

DISTRIBUTION OF THE MANGO MALFORMATION DISEASE IN SOUTHERN SENEGAL

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Abstract: The mango business in Senegal, despite a positive trend in recent years, is facing many diseases from planting to harvest. A part from the devastating impact of anthracnose during the rainy season, mango production is facing another huge challenge in the south of Senegal due to malformation of inflorescences caused by *Fusarium* species. This work was carried out in 2018 to assess the importance and distribution of mango malformation disease (MMD) in Senegal. The results showed a geographical variation of incidence as well as severity of MMD over the different regions in the southern production basin. The disease is located in the south of the country, but a very low contamination rate is detected in the northern production areas in the region of Thies. In the south, MMD was more heavily present in the region of Sédhiou with an incidence of 91.94 % on mango tree populations and a severity of 55% of flowers on tree. No diseased plants were noted in the Tambacounda region in the east.
Keywords: *Fusarium*, incidence, mango malformation disease, Senegal.

Introduction

The development of the horticulture sector, is a major asset for economic growth in many sub-Saharan countries in Africa. This sector has now become a tremendous contributor for the growth of developing countries. In the fruits and vegetables sub-sector, the Mango business has become a promising and growth-enhancing value chain. World production of mangoes is estimated at over 43 million tons (FAOSTAT, 2015). Asia is the largest supplier with 76.3% of world production followed by America 12.3% and Africa 11.4% (FAOSTAT, 2015).

In Senegal, mango production has long existed in traditional form mainly in the southern and central part of the country. With the downward trend of the major cash crops such as groundnuts and millet, farmers needed to look for alternative income-generating activities. This situation has stimulated a dynamic promotion and development of fruit growing and in particular of the mango business. As a result, beside newly planted mango orchards, a modernization of traditional plantations is taking place for export purposes.

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As a consequence, Senegalese mango exports towards the European Union increased from 300 tons in 1998 (Rey, 2011) to 16770 tons in 2015 (ASEPEX, 2016).

The actual mango tonnage in Senegal accounts for 60% of the country's fruits of an estimated annual production of 150 000 tons (Diedhiou *et al.*, 2014, ASEPEX, 2016). The use of appropriate technologies along the value chain offers employment opportunities, especially to rural women and young people and consequently has a boosting effect on mango industry. The mango producing regions are: Dakar, Thies, Saint-Louis, Fatick, Kolda, Ziguinchor and Sedhiou (Diedhiou *et al.*, 2014).

However, despite its significant growth and the economic impact on the populations, the mango yields remain low in Senegal compared to other African countries. This is to be linked principally to diseases such as anthracnose, gummosis, Alternariose, mango malformation disease (MMD) due to *Fusarium* spp., among others (Johnson *et al.*, 1992, Sharma 1993, Ploetz *et al.*, 1996, Al Adawi *et al.* 2003, Senghor *et al.*, 2012). Mango malformation disease is considered one of the most lethal diseases of the mango tree (Nafees *et al.*, 2010). This disease affects flowers and vegetative shoots with high yield losses as a consequence (Kumar *et al.*, 2011). MMD has a high negative impact on yield with a reduction reaching 50% to 80% (Freeman *et al.*, 2014).

MMD is due to pathogenic fungal species belonging to the genus *Fusarium*. It was first reported time in southern Senegal in 2009 (Senghor *et al.*, 2012). MMD reappeared thereafter in 2015 in several localities in the south of Senegal with a tendency to invasiveness and potential threat to the rest of the country and beyond. This study was therefore carried out to assess the distribution of MMD in the southern part of Senegal.

2. Material and methods

2.1 Study site

2.1.1 Scouting for MMD

All mango production basins in Senegal were prospected (figure 1). The 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 (USAID-PCE, 2006).

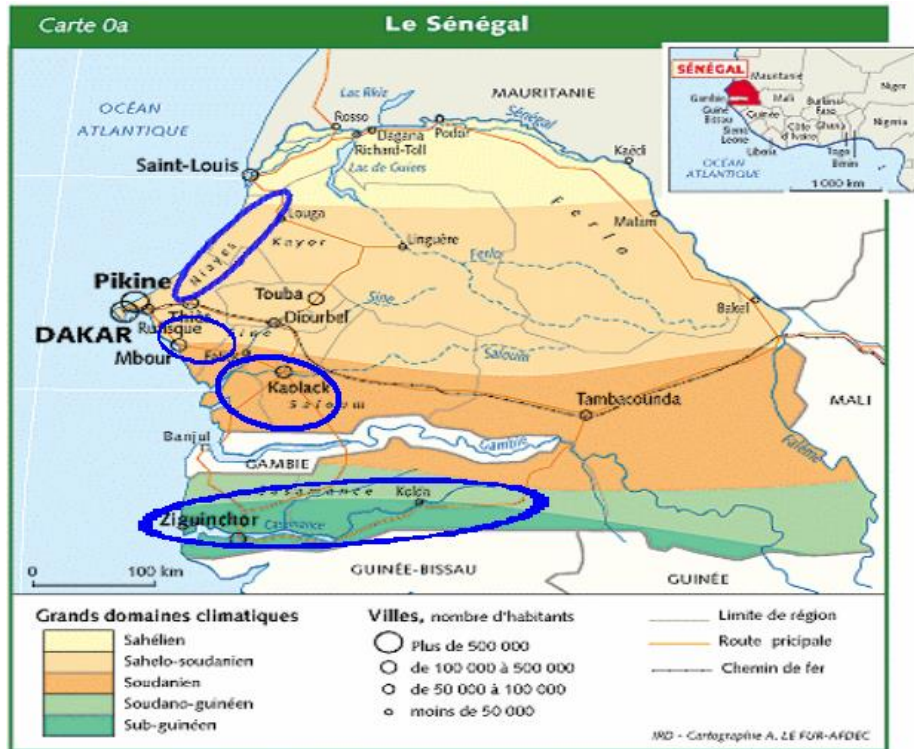
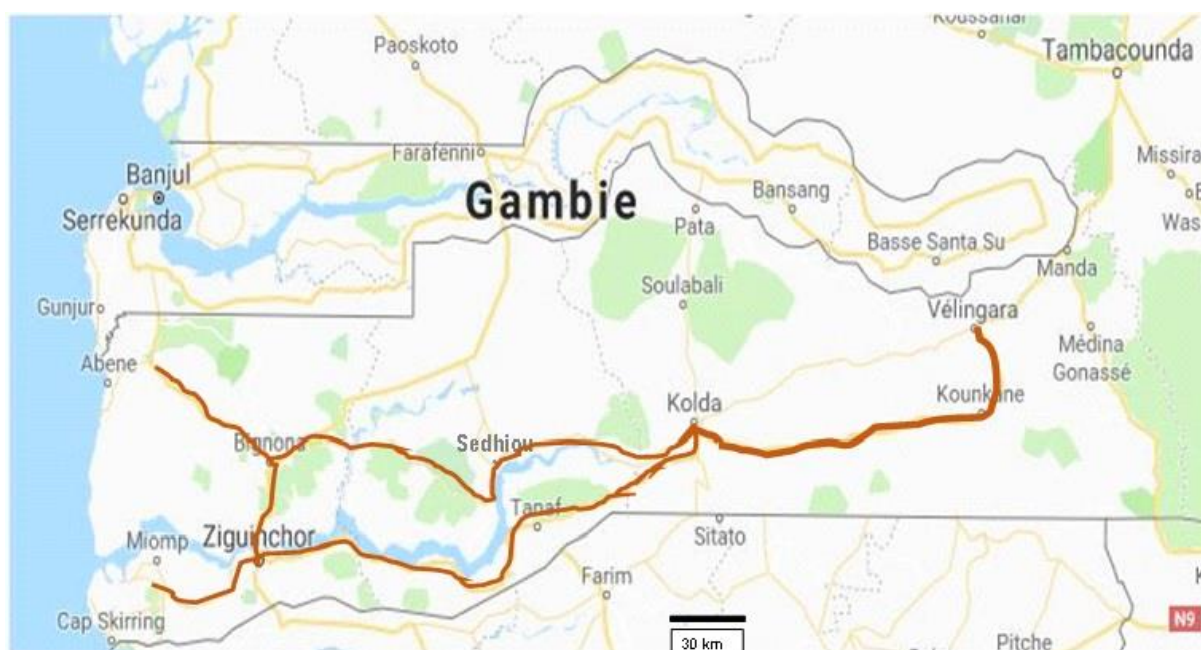


Figure 1: Main mango production areas in Senegal (USAID-PCE, 2006)

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 ± 5 km 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:

$$\text{Incidence} = (\text{number of infected plants} \div \text{total number of plants observed}) \times 100$$

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 Newman 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 ($87.50 \pm 0.97\%$) at $91.94 \pm 11.39\%$ in Sédhiou) displayed the symptoms of MMD. In the transitional districts, the disease was very present, in Ziguinchor ($48.50 \pm 19.20\%$) in the West and Kolda in the East ($65.96 \pm 20.80\%$).

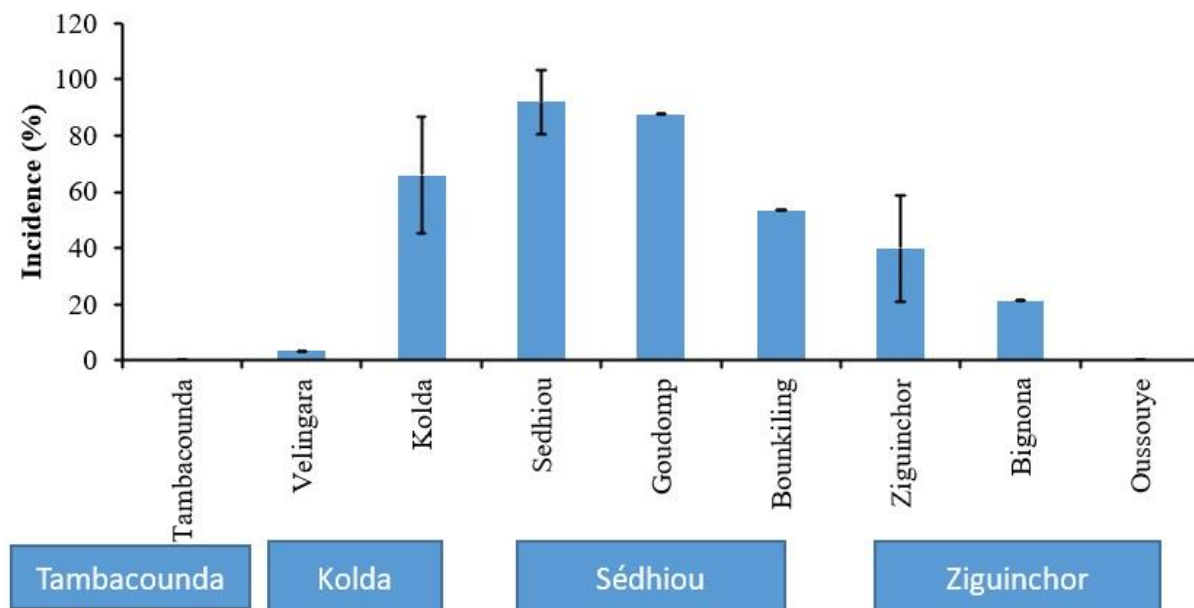


Figure 3: Variation of incidence of MMD along the East-West road axis in southern Senegal



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 Sédhiou, nor that of Kolda.

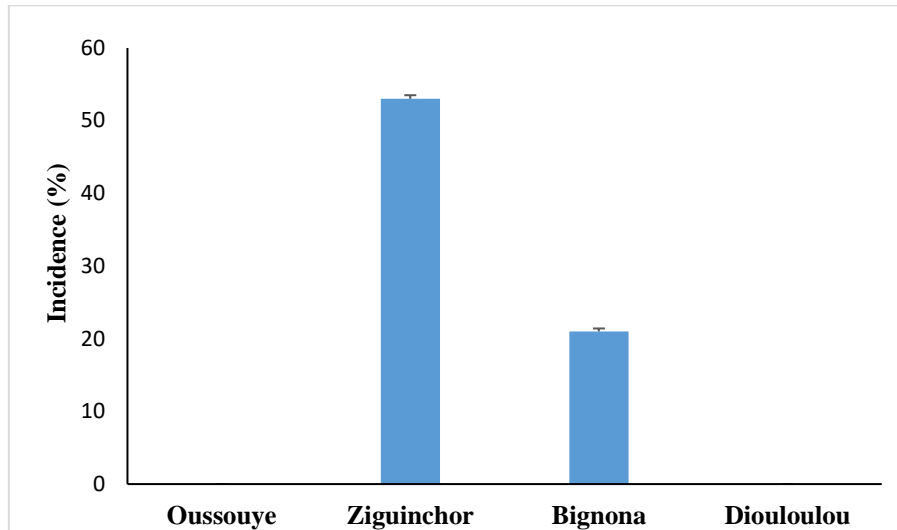


Figure 5: Variation of incidence of MMD along the North-South axis in southern Senegal

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 ($55\% \pm 25.16$) (figure 6). The orchards in the region of Kolda were also highly hit by the disease ($30\% \pm 21.64$), followed by Ziguinchor ($15\% \pm 10$).

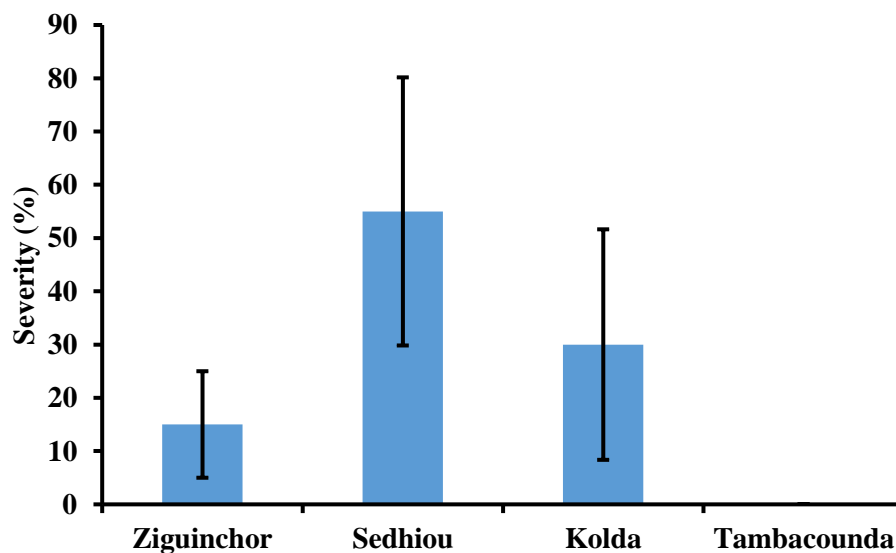


Figure 6: Variation of severity of MMD along the West -East axis in southern Senegal

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 law, 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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