PAB
Pesquisa Agropecuária Brasileira

ISSN 1678-3921

Journal homepage: www.embrapa.br/pab

For manuscript submission and journal contents, access: www.scielo.br/pab

Pomology/ Scientific Notes

Changes in the nutritional status of 'BRS Thap Maeo' banana induced by *Banana streak virus*

Abstract – The objective of this work was to evaluate the effect of *Banana streak virus* (BSV) on the nutritional status and yield of 'BRS Thap Maeo' banana plants cultivated in the state of Amazonas, Brazil. Thirty-six plants were analyzed: 18 with and 18 without visible BSV symptoms. The infected plants showed nutritional disorders, with reduced foliar concentrations of nitrogen, phosphorus, potassium, and magnesium, as well as higher levels of calcium, zinc, iron, sulfur, boron, copper, and manganese. The banana plants with BSV symptoms present, in average, a 60% reduction in bunch weight.

Index terms: *Musa* spp., Amazon region, nutrient use efficiency.

Alterações no estado nutricional da bananeira 'BRS Thap Maeo' induzidas pelo *Banana streak virus*

Resumo – O objetivo deste trabalho foi avaliar o impacto do *Banana streak virus* (BSV) no estado nutricional e na produção de bananeiras 'BRS Thap Maeo' cultivadas no estado do Amazonas, Brasil. Foram analisadas 36 plantas: 18 com e 18 sem sintomas visíveis do BSV. As plantas infectadas apresentaram distúrbios nutricionais, com concentrações foliares reduzidas de nitrogênio, fósforo, potássio e magnésio, bem como maiores níveis de cálcio, zinco, ferro, enxofre, boro, cobre e manganês. As plantas de bananeira com sintomas do BSV apresentam, em média, redução de 60% no peso dos cachos.

Termos para indexação: *Musa* spp., região amazônica, eficiência de uso de nutrientes.

Adônis Moreira[(1 ✉)],
Luadir Gasparotto[(2)],
José Clério Rezende Pereira[(3)] and
Larissa Alexandra Cardoso Moraes[(1)]

[(1)] Embrapa Soja, Rodovia Carlos João Strass, s/nº, Acesso Orlando Amaral, Distrito de Warta, Caixa Postal 4006, CEP 86085-981 Londrina, PR, Brazil. E-mail: adonis.moreira@embrapa.br, larissa.moraes@embrapa.br

[(2)] Embrapa Amazônia Ocidental, Rodovia AM-010, Km 29, s/nº, Zona Rural, Caixa Postal 319, CEP 69010-970 Manaus, AM, Brazil. E-mail: luadir.gasparotto@embrapa.br

[(3)] *In memoriam.*

✉ Corresponding author

Received
February 01, 2024

Accepted
June 20, 2024

How to cite

MOREIRA, A.; GASPAROTTO, L.; PEREIRA, J.C.R.; MORAES, L.A.C. Changes in the nutritional status of 'BRS Thap Maeo' banana induced by *Banana streak virus*. **Pesquisa Agropecuária Brasileira**, v.59, e03663, 2024. DOI: https://doi.org/10.1590/S1678-3921.pab2024.v59.03663.

Banana (*Musa* spp.) holds a prominent position as one of the primary fruits produced and consumed in Brazil, which ranks as the third largest global producer, with a regular output of 6.8 million tons per year from an estimated area of 453.000 hectares (IBGE, 2023). However, the *Musa* genus, comprising diverse species, is susceptible to various phytosanitary issues, particularly to viral infections such as those caused by *Banana bunch top virus* (BBTV), *Banana bract mosaic virus* (BBMV), *Cucumber mosaic virus* (CMV), and *Banana streak virus* (BSV) (Gasparotto & Pereira, 2010).

A marked incidence of BSV has been observed across areas cultivated with banana plants, which show intensified symptoms under conditions of water stress or nutritional imbalance. The characteristic symptoms of the virus are chlorotic and necrotic streaks on the leaves, plant dwarfism, fruit distortion, and a progressive reduction in clusters

This is an open-access article distributed under the Creative Commons Attribution 4.0 International License

(Brioso et al., 2011). Additional symptoms include a reduced plant vigor, the occasional death of the top of the plant, the internal necrosis of the pseudostem, and a decrease in the size of the fruits that are also deformed (Gasparotto & Pereira, 2010). Depending on the species or cultivar, the viral infection rate can reach up to 84% (Gasparotto & Pereira, 2010). Moreover, BSV can occur in all seedling types, including micro-populated seedlings, increasing the risk of contamination (Gasparotto & Pereira, 2010). Unfortunately, there is currently no known method to eliminate the virus from infected plants because tissue culture does not allow of the production of healthy seedlings from contaminated matrices (Gasparotto & Pereira, 2010).

In this context, nutrient dynamics plays a crucial role in plant physiological processes, directly affecting vegetative growth and development, maturation, and senescence. Given their rapid growth, banana plants demand high concentrations of certain nutrients to meet their nutritional requirements (Moreira et al., 2010), which, together with the substantial vegetative mass of the species, explain why the exported fruit contains significant nutrient amounts (Fratoni et al., 2017). These nutrients can be supplied via soil and foliar fertilization, being, subsequently, reintroduced into the system through the recycling of the plant remains produced during the crop cycle, such as stems, unsorted fruits, leaves, floral remains, and pseudostem.

Nutrient availability is influenced by several factors, such as plant physiological processes, and is linked to soil nutrient availability. Furthermore, the nutrients absorbed by and redistributed within the plant are the primary components used to estimate the amount of fertilizer to be replenished after each harvest (Moreira & Fageria, 1999a). Particularly, nitrogen and potassium are the most crucial macronutrients for banana plants, while boron and zinc are limiting factors (Moreira et al., 2010). The banana plant predominantly absorbs macro- and micronutrients in the following order: K > N > Ca > Mg > S > P and Cl > Mn > Fe > Zn > B > Cu, respectively (López & Espinosa, 1995). Zhang et al. (2019), when studying the nutritional status of banana crops in China, found significant limitations in nutrients, particularly in N and K, which hindered the plants from reaching their full productive potential.

The objective of this work was to evaluate the effect of BSV on the nutritional status and yield of 'BRS Thap Maeo' banana plants cultivated in the state of Amazonas, Brazil.

The evaluated banana plantations were of the BRS Thap Maeo (triploid - AAB) cultivar, cultivated in a typical Oxisol in the municipality of Iranduba, in the state of Amazonas, Brazil (03°17’06”S, 60°11’09”W, at an altitude of 92 m). Plant spacing ranged from 3×2 to 3×3 m, and fertilizers were applied at planting and broadcast following the recommendations of Moreira et al. (2010) for banana crops in the state. The predominant climate in the region is moist tropical, classified as Afi, with a relative abundant rainfall and a high relative humidity.

For the analysis, 36 banana plants were selected: 18 visibly infected by BSV and 18 visibly healthy. Additionally, five plants with BSV symptoms and five without symptoms were collected from the seedling nursery of Embrapa Amazônia Ocidental, located in the municipality of Manaus, also in the state of Amazonas. During flowering, banana trees infected with BSV show dark brown streaks tending towards black along secondary veins, as well as longitudinal necrosis originating from the main vein (Brioso et al., 2011), which were the criteria used in the selection process.

Following selection, samples were collected from the median portion of the third leaf limb of the banana plants with inflorescences at the stage of all-female bunches without bracts (Zhang et al., 2019).

After sample collection, the leaves were oven-dried, at 65ºC, in a forced-circulation oven until constant weight. This was done to determine the concentrations of: total N, using the Kjeldahl method; total P, via metavanadate calorimetry; K, through flame photometry; S, by turbidimetry in $BaCl^2$; B, using azomethine-H; and Ca, Mg, Cu, Fe, Mn, and Zn, with atomic absorption spectrophotometry (Malavolta et al., 1997). At the end of the crop cycle, banana bunch yield and leaf number were registered.

The reduction and increment in plant nutrients, expressed in percentage (Δ), were calculated using the following equations, respectively:

$$\Delta\,(\%) = 100 - \left(\frac{\text{Plant with symptoms} \times 100}{\text{Plant without symmptons}}\right)$$

$$\text{and } \Delta\,(\%) = \left(\frac{\text{Plant with symptoms} \times 100}{\text{Plant without symmptons}}\right) - 100$$

Leaf nutrient concentrations were tested for normality and analyzed using a completely randomized experimental design with two treatments (with and without BSV symptoms) and 18 replicates. The data were subjected to the analysis of variance and to the t-test, at 5% probability.

The BSV symptoms observed in the 'BRS Thap Maeo' banana plants (Figure 1), characterized by longitudinal streaks or bands on the leaves and pseudostem, are associated with phenotypic changes that cause a delayed development and shortened bunches, leading to a reduction in productivity, as highlighted by Brioso et al. (2011). In the present study, the banana trees with visual symptoms showed an average reduction of 60% in bunch weight, as well as a decrease in the leaf emission rate during flowering (six to eight leaves) and compacted bunches at the rachis. These signs indicate a reduction in plant metabolic activity and vigor, confirming the detrimental effects of BSV infection on banana performance.

In the plants with visual symptoms of BSV, there was also a reduction in nutrient remobilization in the phloem vessels of 26.6, 31, 27.6, and 44.1% in leaf N, P, K, and Mg concentrations, respectively. Concomitantly, the concentrations of the low-mobility leaf nutrients Ca, S, B, Cu, Fe, Mn, and Zn increased by 35.7, 14.3, 31.3, 50, 145.8, 234.8, and 46.1%, respectively (Table 1). These changes in nutrient uptake, redistribution, and remobilization suggest that BSV directly interferes with the active mechanisms of plant metabolism, which may be associated with the activity of ATPase, a crucial enzyme for an efficient root uptake of nutrients from the soil, especially of those that are actively absorbed, such as Zn and Mn (Malavolta et al., 1997). Notably, nutrient remobilization is particularly important during the reproductive stage of the plant, when fruits and storage organs are formed and root activity usually declines because of the reduced carbohydrate supply to the shoots (Moreira & Fageria, 2009c). Through the relationship between BSV infection and nutritional-profile changes, these findings highlight the complexity of the effects of this virus on the physiological processes of banana plants.

Despite the effects of BSV on plant nutritional status, leaf N, P, K, and S concentrations in the plants with and without symptoms of the virus were within the ranges considered adequate. However, the concentrations of Ca, B, Fe, and Mn were below the values recommended by Moreira et al. (2010) for asymptomatic plants. As for Mg, the concentrations were within or above the range of 1.3 to 2.0 g kg^{-1} considered as adequate, while Cu and Zn concentrations were lower than the ideal range of 6.5 to 12 mg kg^{-1} for Cu and of 15 to 22 mg kg^{-1} for Zn (Moreira et al., 2010). The low values obtained for these two micronutrients are in alignment with those found by Moreira & Fageria (2009c) for banana crops grown in the edaphoclimatic conditions of the state of Amazonas. Moreira & Fageria (2009b) highlighted that the soils in the region have a low natural fertility, requiring the application of large amounts of fertilizer

Figure 1. 'BRS Thap Maeo' banana (*Musa* spp.) plants with symptoms of *Banana streak virus*, when evaluated in the municipality of Iranduba, in the state of Amazonas, Brazil. Photos by Luadir Gasparotto.

DOI: 10.1590/S1678-3921.pab2024.v59.03663

for an economically viable crop production (Moreira et al., 2010). To increase plant productivity in the presence of BSV, an alternative strategy might be foliar fertilization, at the beginning of flowering, with nutrients with a high mobility in the phloem, such as N, P, K, and Mg (Fageria et al., 2009).

The asymptomatic plants followed the same order of nutrient uptake observed by Moreira & Fageria (2009c) for cultivar BRS Thap Maeo, i.e.: K > N > Ca > Mg > P > S. However, in symptomatic plants, there was a variation in the amount of nutrients absorbed, with a significant reduction in Mg concentration, resulting in the following order: K > N > Ca > S > P > Mg. Regarding micronutrients, the respective change in the order of Cu and Zn concentrations was observed between asymptomatic and symptomatic plants: Mn > Fe > B > Zn > Cu and Mn > Fe > B > Cu > Zn.

Table 1. Nutrient concentration and composition in 'BRS Thap Maeo' banana (*Musa* spp.) plants without and with visual *Banana streak virus* symptoms, when evaluated in the municipality of Iranduba, in the state of Amazonas, Brazil[1].

Nutrient	Nutrient concentration[1]		
	Plants without	Plants with	Δ (%)
N (g kg^{-1})	25.6±2.1a	18.8±2.3b	-26.6
P (g kg^{-1})	2.9±0.5a	2.0±0.3b	-31.0
K (g kg^{-1})	38.0±3.3a	27.5±2.9b	-27.6
Ca (g kg^{-1})	4.2±1.2b	5.7±1.4a	35.7
Mg (g kg^{-1})	3.4±1.0a	1.9±0.5b	-44.1
S (g kg^{-1})	2.1±0.7b	2.4±0.6a	14.3
B (mg kg^{-1})	16.0±4.1b	21.0±5.2a	31.3
Cu (mg kg^{-1})	2.0±0.5b	3.0±0.8a	50.0
Fe (mg kg^{-1})	29.5±7.3b	72.5±15.1a	145.8
Mn (mg kg^{-1})	125.0±62.4b	418.5±112.5a	234.8
Zn (mg kg^{-1})	6.5±1.8b	9.5±2.7a	46.1
Relationship	Nutrient composition[2]		
	Plants without	Plants with	Average
N/K ratio	0.7 (comparable)[1]	0.7 (comparable)	0.7
K/N ratio	1.5 (comparable)	1.5 (comparable)	1.5
K/Ca ratio	9.1 (higher)	4.8 (-)	6.9
K/Mg ratio	11.2 (lower)	14.5 (-)	12.8
Ca/Mg ratio	1.2 (lower)	3.0 (-)	2.1
K/(Ca+Mg) ratio	5.0 (higher)	3.6 (-)	4.3
Ca/B ratio	262.5 (lower)	271.4 (-)	267.0
Fe/B ratio	1.8 (lower)	3.5 (-)	2.7
Fe/Mn ratio	0.2 (comparable)	0.2 (comparable)	0.2

[1]Means followed by different letters, in the same row, differ from each other by the t-test, at 5% probability. [2]Relative to the values observed in plants with symptoms. -, the specific ratio is not applicable or available.

For the K/Mg ratio, the obtained value was approximately 11.2 for asymptomatic plants and 14.5 for symptomatic plants (Table 2). Moreira et al. (2010) observed that a K/Mg ratio in the leaf tissue higher than 14.7 caused a physiological disorder in the banana plant, characterized by a brownish-violet mottling of the lower surface of the petioles, implying a reduction of up to 50% in bunch weight. In the present work, in BSV-infected plants, the reduction in nutrient levels and mobility in the phloem vessels, associated with the high values of the K/Mg-ratio, predominately explain the reduction in leaf emission rate and bunch weight.

Regarding the K/N ratio, which largely reflects fruit quality (Moreira et al., 2010), the obtained average was 1.5 and the values were within the ideal range of 1.5±0.2. These results are an indicative that, despite the variations in the K/Mg ratio, the values for K/N and N/K were at adequate levels (Reis & Chepote, 2008). According to Moreira et al. (2010), the imbalance between N and K causes postharvest problems, as K levels below those considered adequate favor the accumulation of ammonia-N, inducing early ripening and a large proportion of small and thin fruits.

As for Ca and B, which play important roles in plant structure (Malavolta et al, 1997), BSV had no effect on their concentrations in the leaves, and the Ca/B ratios were similar for symptomatic and asymptomatic plants. In contrast, the K/Ca, Ca/Mg, K/(Ca+Mg), and Fe/Mn ratios all decreased, whereas Fe/B increased in BSV-infected plants with visible symptoms (Table 2).

'BRS Thap Maeo' banana plants infected with BSV and with visible symptoms show a reduction in leaf N, P, K, and Mg concentrations, coupled with an increase in Ca, S, B, Cu, Fe, Mn, and Zn. In addition, the visual symptoms of BSV are associated with a significant reduction of up to 60% in the bunch yield of the studied banana cultivar.

References

BRIOSO, P.S.T.; PEREIRA, J.C.R.; GASPAROTTO, L. Ocorrência de *Badnavirus* em frutos de bananeira no Estado do Amazonas, Brasil. **Revista Brasileira de Fruticultura**, v.33, p.1353-1355, 2011. DOI: https://doi.org/10.1590/S0100-29452011000400037.

FAGERIA, N.K.; BARBOSA FILHO, M.P.; MOREIRA, A.; GUIMARÃES, C.M. Foliar fertilization of crop plants. **Journal of Plant Nutrition**, v.32, p.1044-1064, 2009. DOI: https://doi.org/ 10.1080/01904160902872826.

FRATONI, M.M.J.; MOREIRA, A.; MORAES, L.A.C.; ALMEIDA, L.H.C.; PEREIRA, J.C.R. Effect of nitrogen and potassium fertilization on banana plants cultivated in the humid tropical Amazon. **Communications in Soil Science and Plant Analysis**, v.48, p.1511-1519, 2017. DOI: https://doi.org/10.1080/00103624.2017.1373791.

GASPAROTTO, L.; PEREIRA, J.C.R. (Ed.). **A cultura da bananeira na região Norte do Brasil**. Brasília: Embrapa Informação Tecnológica, 2010. 310p.

IBGE. Instituto Brasileiro de Geografia e Estatística. **Produção de banana**. Brasília, 2023.

LÓPEZ M., A.; ESPINOSA M., J. **Manual de nutricion y fertilizacion del banano**. Quito: International Plant Nutrition Institute, 1995. 82p.

MALAVOLTA, E.; VITTI, G.C.; OLIVEIRA, S.A. de. **Avaliação do estado nutricional de plantas**: princípios e aplicações. Piracicaba: POTAFOS, 1997. 319p.

MOREIRA, A.; BORGES, A.L.; ARRUDA, M.R. de; PEREIRA, J.C.R. Nutrição e adubação dos bananais cultivados na região amazônica. In: GASPAROTTO, L.; PEREIRA, J.C.R. (Ed.). **A cultura da bananeira na região Norte do Brasil**. Brasília: Embrapa Informação Tecnológica, 2010. p.97-132.

MOREIRA, A.; FAGERIA, N.K. Repartição e remobilização de nutrientes na bananeira. **Revista Brasileira de Fruticultura**, v.31, p.574-581, 2009a. DOI: https://doi.org/10.1590/S0100-29452009000200036

MOREIRA, A.; FAGERIA, N.K. Soil chemical attributes of Amazonas State, Brazil. **Communications in Soil Science and Plant Analysis**, v.40, p.2912-2925, 2009b. DOI: https://doi.org/10.1080/00103620903175371.

MOREIRA, A.; FAGERIA, N.K. Yield, uptake, and retranslocation of nutrients in banana plants cultivated in upland soil of Central Amazonian. **Journal of Plant Nutrition**, v.32, p.443-457, 2009c. DOI: https://doi.org/10.1080/01904160802660750.

REIS, E.L.; CHEPOTE, R.E. Efeito do nitrogênio, fósforo e potássio no desenvolvimento e produção da bananeira no sul da Bahia. **Agrotrópica**, v.20, p.13-20, 2008.

ZHANG, J.; WANG, C.; FANG, Z.; LI, B.; CHRISTIE, P.; LI, X. Nutrient and dry matter accumulation in different generations of banana at different growth stages. **Fruits**, v.74, p.82-92, 2019. DOI: https://doi.org/10.17660/th2019/74.2.4.