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Control of foliar diseases by the axillary application of systemic fungicides in Brazilian coconut palms

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ABSTRACT

Endemic fungal foliar diseases, such as leaf blight – LB [*Lasiodiplodia theobromae* (Pat.) Griffon and Maubl] and leaf verrucosis, or "lixa-pequena" – LP [*Camarotela torrendiela* Batista (Bezerra) and Vitoria], reduce the productivity of the coconut palm in Brazil. Damage arises from extensive necrosis of the leaflets, resulting in early abscission of basal leaves and fruit. In Brazil, fungicide terrestrial sprayings has not been a commonly employed practice for the control of coconut foliar diseases because it is not cost-effective, once requiring high-volume of fungicide spraying. Coverage gaps and extensive drift of chemicals can occur due to technological limitations of terrestrial spraying of the tallest mature trees and is further complicated by the peculiar architecture of the palms. The aim of this study was to evaluate the efficacy of systemic fungicides applied directly to the leaf axil of the coconut palm (variety Brazilian Green Dwarf of Jiqui) for the control of foliar diseases. During 2007–2010 and 2009–2012, two field plot experiments were conducted at distinct locations (farms) in the North Fluminense region. Two to 4-monthly applications of the fungicides to the leaf axil of cyproconazole (alone), cyproconazole plus azoxystrobin, cyproconazole plus trifloxystrobin, and flutriafol (alone) were efficacious in controlling coconut palm leaf diseases, resulting in a significant reduction of the LB severity and the number of necrotic LP lesions. When compared with the control treatment, significant increases in the total number of leaves per plant were observed for the most efficacious treatments after one year (2–4 leaves more) and after the second year (3–6 leaves more) after initiating the axillary applications of fungicides in both experiments. This trend continued even after the third year, when there was an average of 8 leaves more for the most efficacious treatment (27 leaves per plant) compared to control (19 leaves per plant) at the end of second experiment. The control of foliar diseases based on the results could ensure a significant increase in regional coconut production.

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1. Introduction

Located in the tropical regions of the world, the coconut tree (*Cocos nucifera* L.) is a palm species with major socio-economic importance, as the products and byproducts of the coconut palm crop generate employment and foreign revenue for rural workers in approximately 90 countries. The coconut palm can be intercropped with other plant species and plantations can be used as pastures for animals. Its cultivation is an important activity for smallholders in developing countries. The three largest producers of coconut oil, Philippines, Indonesia and India account for approximately 75% of the world's coconut fruit production. Brazil is the 4th largest producer of coconuts, with production estimated at nearly three million tons of fruit (4.5% of the world's production) occupying an area of 286,000 ha. Coconut for oil and copra is primarily produced (>80%) in the northeastern region of Brazil. However, higher productivity has been achieved in the southeast region, where the early fruiting and productive variety, Brazilian Green Dwarf of Jiqui (AVeBrJ), is cultivated. This variety is more suitable for fresh fruit marketing for coconut water consumption, with the most significant plantations concentrated in the coastal areas of the States of Espirito Santo and Rio de Janeiro (Agrianual, 2011; Costa et al., 2005; Mirizola-Filho, 2002).

The leaves of the coconut palm are usually enumerated from the newest completely expanded leaf (leaf 1) and every leaf generates an inflorescence that emerges upward from the leaf axil. A vigorous

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adult plant of the AVeBrJ variety typically has a maximum of 25 healthy (green) leaves. For coconut water consumption fresh fruits are harvested from bunches corresponding the leaf number 20 or near this leaf. Therefore, to achieve satisfactory coconut fruit production the plants of the AVeBrJ variety should have a minimum of 20 leaves (Mirizola-Filho, 2002). In the north of Rio de Janeiro State, unproductive coconut plantations having on average 15–18 leaves per plant are commonly found, reflecting the presence of severe fungal leaf disease attacks. In these plantations, the fruits are harvested from bunches without supporting leaves. In Brazil, coconut palm foliar diseases are associated with leaf blight (LB), caused by *Lasiodiplodia theobromae* (Pat) Griffon and Maubl. and small and large verrucosis, namely respectively as: "Lixa Pequena", which is caused by *Camarotella torrendiella* (Baptist) Bezerra and Win [syn.: *Phyllachora torrendiella* (Baptist) Subileau, Phyllachorales, Ascomycota)], and "Lixa Grande" (LG), which is caused by *Camarotella acrocomiae* (Mont.) Cannon and Hyde (Vitória et al., 2008; Hyde and Cannon, 1999; Subileau et al., 1994, 1993). These leaf diseases frequently occur in all Brazilian coconut-producing areas, although these pathogens are only present in Brazil and French Guiana (Warwick and Abakerli, 2001; Warwick and Leal, 2000). The damage to the coconut crop attributed to foliar diseases results from desiccation or death of the basal leaves. Without the support of the basal leaves, fruits and bunches fall before harvest time (Souza-Filho et al., 1979).

The LP and LB diseases are more harmful to the plant than LG, as the first two diseases induce extensive necrosis on leaflets, while LG induces occasional leaf chlorosis in the lateral plant limbs. The 5–7-cm-long diamond-shaped LP lesions that typically develop on the midrib of the leaves are initially chlorotic and become necrotic. The damage from LP is reflected in a large number of coalescing necrotic lesions on the leaflets, culminating in the collapse of the entire leaf (Warwick and Abakerli, 2001). Twenty or more necrotic LP lesions can be seen on the midrib of one leaflet. LB induces apical necrosis of lower leaves with an inverted "V" shape, and symptoms similar to those induced by drought (water deficit) and other stresses. The leaflets have extensive necrotic lesions with defined edges and without transition areas between the necrotic and healthy tissues. *L. theobromae* can internally colonize the rachis, inducing internal necrosis that moves upward toward the stem (systemic invasion). The necrotic tissues develop exposed cracks that release gums under the leaf rachis and at petiole insertion (Souza-Filho et al., 1979).

Although there is some variability in susceptibility to foliar diseases among coconut genotypes (Passos et al., 2007; Siqueira et al., 1995; Warwick et al., 1990), the cultivation of the AVeBrJ offers insufficient resistance levels, which does not contribute to economic control of foliar diseases. To reduce stress to the plants, balanced fertilizations, controlled irrigation, pruning and burning of the blighted basal leaves (sanitation) and albeit palliative, foliar fungicide sprayings, has been the recommended practice. Although some studies have demonstrated the relative effectiveness of spraying with systemic fungicides to control LB and LP diseases (Warwick and Abakerli, 2001; Ram, 1994, 1990, 1989; Souza-Filho et al., 1979), growers in Brazil rarely employ this practice thereby raising doubts concerning the technical-economic efficacy of the fungicide sprays currently used on the Brazilian coconut crops (Warwick and Abakerli, 2001). Coverage gaps and drift commonly occur in the spraying of adult coconut palm trees, reflecting the coconut palm architecture and the deficient technology used for terrestrial application. Thus, high volumes of fungicide sprays are required for adult coconut crop protection.

The administration of foliar fertilizers directly into the leaf axil is commonly used on plants with dominant apical growth, such as bananas and pineapples (Camargo and Silva, 1975). Several studies have confirmed the efficacy of the application of boron into the leaf axil to correct mineral deficiency of coconut palm (Santos et al., 2003; Pinho et al., 2008). The axillary application of systemic fungicides on fruit crops in Brazil has previously been tested for the control of Black "Sigatoka" on banana trees (Gasparotto et al., 2005). These authors found that the application of systemic fungicides directly into the axils of the youngest banana leaves was effective in controlling Black "Sigatoka", with positive effects on the number of leaves per plant. Because the coconut palm growth pattern is similar to that of the banana, forming new leaves from a single apical meristem ("eye"), in this study, we compared the effectiveness of systemic fungicides applied directly on the leaf axils of coconut palms (var. AVeBrJ) with the aim of controlling LB and LP diseases.

2. Materials and methods

2.1. Field trials

Two experiments were conducted under natural inoculation of 2 fields of coconut palm in northern Rio de Janeiro from 2007 to 2008 and 2009–2012. Systemic triazole and strobilurin fungicides and a benzothiadiazole plant resistance inducer, acibenzolar-s-methyl, were selected according to their action spectrum against Ascomycetes (Table 1). In the first experiment, we examined the effectiveness of systemic applications of triazole and strobilurin fungicides, alone or in combined formulations, applied directly into

Table 1
Products, formulations, doses and application intervals of systemic fungicides on the axilla of coconut palm leaves (var. Brazilian Green Dwarf of Jiqui) for the control leaf blight and "Lixa-Pequena" diseases.

Experiment 1 – Campos dos Goytacazes, July/2007 to August/2008 (8 applications at intervals of 60 days)

Treatment	Dose 1 g i.a. per plant	Dose 2 g i.a. per plant	Commercial product (formulation and i.a.%)
1 Untreated	Water	Water	–
2 Tebuconazole	0.5	1	Folicur (CE 20)
3 Difenoconazole	0.5	1	Score (CE 20)
4 Propiconazole	0.5	1	Tilt (CE 20)
5 Cyproconazole	0.5	1	Alto 100 (CS 10)
6 Azoxystrobin	0.5	1	Amistar (WG 50)
7 Cyproconazole + azoxystrobin	0.5 + 0.2	1 + 0.4	Priori Xtra (SC 20 + 8)

Experiment 2 – S. F. Itabapoana, August/2009 to December/2011 (total of 9 applications as follows: three every 60 days of July–December/2009, three every 90 days of February–October/2010, three every 120 days of January–December/2011.

Treatment	Single dose g i.a. per planta	Commercial product (formulation and i.a.%)
1 Cyproconazole	0.7	Alto 100 (CS 10)
2 Cyproconazole + azoxystrobin	0.65 + 0.05	Priori Xtra (SC 20 + 8)
3 Propiconazole	1	Tilt (CE 25)
4 Acibenzolar-S-methyl	0.25	Bion (GDA 50)
5 Cyproconazole + trifloxystrobin	0.64 + 1.5	Sphere Max (SC 16 + 37.5)
6 Tebuconazole + trifloxystrobin	1 + 0.5	Nativo (SC 20 + 10)
7 Flutriafol	1	Impact (SC 12.5)
8 Untreated	Water	–

Note: The volume of diluted fungicide suspension used in the first experiment consisted of 50 ml plant^{-1}, applied directly into the axil of leaf 9, while in the second experiment, the volume of solution/suspension used in the first five applications consisted of 100 mL plant^{-1}, applied into the axil of leaf 9. In the last four applications, this volume was equally divided between leaves 8 and 9. In the second experiment, methyl soybean oil (Golden®) 0.5% was added to the fungicide suspension of the formulations CS, SC and SL, corresponding to treatments 1, 2, 5, 6 and 7.