

CONTROL METHODS FOR POST-HARVEST DISEASES OF BANANA (*Musa sinensis*) PRODUCED IN SENEGAL

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Abstract: Banana production in Senegal is achieved in the eastern and southern parts of the country and along the valley of the Senegal River as well. The production is still far below the domestic market demand. In addition, a lot of failures are associated with different steps of the production and post harvest process of fruits. As a consequence, poor fruit quality with low commercial value is produced. This study was undertaken to determine the disease causing agents responsible for post harvest deterioration of banana fruit in Senegal.

Fruit infection and subsequent losses were caused essentially by anthracnose due to *Colletotrichum musae* and *Fusarium* spp., in frequent associations and with various fungal species like *Aspergillus flavus*, *Aspergillus niger*, *Alternaria* sp., *Curvularia* sp., and *Heminthosporium* sp., *Thielaviopsis* sp. High temperatures as well as a lack of sanitation in storage room play an important role on shelf life of banana and therefore market value.

Fruits dip treatment in a solution of imazalil for 5 minutes allowed extending shelf life of banana while preserving a good quality and reducing disease incidence.

Keywords: Fruit quality, banana (*Musa sinensis*), fungal diseases, Senegal, post harvest treatment.

1. INTRODUCTION

Banana constituted the fourth most important global food commodity after rice, wheat and maize in terms of gross value of production. Postharvest loss of fresh fruits is one of the major problems in the tropics. In Senegal banana is produced for the sole purpose of the national market. This banana is planted mainly in eastern Senegal on the upper valley of the River Gambia. Given its importance in the diet of local populations and in national and international trade, banana production is experiencing a fairly rapid expansion in recent years. Banana farms are either individual, usually extensively managed, or belong to farmers associations. The main varieties grown in Senegal are the "Grand Naine", "Poyo" Robusta and Williams [1]. Banana production has increased remarkably in recent years due to the

entry of private players in the sector to reach 12,000 t / year [1]. This production does however not cover the demand of the domestic market. There is therefore a consistent banana importation stream from Côte d' Ivoire and Guinea [1]. This imported banana is preferred by consumers to the banana produced in Senegal despite its price typically 40 % cheaper than imported banana. Many constraints particularly in terms of quality of product are lead to this situation. Banana quality is related among others to organoleptic and phytosanitary status in relation with diseases, packaging, transportation, storage etc. Senegalese banana are more prone to anthracnose leading to shorter shelf life and poorer quality [2]. Infected fruits are safe for humans to consume; however, the infections reduce fruit quality, shelf life, and marketability.

A considerable quantity of harvested banana goes waste due to its perishable nature and the extend of postharvest losses of banana in Senegal is 30-60% [2], and it is only 5-25% in developed countries [3].

It is accepted that high profit to the banana value chain players might come from conservation after harvest as well as a further boost to its production [2]. Banana fruits are not generally allowed to ripen on the plant. The period from harvest to ripeness is generally used for distant markets and then to enhance ripening for the retail sale.

Therefore, it is necessary to improve the postharvest behavior of banana attempting extend shelf life and quality of fruits. The probable reasons for the postharvest losses in bananas are poor handling and storage characteristics, postharvest physiological and biochemical changes (e.g. respiration and etylene production), and high incidence of postharvest diseases. The objective of this study is to improve the phytosanitary status of domestically grown banana focusing thereby after on post harvest stages, in the warehouses. The present study was therefore undertaken to evaluate the effect of post harvest treatments on disease incidence and severity during storage condition of banana.

2. Materials and Methods

2-1 Fruit sampling

Green mature banana just brought from the field were sampled in 10 warehouses in Thies (Senegal). A 2 kg sample of bananas is taken at each warehouse to the laboratory for detailed studies. Incidence and symptoms of diseases as well as severity were recorded. The disease causing agents were also identified. For each warehouse, a 20 fruits sample was taken.

2-2 Isolation of fungi.

The isolation of pathogenic fungi responsible for banana rotting is was performed at the front progression of developing disease symptoms according to the

methodology described by Diédhiou et al. [4]. The fruits are first soaked in a 2% solution of sodium hypochlorite for 1 minute. A sterilized scalpel incision is made in order to cut a small fragment of pulp and peel at the front progression of disease spot. The fragment is placed in a petri dish containing PDA (Potato Dextrose Agar) supplemented with 100 ppm of chloramphenicol. The petri dishes are incubated at room temperature in the dark. After 24 h, the mycelium growing out of the banana fragment is transplanted into fresh petri dishes. When the pure cultures are obtained, petri dishes are incubated for 7 to 10 days to allow sporulation. Features of fruiting bodies like spores and conidiophores were used for the identification of fungi.

2-4 Fungicide solutions dip tests

Four fungicides (imazalil, azoxystrobin , myclobutanil and mancozeb) were tested for their efficacy against post- harvest diseases of banana resulting from infection in the field (Table 1).

Table 1: Characteristics of different fungicides tested.

Active ingredient	Nom commercial	Class	Type	Concentration	Dose of application
Azoxystrobin	Ortiva	Strobilurins	syste mic	250g/L	0,8 l/400 L water
Imazalil	Martibanane®	Imidazole	syste mic	450g/L	500ml/100 L water
Mancozèbe	Mancozèbe 80 W.P	Dithiocarbama te	Conta ct	800g/Kg	25g/10 L water
Myclobutanil	Systane EC	Triazole	syste mic	240g/L	25g/10 L water

Green mature bananas from the warehouse were soaked in the fungicide solutions for 5 minutes, in accordance with the guidance provided for Martibanane ® (imazalil), manufactured for the purpose of controlling the post- harvest diseases of fruits and vegetables. Treatment was performed at recommended concentration for each fungicide. The control treatments concerned bananas dipped in a 2% sodium hypochlorite solution (T1) and unwashed bananas (T0). Each treatment was repeated 4 times, with a repetition consisting of 5 bananas, resulting in 20 fruits. Fruits were thereafter incubated at room temperature in the laboratory or at 14 °C. The bananas were monitored every 2 days for diseases until ripening of all fruits. Disease severity was assessed on the basis of fruit surface affected with: 0: no symptoms of the disease, 1: up to 5% of the fruit surface showing symptoms of the disease, 2:

6 to 10 % of the fruit surface is affected, 3: 11-20 % of the surface area showing symptoms of the disease, 4 : 20-40 % of the surface area showing symptoms of the disease, 5 : 41-60 % of the surface area showing symptoms of the disease, 6 : 61 to 80 % of the surface area showing symptoms of disease, and 7 : more than 80 % of the surface area showing symptoms of the disease[4].

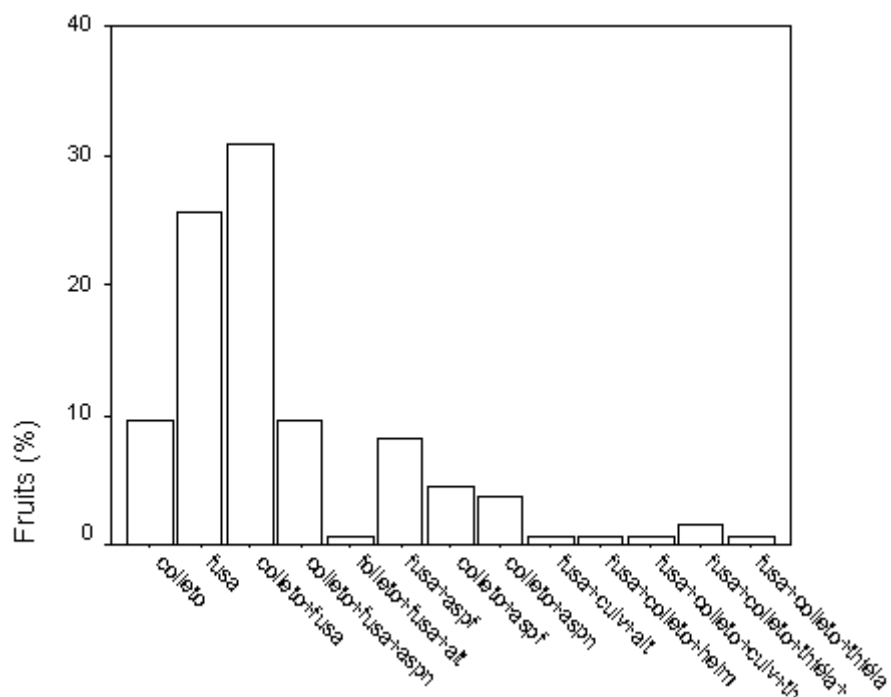
2.5 Data analysis

The data were submitted to an analysis of variance (ANOVA) with SAS software (version 9.1, SAS Institute, Cary, NC) with a confidence interval of 95%. Mean values was separated through Tukey's tests pairwise comparisons.

3. Results

3.1 Incidence of crown rot in warehouse

Fruits rotting started at onset of ripening for all fruits, after 5 days storage at room temperature with 100% incidence. The severity was however variable. Crown rot of banana was noticed on almost all fruits. The causing agents were diverse (figure 1). More than 80 % of cases were due to *Colletotrichum musae* and *Fusarium* sp either alone or in association between them or with other fungi like *Aspergillus flavus*, *Aspergillus niger* , *Alternaria* sp , *Curvularia* sp, *Helminthosporium* sp , *Thielaviopsis* sp.

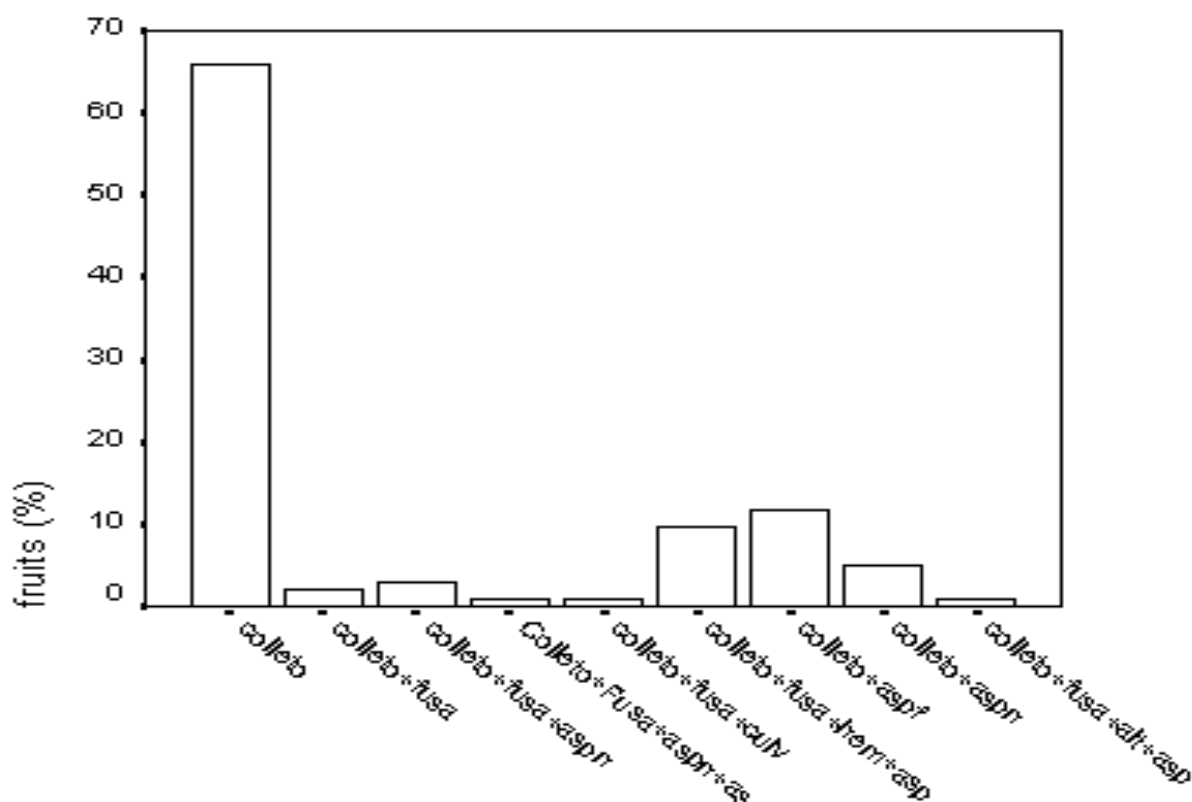


(colleto: *Colletotrichum*, fusa: *Fusarium*, aspf: *Aspergillus* groupe *flavus*, aspn: *Aspergillus niger*, alt: *Alternaria*, culv: *Curvularia*; thiela: *Thielaviopsis*, helm: *Helminthosporium*)

Figure 1: Frequency of fungal agents isolated from rotting banana peduncle.

3.2 Rotting of banana fingers

Banana fruit body and angular edges were infected by *Colletotrichum musae* alone in more than 60% of cases (figure 2). In the remaining fruits, *Colletotrichum musae* infected fruits in association with *Fusarium* sp, *Aspergillus flavus*, *Aspergillus niger*, *Alternaria* sp, *Curvularia* sp and *Helminthosporium* sp.

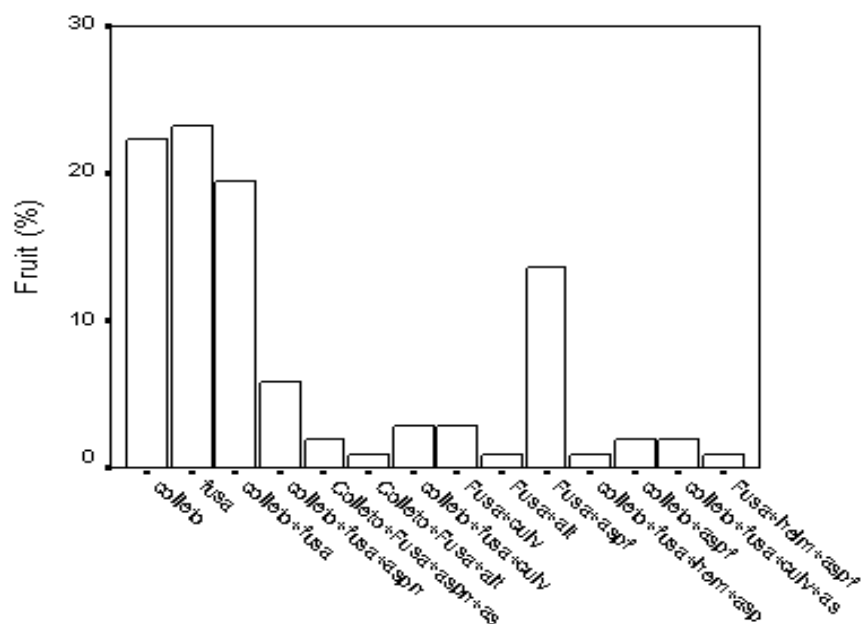


(colleto: *Colletotrichum*, fusa: *Fusarium*, aspf: *Aspergillus* groupe *flavus*, aspn: *Aspergillus niger*, alt: *Alternaria*, culv: *Curvularia*; thiela: *Thielaviopsis*, helm: *Helminthosporium*)

Figure 2: Frequency of fungal agents on necrotic spots covering fruit body and edges of bananas.

3.3 Rotting of fruit apex

From disease spots symptoms at the apex of banana fruits, *C. musae* and *Fusarium* sp were isolated alone from more than 20% of cases (Figure 3). On the remaining fruits, these two fungi were associated with a third species. *Aspergillus flavus*, *Aspergillus niger*, *Alternaria* sp, *Curvularia* sp, *Helminthosporium* sp. were the accompanying species.



(colleto: *Colletotrichum*, fusa: *Fusarium*, aspf: *Aspergillus* groupe flavus, aspn: *Aspergillus niger*, alt: *Alternaria*, culv: *Curvularia*; thiéla: *Thielaviopsis*, helm: *Helminthosporium*)

Figure 3: Frequency of fungal agents on infected apex of bananas.

3-4 Effect of fungicide dip treatments against banana diseases

The results for the efficacy test of fungicide dip against post harvest diseases of banana, involving imazalil, myclobutanil, azoxystrobin and mancozeb, is presented in Figure 4.

When fruits were incubated at room temperature, total rot of banana from control treatment was reached after 8 days of storage. By that time, all treatment allowed to maintain at least 20% of fruits free of diseases.

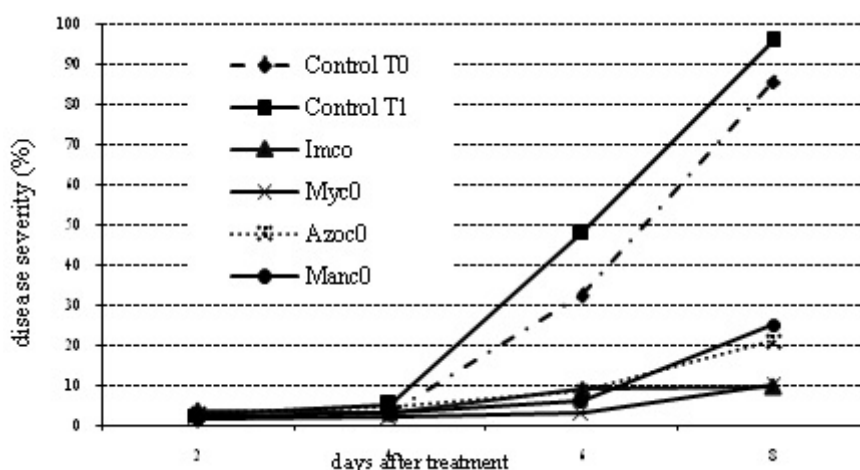


Figure 4: effect of dipping banana fruits in different fungicide solutions for 5 min and storage at room temperature, on fruits rot due to diseases. (T0: water control, T1: treatment with 2% sodium hypochlorite, Imc 0: imazalil at recommended concentration (n = 4 repeats of 10 fruits, p ≤ 5%.)

When fruits were incubated at 14 °C, rotting started at the 8th day but went faster from the 12th day onward (figures 5). It reached 100% at the 24th day for the control. Treatment with myclobutanil, azoxystrobin and mancozeb did not allow a satisfactory protection of fruits, since rotting reached over 70% and was not statistically different to control treatments. Dipping in imazalil solution allowed keeping more than 85% of fruits free of diseases for 24 days.

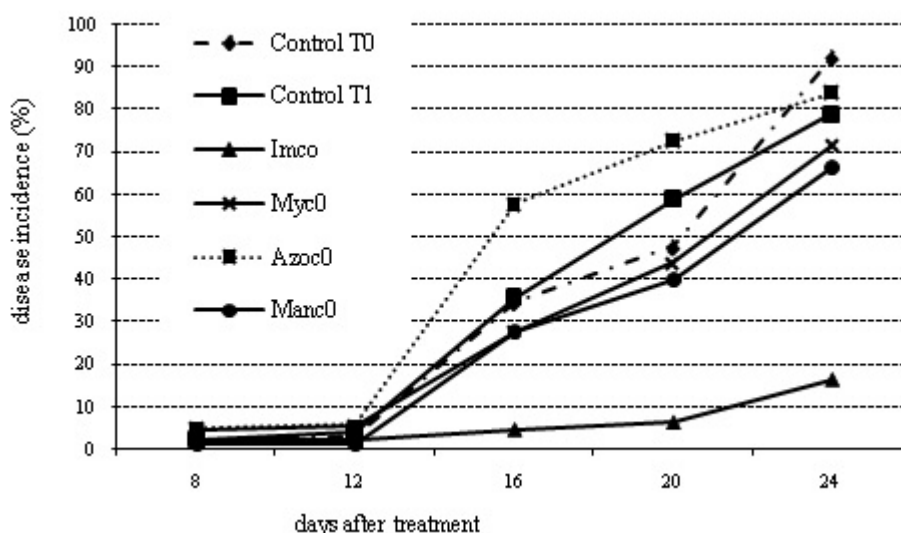


Figure 5: effect of dipping banana fruits in different fungicide solutions for 5 min and storage at 14 °C, on fruits rot due to diseases. (T0: water control, T1: treatment with 2% sodium hypochlorite, Imc 0: imazalil at recommended concentration (n = 4 repeats of 10 fruits, $p \leq 5\%$.)

4. Discussion

Postharvest diseases of fruits in general and banana in particular are of huge economic importance worldwide.

In the present study, all fruits from the warehouses showed symptoms of postharvest rots. Infection by the causing fungal agents could have started from the field. In fact, the fungal pathogens, mostly, *C. musae* and *Fusarium* spp. exist in banana fields on dead banana leaves or inflorescence tissues. Anthracnose caused by *Colletotrichum musae*, spreads from floral parts and senescent bracts to contaminate fruit in plantations [5]. Conidia reach the fruit surface in runoff rainwater or dew on the banana bunch [6]. They quickly germinate and form melanised appressoria, which are quiescent structures of the pathogen [7]. Therefore, mature fruits from the field look healthy and are sold to warehouse holders.

The fact that all fruits were infested by ripening may derive from the latent infection structure of the fungi. It is documented that dormant appressoria from infecting fungi, germinate during fruit maturation and form infection hyphae that colonize the peel and then penetrate into the fruit pulp [8].

For locally produced bananas, despite having similar size and taste (the same varieties) with imported ones, they still remain not competitive in the market because of their poor quality. This is due to a lot of failures during production and after harvest, that promote fungal infections. In the field, good production practices are not implemented. For transportation, banana bunches are dumped onto a big lorry for a 500 km trip at almost 35 °C. In the field, deflowering to remove fungal substrates and generally sanitation, or even treatment with pesticides when appropriate, are measures that normally help preserve the phytosanitary quality of fruits. None of those measures is implemented on production sites [2]. This may explain why, despite their price 40% lower than imported fruits, locally produced bananas fail to be competitive in the market.

Banana dipping test in different solutions of fungicides like imazalil and myclobutanil helped maintain a good fruit quality during 25 days of storage in low temperatures and 8 days at room temperature. Banana fruits from control treatments got all rotten after 4 days at room temperature and 12 days at 14 °C. Treatment with azoxystrobin and mancozeb in contrast showed no efficacy against post-harvest diseases of banana, even at 14 °C. Imazalil treatment in particular allowed to improve the phytosanitary quality of banana and extended shelf life. This is in line with the results reported for the USA, Spain and Malaysia, where this fungicide is dedicated to postharvest treatment [9]. Controlling anthracnose of banana after harvest could be also achieved by using edible composite coating [10].

When dipping in a solution of imazalil was combined with storage of bananas at low temperature, onset of infestation was delayed. Disease incidence as well as shelf life of the fruits was very significantly improved as also reported by Amin *et al* [11].

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