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CONTROLLING MANGO MALFORMATION DISEASE IN SOUTH SENEGAL: PREVENTION AND MANAGEMENT TECHNIQUES

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Article Info

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Abstract

The mango industry in Senegal has experienced a positive growth in recent years. However, it is currently facing numerous challenges, particularly diseases affecting the plants throughout their growth cycle. One significant issue during the rainy season is the devastating impact of anthracnose. Moreover, mango production is severely affected by malformation of inflorescences caused by Fusarium species in the southern region of Senegal. In 2018, a study was conducted to evaluate the significance and distribution of mango malformation disease (MMD) in the country. The findings revealed a geographical variation in both incidence and severity of MMD across different regions within the southern production basin. The disease predominantly affects the southern part of Senegal, with a considerably lower contamination rate detected in the northern production areas, specifically in the Thies region. Among the southern regions, MMD was most heavily concentrated in Sédhiou, with an incidence rate of 91.94% on mango tree populations and a severity rate of 55% of flowers on trees. Interestingly, no diseased plants were observed in the Tambacounda region, located in the east. To address this issue, it is crucial to implement effective strategies and measures to prevent the spread of MMD in South Senegal. These may include regular monitoring and surveillance of mango production areas, early detection and removal of infected plants, and the application of appropriate fungicides to control the disease. Additionally, it is essential to promote the use of resistant cultivars and adopt proper agricultural practices, such as crop rotation and field sanitation, to minimize the risk of MMD infection. By implementing these preventive and management techniques, it is possible to mitigate the impact of MMD on Senegal's mango industry and ensure the continued growth and sustainability of this vital agricultural sector.

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Introduction

Mango (Mangifera indica L.) is a highly valued fruit crop and a significant source of income for many smallholder farmers in the tropical and subtropical regions of the world (FAO, 2018). In West Africa, and particularly in South Senegal, mango production plays a crucial role in the livelihood of rural communities, contributing to both food security and economic development (Diop et al., 2015). However, the mango industry in this region faces numerous challenges, including the devastating impact of mango malformation disease (MMD) (Araujo et al., 2018). MMD is a fungal disease caused by the species complex Fusarium mangiferae, which causes severe deformation in inflorescence, vegetative shoots, and fruits, resulting in significant yield losses (Freeman et al., 2014). This paper aims to provide an overview of the current knowledge on the prevention and management techniques for controlling MMD in South Senegal, with the goal of informing future research and interventions to address this pressing issue. MMD was first reported in Senegal in the late 1980s (Diallo et al., 1992) and has since been recorded in several other West African countries, including Nigeria, Benin, and Ghana (Dann et al., 2012; Araujo et al., 2018). The disease is characterized by the formation of malformed vegetative and reproductive structures, which leads to reduced fruit set and ultimately, decreased fruit yield and quality (Freeman et al., 2014). In South Senegal, MMD has been reported to cause yield losses of up to 80%, posing a significant threat to the livelihoods of smallholder farmers who rely on mango production for their income (Diop et al., 2015). The exact mechanisms of MMD infection and spread are still not fully understood, but it has been shown that the disease is primarily transmitted through airborne fungal spores and can also spread through infected plant material, such as grafts and pruning debris (Freeman et al., 2014; Araujo et al., 2018). Additionally, some insect species, such as thrips and mites, have been implicated in the transmission of the disease, although their role remains unclear (Freeman et al., 2014). The complex nature of MMD epidemiology has made it difficult to develop effective control strategies, and currently, there are no chemical or biological treatments that can completely eradicate the disease (Araujo et al., 2018).

Several cultural practices have been proposed for the management of MMD, including the use of disease-free planting material, the removal and destruction of infected plant parts, and the implementation of proper orchard sanitation measures (Freeman et al., 2014; Araujo et al., 2018). Additionally, the application of fungicides, such as copper-based compounds, has been shown to provide some level of control, although their effectiveness is limited and can be influenced by factors such as application timing and environmental conditions (Diallo et al., 1992; Dann et al., 2012). More recently, the use of biological control agents, such as Trichoderma harzianum, has shown promising results in reducing MMD incidence and severity in greenhouse studies, but their efficacy under field conditions remains to be determined (Araujo et al., 2018).

Despite the progress made in understanding MMD and its management, further research is needed to develop more effective and sustainable control strategies tailored to the specific conditions of South Senegal. This includes studying the local epidemiology and biology of the disease, as well as identifying the most appropriate and cost-effective prevention and management techniques for smallholder farmers in the region. Additionally, it is crucial to raise awareness of MMD among farmers and extension agents, and to promote the adoption of recommended management practices through targeted training and information campaigns.

2. Material and methods

2.1 Study site

2.1.1Scouting for MMD

All mango production basins in Senegal were prospected (figure 1). Le main mango production areas are located in the Niayes zone, in the coastal area south west of Dakar (Mbour zone), in the peanut basin in the zone of Sine -Saloum and in the southern part of the country (USAIDPCE, 2006).

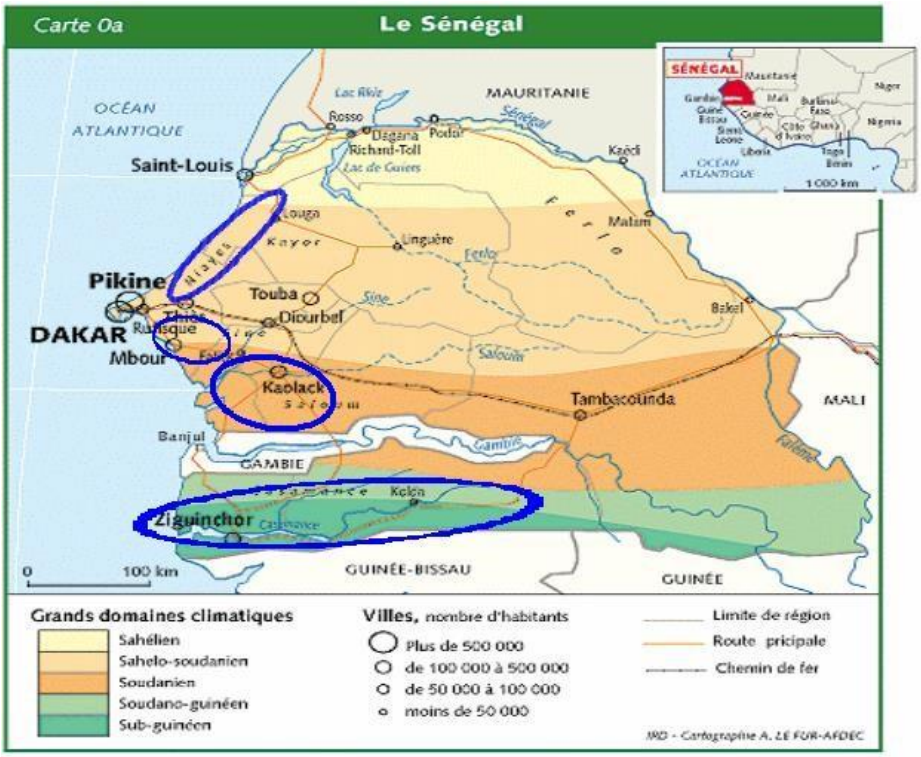
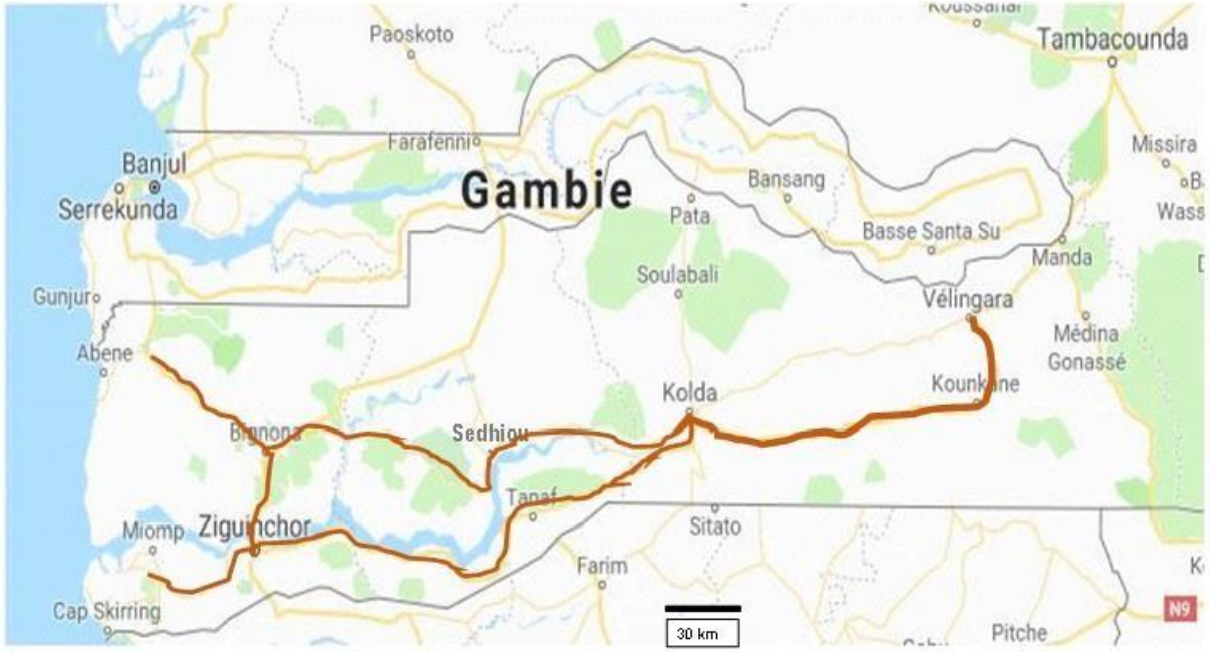


Figure 1: Main mango production areas in Senegal (USAID-PCE, 2006)

2.1.2. Field assessment of MMD

In the southern regions of Senegal where MMD occurs, mango orchards were sampled along the main road axis (Kolda, Sedhiou and Ziguinchor) (Figure 2) in April 2018. The climate is of Sudano-Guinean type, characterized by the longest rainy season in Senegal (5 months from June to October) and with a yearly rainfall height above 1200 mm.



Sampling road axis

Figure 2: Map of the southern region of Senegal with the sampled road axis for mango malformation disease

2.2 Sampling

Mango plantations in the villages were surveyed along the main road axis in the southern regions of Senegal. First sampling took place in Velingara and the following sampling points were chosen in a village around 50

± 5km from previous point (figure 2). At the sampling point, 30 mango trees were randomly assessed in three directions at an angle of about 60° from another over walking distance of at least 500 m. The major East to West road axis were, from Tambacounda to Kolda, then from Kolda to Sedhiou and further to Ziguinchor and from Ziguinchor to Cape Skirring. On the North to South road axis, sampling took place between Ziguinchor and Bignona and further to Diouloulou next to the border to the Republic of Gambia. Also departing from Bignona, the South to North axis to Carrefour Diaroumbé and Eastwards to Kolda was sampled.

At mango tree level in the sampling point, incidence of MMD as well as severity were assessed and symptomatic inflorescences collected. The incidence was expressed as the ratio of diseased trees over the total of 30 sampled in the village:

Incidence = (number of infected plants ÷ total number of plants observed) × 100 The severity was assessed at plant level using a scale from 0 to three where:

- 0 = mango tree is free of malformed inflorescences
- 1 = 1 to 25% of inflorescences show malformation
- 2 = 26 to 50% of inflorescences are malformed - 3 over 50% of the inflorescences are infested.

2.3 Statistical Analysis

The data were analyzed with statistical software R 3.2.1. A two-way analysis of variance was performed using the aov function of the agricolae package. The Student Newmann and Keuls (SNK) multiple comparison test was done using the SNK test function of the agricolae package.

3. Results and discussion

3.1 Occurrence of MMD in Senegal

Mango trees with MMD symptoms were recorded in high numbers in southern Senegal in 3 regions out of four. The disease was not present in the region of Tambacounda (easternmost) and less in Ziguinchor (westernmost), as compared to Sedhiou and Kolda. In the northern part of the country, the disease was not seen in any production basin apart from Thies. In the production basin of Thies, several trees scattered in very few orchards were displaying the symptoms of MMD.

3.2 Occurrence of MMD in southern Senegal

3.2.1 Occurrence of MMD on East-West road axis

The survey carried out on the East-West road axis of southern Senegal showed a variation of disease incidence according to the district (figure 3). Only floral malformation was observed, except in Kolda where vegetative malformation was seen in a nursery (Figure 4). MMD was absent in the Easternmost and the Westernmost districts in the regions of Tambacounda and Ziguinchor respectively. Its distribution showed a pic of incidence half way between Tambacounda and Oussouye, namely in the districts belonging to the region of Sedhiou. In this region, almost all mango trees (Goudomp (87.50 ± 0.97%) at 91.94 ± 11.39% in Sédhiou) displayed the symptoms of MMD. In the transitional districts, the disease was very present, in Ziguinchor (48.50 ± 19.20%) in the West and Kolda in the East (65.96 ± 20.80%).

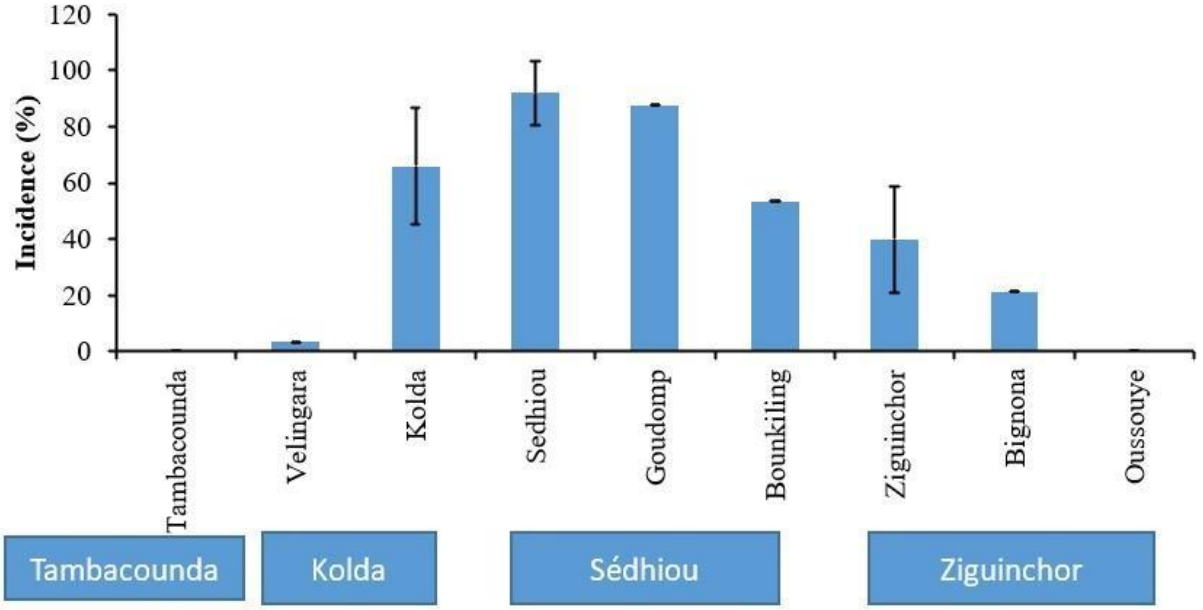


Figure 3: Variation of incidence of MMD along the East-West road axis in southern Senegal

Floral malformation Vegetative malformation

Figure 4: The 2 mango malformations occurring in southern Senegal



Occurrence of MMD on North-South road axis in southern Senegal

On the North-South road axis, Oussouye, Ziguinchor, Bignona and Diouloulou displayed incidence values with a pic in the in between districts (50% in Ziguinchor and 20% in Bignona) (figure 5). Both northernmost main city (Diouloulou 0%) and southernmost main city (Oussouye 0%) districts were free of disease. It should be noted that the North-South road axis do not cross the region of Sedhiou, nor that of Kolda.

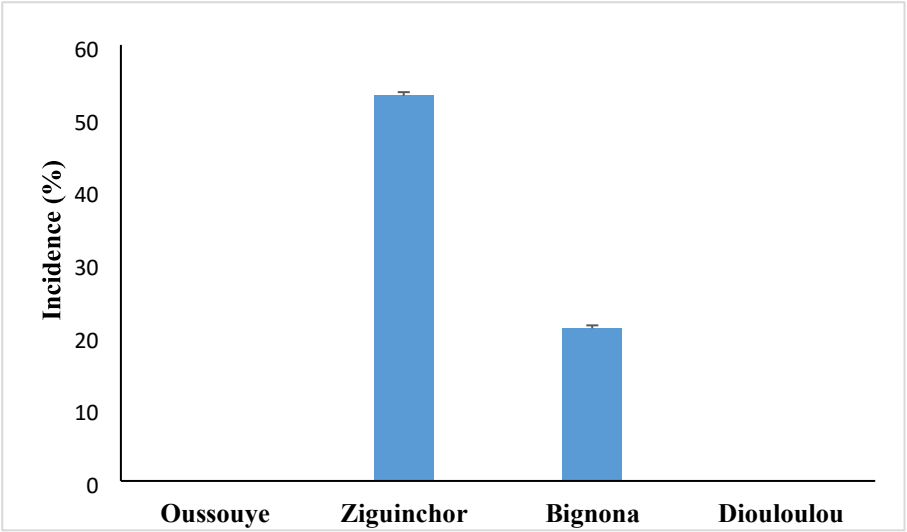


Figure 5: Variation of incidence of MMD along the North-South axis in southern Senegal

Severity of MMD in the prospected regions

With the noticeable absence of the MMD in the region of Tambacounda, disease severity was the highest in the region of Sedhiou (55% ± 25.16) (figure 6). The orchards in the region of Kolda were also highly hit by the disease (30% ± 21.64), followed by Ziguinchor (15% ± 10).

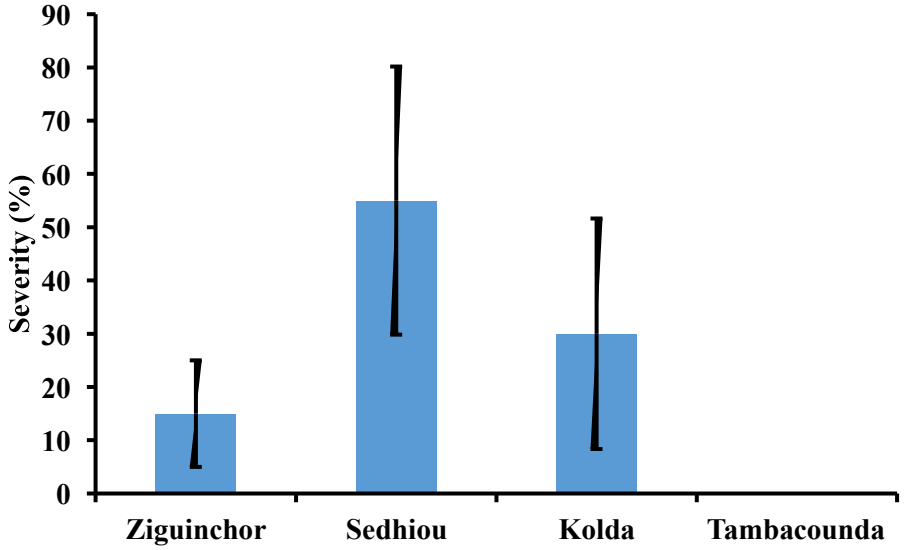


Figure 6: Variation of severity of MMD along the West -East axis in southern Senegal

3.2 Discussion

Mango malformation disease is a major phytopathological constraint causing severe economic losses in mango production around the world (Iqbal *et al*., 2010, Ansari *et al*., 2015). The southern region of Senegal is heavily infested. The floral malformations is largely predominant. The vegetative malformation was observed only once on one individual in a nursery. Those symptoms at the roads axis are characteristic of mango malformation disease. The isolations in the laboratory confirmed the implication of Fusarium spp. in this malformation as already reported by Krishnan *et al*., (2009), Wafaa *et al*., (2010), Iqbal *et al*., (2010), Kumar *et al*., (2011) and Senghor *et al*., (2012). The morphological characterization of strains of Fusarium spp. is identical to that described by Senghor *et al*. (2012) who reported for the first time the presence of mango malformation in Senegal.

The incidence and severity of MMD varied from a region to another and within the region from a district to the next. This is typical to biological phenomena and confirms the reports from Verma *et al*. (1971) on the particular case of MMD. This should be associated to the dispersion means of the Fusarium spp, the causal agent of MMD, which spread is facilitated by the wind, and or water as well as soil, in addition to human activity and some insects (Ahsan *et al*., 2016). With respect to insects, *Aceria mangiferae* was reported as a vector Fusarium spp associated with MMD (Ahsan et *al.* 2016). The short distance dispersion, within a tree, in an orchard as well as in a village and a district could be speculated to derive from wind, insect and rain activity (Ahsan et *al*. 2016). Long distance spread is associated with human activity. In fact, mango fruits, nursery plantlets and grafts are traded between orchards in villages belonging to different districts and sometimes to farmers from other regions in southern Senegal and rarely beyond to the northern part, threatening the whole business in the country. For disease containment purposes in Senegal, an in country quarantine regulation was put in place to prevent contamination of mango orchards in the northern part of the country (FAOLEX, 2011). In fact, the results of the present study shows a relatively quick spread of the disease in the south, backing therefore the relevance of this regulation. The region of Sedhiou was the most impacted and seems to represent the departing and nodal point of the disease in Senegal. Since this disease appeared around the year 2009, the question of its origin is still not resolved. Despite the fact that the first

MMD was firstly reported from Tendouck in the district of Bignona (region of Ziguinchor), Sedhiou is thought to be the most likely point of origin. This assumption derives from the fact that all the districts of this region showed a very high incidence as well as a high severity of MMD. The climatic conditions in the south are almost the same. The climatic factors are speculated to be the main drivers for the epidemics, what would contradict the findings of Kumar *et al*. (2011). MMD incidence and severity declined in value, the further mango orchards are located from the region of Sedhiou on the East-West road axis as well as on the North-South road axis. The declining importance of MMD from the nodal area of Sedhiou could indicate a long distance origin of primary contamination, since the disease is not reported in the neighboring countries. Fruits and kernels are less prone to contamination (Biosecurity Australia, 2008), leaving room grafts or nursery plants to become the main suspected vectors for the first contamination. In fact, *F. mangiferae,* one of the causal agents of MMD, was suspected to be moved in great distances via infected budwoods and plants, whereby latently infected materials, which would not be evident to production managers or quarantine personnel, could move undetected within and between countries (Freeman *et al*, 2014). Importing whole plantlet with their soil substrate is prohibited by Senegalese low, but not plant parts like grafts. Another hypothesis could be an infection through existing fungal strains living on other crops or the mango tree itself triggered by an unknown event like climate change, but this seems to be the most unlikely since the host range of the fungi is narrowed down to the only Mangifera species (Biosecurity Australia, 2008).

It should be mentioned that a scattered few number of mango trees in the region of Thies in the north, were infested by MMD. The presence of the disease, at very low level in the region of Thies could be interpreted as a failure in the enforcement of the in country regulation. It should be however added that during the mango trade season, big trucks are bulk loaded with tons of mangoes and covered with branches and floral rests in the south and sent to the main markets in Touba, Thies, Pout and Dakar, all located in the north of the country. This might be the transmission pathway, which contributed to disease escape from the south.

The additional pressure due to MMD on mango business, beside the existing ones due to fruit flies and anthracnose during the rainy season, are contributing to a negative trend in the mango business. As a consequence, some orchard owners tend to fell mango trees and turn towards others crops, threatening the whole mango value chain. A rapid and efficient response to this emerging disease needs to be found in the Senegalese economic context. The mango business accounts for 16,000,000 USD annually in domestic market as well as in export markets and generates more than 30 000 jobs involving 44,7% of women (Diouf, 2012).

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