at each observation. Weekly records of diseases started from the 30th Day after emergence. At each observation, affected cotton trees were counted and the operation was repeated every week. At the end the number of plants attack by floral virescence disease was expressed in percentage.

***Data analysis*:** All the data were entered and organized with Excel 2013 software. The statistical analysis of the data collected and Variances (ANOVA) was done using R software (2013). The averages were compared by the Fischer test at 5% threshold.

RESULTS

*Foral virescence of cotton plant and cotton genotype***.** Floral virescence disease was triggered naturally in the farms studied and the symptoms appeared as from the flowering stage. Disease prevalence rate in the 3 zones ranged between 3.45% and 18.44%. The largest number of diseased plants was observed in Bouandougou and Nianramandougou with 18.44% and 11.69% respectively while the locality of Séguéla recorded a low rate of 3.45% (Table 2). All the 3 cotton genotypes

studied expressed sensitivity to the disease, but with a great variability of response (Table 3). In fact, the analysis of variance relating to the average severity of attack showed a very highly significant difference between the 3 varieties tested. Comparing averages made it possible to classify the 3 cotton varieties into two distinct groups. The first group included variety Y301 AR4 which was the most attacked followed by Y301 AR3 and Y 331BR4

Table 2. Prevalence rate of floral virescence disease per locality

Locality	Prevalence rate	Class
Bouandougou	18.44%	A
Niankaramadougou	11.69 %	A
Séguéla	3.45%	B
Total	11.19%	

Table 3. Ranking of floral virescence attack severities in cotton genotypes

Varieties	% of attack severity	Class
Y301 AR3	3.45 %	B
Y301AR4	18.44 %	A
Y 331BR4	8.20 %	B
Total	11.19%	

Floral Virescence of cotton plant and seed treatment before sowing

Cotton seed treatment before sowing using a fungicide-insecticide did not have any significant impact on the occurrence of the disease in cotton farms (Table 4). In fact, the disease appeared in the farms which had received treated seed (87.5%) as well as in the control farms which had not received treated seeds (62%). Similarly, varieties Y301AR4 and Y 331BR4 did not show significant differences between each other depending on the treatments regarding disease occurrence in the farms.

Table 4. Effect of seeds qualities on the manifestation of floral virescence of cotton plant

varieties	Farms with treated seeds	Farms with treated seeds and attacked by disease (%)	Farms with untreated seeds and attacked by disease (%)
Y301 AR3	0	0 %	66 %b
Y301AR4	4	75 %a	100 %a
Y 331BR4	4	100 %a	47,05 %b
Total	8⁄30	87.5%	62 %

Floral virescence of cotton plant and influence of sowing dates

The analysis of variance relating to the presence of floral virescence shows a highly significant difference between sowing dates (Table 5). Thus, three groups of sowing dates emerge. Group 1 is composed of ten-day periods D1, D2 and D3, that is to say the sowing carried out between 20 May and 20 June. In this group, all varieties were affected and 90 % of the farms showed the disease. The second group includes sowing carried out between 21 June and 10 July and the presence of the disease was detected only on half of the plots on average. The symptoms of the disease did not appear on the third sowing date.

Table 5. Effect of sowing dates on Floral Virescence manifestation in the farms

Sowing dates	Farms attacked (%)	CLASS
D1	100 %	A
D2	100 %	A
D3	73%	A
D4	67%	B
D5	50%	B
D6	0%	C

DISCUSSION

With regard to diseases transmitted by insects, it is strongly recommended to use genetic control (Fargette, 1985; A. Renou, 2000; D. F. Soko *et al*, 2015). All the cotton varieties used by farmers in the area of study showed sensitivity to floral virescence disease. These results are similar to those obtained in 2001 during a screening test for the assessment of the resistance of several local cotton varieties to floral virescence in the localities of Nambingué and Korhogo. All the varieties tested were sensitive (data not published). These findings show that the sources of resistance to the disease are still poorly or less known in Côte d'Ivoire and argue in favor of the search for resistant genotypes so as to obtain initial breeding lines in the genetic control of the disease. Obtaining resistant and yielding cultivars is therefore an objective in order to anticipate a possible extension of the distribution area which might be located mainly in the northern parts of the Growing area. In fact, the localities of Niankaramadoudou and Bouandougou, which are located in the northern part, showed a higher disease incidence rate than the locality of Seguéla which is further south, confirming the previous works (J. C. Follin, 1982; D. C. Tonessia *et al*, 2018b). Indirect treatment by insecticide application for vector control is currently the most commonly used method for the management of phytoplasma diseases. Thus, in Côte d'Ivoire, protection strategies have mainly been directed against jassids which are the main culprits of the disease (Cauquil et J. C. Folin, 1983). However, the cost of synthetic insecticides in cotton cultivation is often considered excessive and too high by producers (J. C. Castela, 1995). And the question that one can ask is the following: at which stage of cotton cycle is insecticide treatment effective to prevent the expression of virescence disease? Indeed our work has shown that floral virescence was found on cotton plants stemming from seeds treated with insecticide as well as on cotton plants from untreated seeds.

Yet in the past significant results were obtained by chemical treatment of cotton seeds (J. C. Follin, 1982). Although the disease is not transmitted by seeds, we expect in this study that the chemical treatment creates around the seeds a localized reservoir of active ingredients (Thiram + Imidacloprid) likely to protect seedlings and young plants against vector insect attacks. According to Pierre (2012), the persistence of the insecticide-fungicide mixture on the seeds might last up to 45 days, which gives a higher protection to the young seedlings stemming therefrom. The main vectors of floral virescence of cotton plant are insects from the leafhopper family (*Orosius cellulosus*), but the phytoplasma needs reservoir plants (Sida cordifolia L. and Mitracarpus scaber Zucc.) (M. Desmidts et J.

Laboucheix, 1973) to act as an inoculum because transmission by the seed seems nonexistent. As a result, the fight must intensify on the destruction of vectors and host plants. Furthermore, hairy varieties in cotton cultivation have been identified as a natural factor of tolerance to jassids (A. Renou, 2000 ; P. Koné *et al,* 2017). Their use in cotton cultivation can also be envisaged thus helping to reduce the cost of chemical protection against piercing insects. The 3 cotton genotypes studied expressed different levels of attack by floral virescence. Variety Y 301 AR4 showed a relatively higher sensitivity to the disease than varieties Y 301 AR3 and Y 331 BR4. Since the disease is not transmitted by seeds, inoculum intake generally coincides with the development of cotton cultivation in an area (A. Kalhid *et al,* 2009). Thus, the same variety cultivated in the same place under the same climate may show variability of sensitivity, as well as the cultivation pressure exerted on the same variety with respect to another. In the case of vector-borne disease, varietal differences in disease transmission rates could be due to the possible differential attraction between cultivars vis-à-vis the vector without there being any resistance to the disease it transmits (C. Seassau *et al*, 2010). The selection of the sowing date is an essential element in a protection program in cotton cultivation (J. C. Castella, 1995). The variations revealed in our study between the ten-day periods of sowing make it possible to note an influence of the sowing date on the levels of floral virescence attacks. Early sowing in late May and June was more affected by the disease. This study confirms the results of previous works carried out in the cotton belt of Côte d'Ivoire through the PR-PICA project (2015), which concluded that early sowing is the most exposed to floral virescence. These observations are also in the same direction as those described by authors such as Mestries *et al* (2011). Indeed, these authors claimed that vector-borne diseases are often more frequent on early sowing than on late sowing. In the specific case of our study, we believe that early sowing contributed to disease spreading because of the drop in rainfall regimes observed at the study sites during the period preceding the establishment of the crop. Thus, a poor distribution of the latter has created adequate conditions for the development of the vector insect and the receptivity of cotton to floral virescence (S. K Chandani et T. V. Sathe, 2015).

Conclusion

At the end of our study, we note that floral virescence disease of cotton plant, confined for a long time to the northern part of the cotton growing area of Côte d'Ivoire, is extending to the southern part especially in the zone of Séguéla. All the varieties we tested in this study showed a sensitivity to the disease. Carrying out cultivation with seeds disinfected with Thiram + Imidacloprid as practiced by farmers before sowing does not always provide protection for cotton plants or help reduce the incidence of the disease in the farm. From that perspective, genetic resistance is the best method of control. As sources of resistance to floral virescence are still poorly or less known in Côte d'Ivoire, obtaining resistant and yielding cultivars is therefore an objective to be achieved. Thus, the decline in rainfall regimes frequently observed in Côte d'Ivoire in recent years at the beginning of the cotton crop year argues in favor of late sowing. Indeed, a bad distribution of rainfall creates favorable conditions to the receptivity of cotton plant to floral virescence disease.

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