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Exploring the Role of Vitamins in Suppressing Fusarium oxysporum f. sp. cubense: An in vitro Study for Sustainable Management of Panama Wilt in Banana

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Abstract:

Panama wilt, caused by the soil-borne fungus Fusarium oxysporum f. sp. cubense (Foc), is a major threat to worldwide banana production. The increasing crisis justifies the establishment of sustainable and environmentally friendly management options, since the conventional use of chemical fungicides causes resistance development, economic and ecological issues. This in vitro research was undertaken to investigate the possibility of using different vitamins as growth and proliferation suppressors of Foc. Different concentrations of Riboflavin (B2), Ascorbic Acid (C), Thiamine (B1), Pyridoxine (B6), and Niacin (B3) were added to culture media, and fungal growth was determined by measuring the diameter of the colonies. Our results revealed that all tested vitamins significantly promoted the growth of Foc. In summary, our research proves that the vitamins used are not suppressive but rather are very effective promoters of the growth of the Panama wilt pathogen. This is a critical observation that implies that vitamin application-based strategies are not a sustainable or effective approach to managing the disease and may even end up worsening the situation.

Keywords: Fusarium oxysporum f. sp. cubense, Vitamins, Mycelial Growth, in vitro assay, sustainable management

Introduction:

Banana (Musa spp.) is an internationally important crop, vital for food security and livelihoods of millions of people, especially in tropical and subtropical areas. The crop is under constant attack by *Fusarium oxysporum* f. sp. *cubense* (Foc), the pathogen responsible for Panama wilt disease. Foc has made devastating incursions into banana farms across the world, especially Cavendish-producing farms, which hold a majority share of the world's exports (Ploetz, 2015). The appearance of Tropical Race 4 (TR4) has worsened the situation, with control measures becoming even more imperative (Koenig et al., 2017).

In the past, chemical fungicides, fumigation of the soil, and resistant varieties have been applied to control Panama wilt. Yet due to the adverse impact of environmental pollution, expense, and the emergence of resistance within the pathogen population, these practices have fallen short (Beresford et al., 2020). As a consequence of these limitations, there has been a growing interest in the use of alternative, more sustainable strategies for the prevention of disease. Deployment of plant growth-promoting agents, like vitamins, that have been reported to have a remarkable effect on the strengthening of plant defence systems is one of the most promising approaches (Zhang et al., 2022; Thirumurugan et al., 2019).

The aim of research is to explore the potential role of selected vitamins in inhibiting *F. oxysporum* f. sp. *cubenses* growth and

pathogenicity in vitro. The findings may provide useful information regarding the viability of vitamins as components of an integrated, sustainable method of Panama wilt control, minimizing the use of toxic chemicals, and enhancing banana crop resilience against new pathogens.

Material and Method:

Two isolates of *Fusarium oxysporum* f. sp. *cubense* (Foc) were used in this study: a wild-type, sensitive isolate (FOC-4) and a resistant mutant (EMS-FOC-9) developed through ethyl methane sulfonate (EMS) mutagenesis. Five Riboflavin, ascorbic acid, thiamine, pyridoxine and niacin were tested for the growth of the sensitive FOC-4 and resistant EMS- FOC-9 isolates at the concentration of 0.01 %. Plates without vitamin source served as control. The linear growth was measured at different intervals. Growth of *Fusarium oxysporum* f.sp. *cubense* sensitive and resistant isolates was compared with control. A 5 mm diameter agar plug taken from the advancing margin of a 7-day-old culture of each Foc isolate was placed at the center of the prepared plates. The plates were incubated at 25 ± 2°C in the dark and radial growth was recorded in two perpendicular directions on days 3, 5, and 7 post-inoculation. Each treatment was replicated three times, and the entire experiment was repeated twice to ensure reproducibility. Colony diameter was measured, and the percentage inhibition of mycelial growth compared to the control was calculated. Statistical analysis was performed

Result and Discussion:

Five vitamins were tested for the growth of the resistant and sensitive isolates at the concentration of 0.01% amended in Czapek Dox Agar medium. There was significant variation in the growth of both isolates between the various incubation periods. But there was insignificant variation in growth on various vitamins in case of both the sensitive and resistant isolates. All the vitamins tested favour the growth of both sensitive and resistant isolates. Growth of resistant isolate was found to be always higher than the sensitive one. All the vitamins increased the growth of the fungus over non- vitamin control (Tables 01 and 02, Figs. 01 and 02).

From a management perspective, these results highlight the complexity of using vitamins or similar nutritional strategies for controlling Panama wilt in bananas. While vitamins appear to boost the growth of *F. oxysporum*, their role in suppression of the pathogen may require further investigation under in vivo conditions or with different fungal strains. Previous research suggests that nutritional strategies that manipulate fungal growth might not always lead to effective suppression, especially when dealing with resistant strains that can better adapt to such conditions (Denny, 2009). In conclusion, while vitamins may influence fungal growth in *F. oxysporum* f. sp. *cubense*, the application of these findings to the control of Panama wilt in banana plantations requires a more detailed understanding of the underlying molecular interactions between vitamins and the pathogen, as well as a closer evaluation of their effects in field conditions.

Table 01. Effect of different vitamin sources on the linear growth (mm) of *Fusarium oxysporum* f.sp. *cubense* isolate sensitive to benomyl on zapek Dox Agar medium

Vitamins (0.01 %)	Sensitive							
	Days							
	1	2	3	4	5	6	7	8
Ascorbic acid	11.00	15.00	20.00	28.66	32.00	38.33	40.00	58.66
Riboflavin	12.00	16.66	22.33	30.66	34.33	40.33	42.33	58.00
Thiamine	11.66	17.33	24.66	32.66	36.33	41.66	43.33	52.33
Pyridoxine	11.33	16.00	22.33	30.00	34.66	38.66	41.33	53.66
Niacin	11.00	14.66	23.00	31.00	37.33	41.33	44.66	55.00
Control	11.33	18.66	30.33	34.00	39.33	45.00	48.66	64.00

P at 0.05 DF= 7 T value= 2.365

Standard Error Mean = 5.332

Critical Difference Mean = 12.61

F (between Vitamins sources) = 410.597431 $P < 0.0001$

F (between days) = 10.665235 $P < 0.0001$

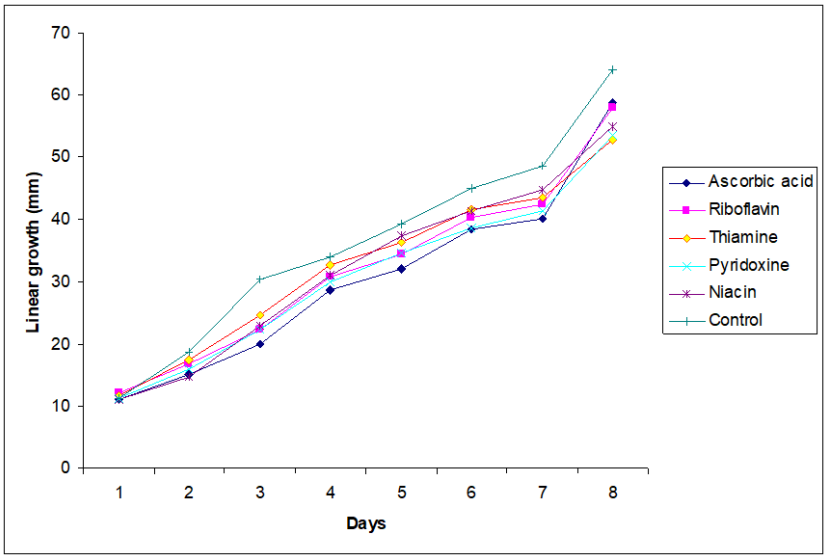

Fig. 01.Effect of different vitamin sources on the linear growth (mm) of *Fusarium oxysporum* f.sp. *cubense* sensitive isolate (FOC- 4)

Table 02. Effect of different vitamin sources on the linear growth (mm) of *Fusarium oxysporum* f.sp. *cubense* isolate resistant to benomyl on Czapek Dox Agar medium

Vitamins (0.01 %)	Resistant							
	Days							
	1	2	3	4	5	6	7	8
Ascorbic acid	11.00	19.00	24.00	32.66	36.00	42.33	44.00	62.66
Riboflavin	12.00	20.66	26.33	34.66	38.33	44.33	46.66	62.00
Thiamine	11.66	21.33	28.66	36.66	40.66	45.66	48.33	56.66
Pyridoxine	11.33	20.00	26.33	34.00	38.66	42.66	45.33	57.33
Niacin	11.00	18.66	27.00	35.00	41.33	45.33	48.66	59.00
Control	11.33	22.66	34.33	38.00	44.33	49.00	52.33	64.00

P at 0.05 DF= 7 T value= 2.365

Standard Error Mean = 5.587

Critical Difference Mean = 13.21

F (between Vitamins sources) = 516.242611 P < 0.0001

F (between days) = 10.554643 P < 0.0001

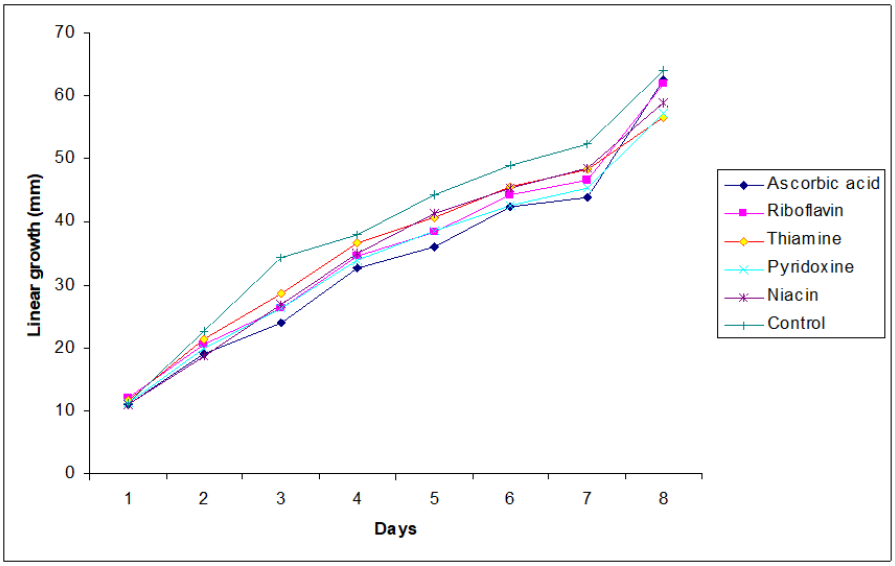

Fig. 02.Effect of different vitamin sources on the linear growth (mm) of *Fusarium oxysporum* f.sp. *cubense* resistant isolate (EMS- FOC -9)

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