International Journal of Agronomy and Agricultural Research (IJAAR)
ISSN: 2223-7054 (Print) 2225-3610 (Online)
http://www.innspub.net
Vol. 12, No. 6, p. 175-185, 2018

INNSPUB

RESEARCH PAPER

OPEN ACCESS

Effect of a mineral fertilizer (Herbagreen®) on the growth of dessert banana (*Musa,* Grande Naine) and resistance to Black Sigatoka cultivated in the area of Aboisso (Côte d'Ivoire)

Camara Brahima*, Badou Odjoutchoni Jean, Chérif Mamadou, Kassi Koffi Fernand Jean-Martial, Tuo Seydou[1], Kouadio Patrick, Ouattara Généfol, Kouamé Konan Didier, Amari Ler-N'ogn Dadé Georges Elisée, Sanogo Souleymane, Et Koné Daouda

Université Félix HOUPHOUËT-BOIGNY, UFR Biosciences,

Laboratoire de Physiologie Végétale, Abidjan, Côte d'Ivoire

Article published on June 30, 2018

Key words: Herbagreen®, Foliar fertilizer, Black Sigatoka, Banana tree, Growth

Abstract

The study was carried out in Akressi banana farm (Aboisso, Côte d'Ivoire). It focused on the banana growth and it resistance to Black Sigatoka. Three doses 1 Kg + 50 ml/ha, 2 Kg + 100 ml/ha and 3 Kg + 150 ml/ha of the fertilizer Herbagreen® were used compared to a control. The product was applied on the leaves during the growth period. The results showed that Herbagreen® had a positive effect on growth period and chlorophyll content of leaves. The highest leaves number and chlorophyll contents of leaves have been obtained by 2 Kg + 100 ml/ha regardless of the observation date. There was no marked effect on the pseudostem height compared. Herbagreen® had no marked effect on the protection of leaves against Black Sigatoka. It didn't affect the flowering date and the harvest diets age. But it haves significantly effect on the diets weight. 2 Kg + 100 ml/ha resulted in the highest regimen weight 33.266 Kg compared to the control (30.053Kg).

* **Corresponding Author:** CAMARA Brahima ✉ camara_ib@yahoo.fr

Introduction

Banana is a perennial herb of the Monocotyledons group belonging to the family Musaceae. It is the fourth most important food crop after rice, wheat and maize (Lassoudière, 2007). In Africa, particularly in Côte d'Ivoire, the dessert banana sector is an important link in the Ivorian economy. This sector contributes 3% of national GDP and 8-10% of agricultural GDP. The production of the dessert banana is estimated about 260,000 tons per year, of which 80%. The banana sector is a source of employment and income for the populations of the producing countries. It employs a large and relatively low-skilled workforce, thus playing a crucial role in the fight against poverty (Loeillet, 2005; De Lapeyre De Bellaire *et al.,* 2010). Despite the importance of dessert bananas, its cultivation is subject to phytosanitary constraints, particularly those related to nematodes, squirrels, weevils and black cercosporiose. Damage caused by these pests and diseases results in yield losses up to 100% (Ganry *et al.*, 2012; Chillet *et al.,* 2014).

In intensive banana plantations, treatment of these diseases and pests is mainly done with chemicals (Lassois *et al.,* 2009). So since 1990s, bananas were treated with high amounts of active components ranging from 17 to 22 kg/ha per year (Lassoudière, 2007). This has caused the problems such as toxicity, accumulation of residues in fruits, destruction of non-target organisms, soil depletion of organic matter and the risk of water pollution (Lassois *et al.,* 2009).

Faced to this situation, lot of control strategies have been advocated. Thus, technical solutions was used to reduce the pesticides by more than 50% (Kassi *et al*, 2014; Tuo *et al.,* 2017). Therefore, the selection and improvement of resistant banana varieties is now used as the preferred way to maintain long-term banana production in current production areas (Tripathi *et al.,* 2007). But this form of struggle by the varietal improvement in the banana has presented limits. Indeed, obtaining plants by artificial hybridization is a rather long process that can take five to ten years of experiments (Lassois *et al.,* 2009).

In addition, international organizations working in the food industry denounce the introduction of genetically modified organisms (GMOs) into banana growing. Fruits obtained from GMOs pose a threat to the health of populations. This could reduce the banana marketing (Anonymous 2, 2011). Utilization of organic fertilizers from natural origin less harmful to human health and the environment would be an interesting solution.

Many studies have shown that combining crops with foliar mineral supplements would promote plant growth. Thus, they would participate in the improvement of their productivity and strengthen their defense mechanism against abiotic and biotic stresses. This is the case of Herbagreen®, a 100% natural foliar fertilizer (Dragutin, 2010) that has been effective in increasing fruit yield and improving the quality of cucumber, melon and zucchini seeds (Velkov and Petkova, 2014).

The general objective of this study is to evaluate the effect of Herbagreen® on the production of dessert banana, considered as a natural fertilizer.

The specific objectives were to:

- determine the influence of the dose of Herbagreen® on the vegetative phase of banana;
- determine the influence of the Herbagreen® dose on the chlorophyll content of banana leaves;
- determine the ability of the plant to resist Sigatoka disease according to Herbagreen® doses applied;
- determine the influence of the Herbagreen® dose on dessert banana yields.

Material and methods

Plant material

The plant material was constituted by the cultivar Great Dwarf older than two weeks. These were collected in nurseries set up by the CANAVESE society which is an institute of dessert bananas production.

Chemical reagent

The foliar fertilizer used is Herbagreen® in solid and liquid form. This product was supplied by the Plant Protection Services of CANAVESE.

Study area

The study of the effect of Herbagreen® on banana growth was carried out in the industrial plantations of CANAVESE in Aboisso. The experiment was carried out in the banana production area of Akressi at 5°37'100" north latitude and 3°05'31.400" west longitude, at an altitude of 87 m.

The Akressi banana production area comprises four sectors: sector A (KJ2), sector B (KGB), sector C (SBAK) and sector D (SMFK). The experiments were carried out in sector B. The vegetation of the locality is the dense forest. The soil is clayey-sandy with a fairly constant texture (Lassoudière, 1978). The climate is tropical humid, characterized by four seasons. The average temperature of Akressi is 26.4°C.

Experimental design

The factors studied were the different doses of Herbagreen® applied to young banana plants. In order to carry out this study successfully, a Fisher block design was adopted. This design was constituted by three repetitions and four treatments with a randomization of the distribution of treatments in each block. For each treatment, 45 plants were used and 180 plants per block.

The treatment doses of Herbagreen® used were:

- T0= control (without addition of products)
- T1= 1 Kg + 50ml/ha
- T2= 2 Kg + 100ml/ha
- T3= 3 Kg + 150ml/ha

Methods

Implementation of the experimental trial

The test was conducted on part of the CANAVESE production plot. The following operations were carried out before the experimental plot was set up.

Soil preparation and banana tree planting

The plot used is a one hectare fallow. After the clearing, the ground was plowed by a special machine (Caterpillar of Volvo brand) of the team of the great works of the company CANAVESE. Mounds in the form of planks 10 m in width and 100m in length were subsequently made with the same machine.

The picketing was done in holes 50 cm in diameter and 50 cm deep. The grounding was carried out on July 18, 2015. In each hole was put a banana tree foot. Planting density was 1820 plants per hectare.

On each board, the banana trees were planted in two double rows. The parcel consisted of three boards. Each board included 180 banana plants.

Maintenance of the plot

Weeding: To avoid competition with weeds and to keep the plant in a normal development environment, the plot has been cleaned regularly.

At early planting, manual weeding was done. Two weeks later, the plot was treated with herbicides.

Watering:

The amount of water required for cultivation is 35 mm. Below this value, a supply of water through an irrigation system is required. Watering is suspended during the rainy season. This is done at regular intervals of one week.

Application of fertilizer:

The study began one month after planting. But before the study, a solid fertilizer contribution was made and so as phytosanitary treatments.

Supply solid fertilizer:

The different fertilizers are summarized in Table 1.

Phytosanitary treatment:

Phytosanitary treatments are listed in Table 2. They consisted in the application of two types of porridge: the first composed of 3 L of Glyphalm (herbicide) + 180 L of water per 1 ha was used to control weeds; The second consisting of 10 kg Ivory (fungicide) + 100 L of water + 3 L of Legumax (fungicide) per 4 ha was used to control insect pests.

Plants leave treatment with Herbagreen®:

The treatment was applied to young banana plants after one month of planting. Treatments were performed monthly until flowering.

Table 1. Doses and dates of application of solid fertilizers to plants.

Date After planting	Dolomite (g/plant)	Nitrogen - Phosphorus - potassium (NPK, g/plant)
18/07/2015	450	-
25/07/2015	50	12,5 – 4 – 28
01/08/2015	-	12,5 – 4 – 28
08/08/2015	-	12,5 – 4 – 28
15/08/2015	-	12,5 – 4 – 28

Table 2. Quantities and periods of fungal and herbicidal treatments of the plots.

Date of applications after Planting(07/18/2015)	Fungicide (Ivory+Legumax)	Herbicide (Glyphalm)
30/07/2015	6 kg + 2 l	-
31.07/2015	-	8 l
13/08/2015	6 kg + 2 l	-
15/08/2015	6 kg + 2 l	-
02/09/2015	-	12l
19/09/2015	-	8 l
22/09/2015	-	10 l

Preparation of the solution (slurry) for the treatment:

The preparation of the slurry for the spraying of banana plants was made on the basis of one hectare. One hectare comprises of 1820 plants and corresponds to 25 liters of spray for the spraying of banana plants. Each treatment was performed on 135 banana plants at a rate of 10 liters of solution. The quantities of Herbagreen® taken were as follows:

- Treatment (T0: control): 0 g of solid Herbagreen® + 0 ml of liquid Herbagreen®;
- Treatment (T1): 400 g of solid Herbagreen® + 20 ml of liquid Herbagreen®;
- Treatment (T2): 800 g of solid Herbagreen® + 40 ml of liquid Herbagreen®;
- Treatment (T3): 1200 g of solid Herbagreen® + 60 ml of liquid Herbagreen®.

The total volume of the Herbagreen® solution is supplemented to 10 liters with water.

Treatment of banana tree:

Treatment was done using a backpack sprayer containing the slurry. Banana plants were sprayed out so that the leaves are completely wet.

Agronomic parameters determination

Number of leaves:

Leaf growth was assessed weekly after each treatment by counting the number of leaves. For each plate, the first 20 plants were used per treatment.

Height of the pseudo-stem:

Bananas pseudo-stem height was measured from base after 10 cm of the soil to the bottom up the plant, at the level of the 'V' formed by the last two functional leaves. The measure involved 20 first feet of banana per treatment for each plate and was done one week after treatment.

Leaves chlorophyll content:

Chlorophyll contents were determined 4 months after treatment. Leaf fragments were taken from the third leaf of the banana tree. This leaf was chosen because it has less necrotic symptom. A weight of 5 g of leaf fragments per treatment was ground in 50 ml of 80% acetone with a Fontainebleau soil. The crusts of each treatment were subsequently filtered. For each obtained extract optical density was read (OD) by spectrophotometer (Milton Spectronic 20 D) at wavelengths of 645 nm and 663 nm. The total chlorophyll contents were calculated from the Mckinney equation (1941).

Tchl (mg/l solution) = $20.2\ OD_{645} + 8.2\ OD_{663}$

Tchl:

Total chlorophyll content; OD: Optical Density. This content will be reduced to mg/g of leaf.

Observations of parameters related to Black Sigatoka

The parameters characterizing Black Sigatoka, the youngest leaf affected (YLA) and the youngest leaf necrosed (YLN), were determined three months after started treatment, two observations were done with 30-day intervals. The foliar observations were done by specifying the affected leaf rank by Sigatoka.

Youngest leaf affected (YLA):

To determine the rank of the youngest leaf affected (YLA), we observed the leaf row showing the first disease symptoms from top to bottom. This observation involved 10 trees of banana per treatment taken randomly in each plate.

Youngest leaf necrotic (YLN):

The youngest leaf necrotic (YLN) is the first fully expanded leaf with necrotic lesions. The latter was obtained by observing the leaves from the oldest leaf.

This observation involved 10 trees of banana per treatment taken randomly in each plate.

Development parameters of bananas dessert at flowering measurement

Planting and Flowering Interval (IPF):

The interval between planting and flowering (IPF) is the time elapsed between the emergence of the flower and the emergence of the flower at the top of the pseudo-trunk expressed during the week. At the level of each plate, 20 bananas were chosen by treatment.

Number of Functional Leaves (NFL):

The number of functional leaves was determined with the inflorescence of bananas. At the level of each plate, 20 bananas trees were chosen by treatment.

Bananas girth (BG):

The girth of the pseudo-trunk was assessed 1 m above the ground. The evaluation involved 20 bananas per treatment at each plate level.

Height of the banana pseudo-stem at flowering (HP):

The height was measured from the collar to the top of the plant, at the level of the 'V' formed by the last two functional leaves. The measure concerned 20 bananas trees per treatment in each plate.

Height of succeeding releases (HR):

The height of the discharge was measured from the collar to the top of the plant, at the level of the 'V' formed by the last two functional leaves. The measure involved 20 discharges of banana per treatment in each plate.

Number of hands of banana diets (NH):

The number of hands was determined by counting. The assessment involved 20 banana diets per treatment in each plate.

Number of fingers per banana diet (NF):

The number of fingers was performed by counting. The assessment involved 20 banana diets per treatment in each plate.

Yield parameters of dessert bananas measurement

Average harvest time (AHT):

The average harvesting time is the time taken by the banana tree from planting to the fruit maturity expressed in months. In each plate, 20 bananas trees were chosen by treatment.

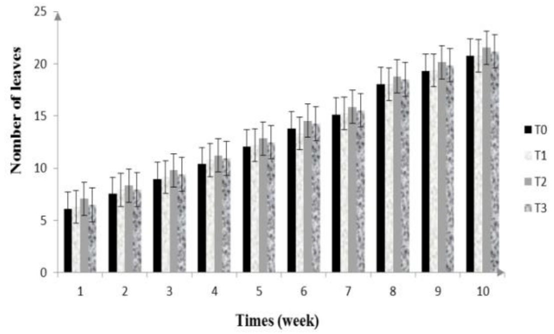
Data analysis

The data is calculated as an average of 3 repetitions using the Excel 2007 software and, also the graphs were made using the same software. The results obtained were analyzed for variance of means to evaluate the significance of the threshold effect $p < 0.05$ compared to the smallest significant difference with the Newman-Keuls test. All these analyzes were carried out with the STATISTICA version 7 software 1.

Results

Effect of Herbagreen® on leaf emission of bananas

Fig. 1 shows the number of banana leaves obtained with the different doses of Herbagreen® as a function of time. Each week, the highest number of leaves was obtained with Herbagreen® T2 treatment (S1: 7.08, S2: 8.35, S3: 9.8, S4: 11.21, S5: 12, 80: S6: 14.55, S7: 15.86, S8: 18.80, S9: 20.11, S10: 21.55).



T0: 0 g + 0 ml; T1: 400 g + 20 ml; T2: 800 g + 40 ml; T3: 1200 g + 60 ml

Fig. 1. Evolution of the number of leaves of bananas treated with different doses of Herbagreen® as a function of time.

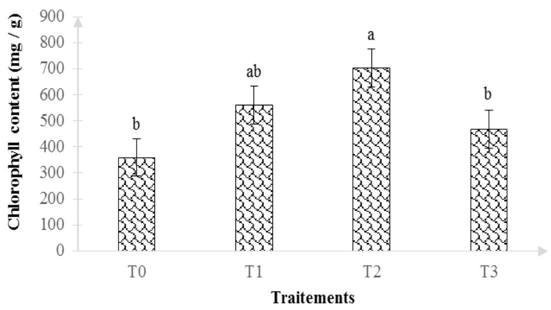
Effect of Herbagreen® on the height of the banana pseudo-stem

Fig. 2 shows the evolution of the pseudo-stem height of bananas treated with the different amounts of Herbagreen® as a function of time.

The pseudo-stem height growth of treated bananas is statistically identical to that of untreated plants regardless of time.

Effect of Herbagreen® on the chlorophyll content of banana leaves

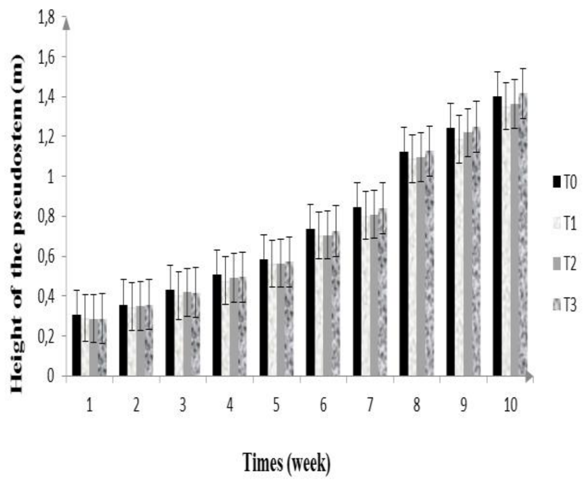
Chlorophyll levels of banana leaves were significant with the T2 dose of Herbagreen® (702.64 mg/g) in Fig. 3. However, the T1 and T3 treated banana leaves had higher levels of chlorophylls than those of the witness.



T0: 0 g + 0 ml; T1: 400 g + 20 ml; T2: 800 g + 40 ml; T3: 1200 g + 60 ml

Fig. 3. Effect of different doses of Herbagreen® on the chlorophyll content of banana leaves.

The Fig. followed by the same letter is not significantly different at the 5%



T0: 0 g + 0 ml; T1: 400 g + 20 ml; T2: 800 g + 40 ml; T3: 1200 g + 60 ml.

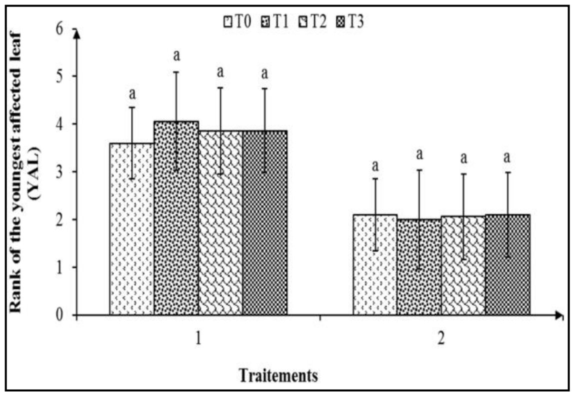
Fig. 2. Evolution of the pseudostem height of bananas treated with different doses of Herbagreen® as a function of time.

Effect of Herbagreen® on Black Sigatoka

Youngest leaf affected:

Leaf observations in the first month (Fig. 4) showed that the youngest leaf affected (YLA) corresponds to the leaf at 3.6 for the control (T0); At grade 4.06 for treatment (T1); At row 3.86 for treatments (T2) and (T3). But in the second month it corresponds to the leaf at rank 2.1 for the control (T0); At grade 2 for treatment (T1); At grade 2.06 for treatment (T2) and at 2.1 for treatment (T3).

Statistical analyzes showed that there was no significant difference between the foliar ranks of the different doses of Herbagreen® and the control of the first to second month of observation. The rank of the YLA decreased by half from the 1 st to the 2 nd month of the observations.



T0: 0 g + 0 ml; T1: 400 g + 20 ml; T2: 800 g + 40 ml; T3: 1200 g + 60 ml

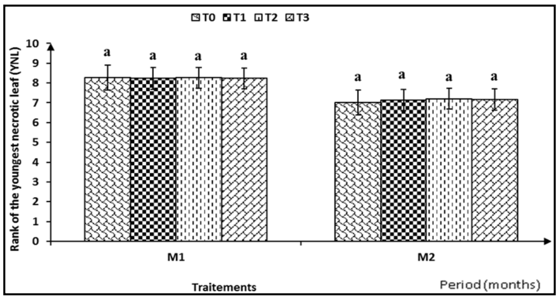
Fig. 4. Evolution of Black Sigatoka (Younger Affected Leaf (YAL)) according to Herbagreen® doses.

The Fig. followed by the same letter is not significantly different at the 5%

Youngest leaf necrotic

Leaf row observations of the youngest leaf necrosis (YLN) showed a reduction from the first to the second month for each treatment (Fig. 5). Thus, for treatment (T1), the YLN is passed from the leave of rank 8.23 to the leave of rank 7.13; For processing (T2) the YLN is passed from the leave of rank 8.26 to the leave of rank 7.2; For processing (T3), it is passed from the leave of rank 8. 23 to the leave of rank 7.16 and the control (T0), the YLN is passed from the leave of rank 8.26 to the leave of rank 7.

However, for the same months considered, no significant differences were observed between the foliar rows of the control and the plants treated whatever the dose of Herbagren®.



T0: 0 g + 0 ml; T1: 400 g + 20 ml; T2: 800 g + 40 ml; T3: 1200 g + 60 ml

Fig. 5. Evolution of Black Sigatoka leaf (necrotic leaf necrosis (PJFN)) according to Herbagreen® doses

The Fig. followed by the same letter is not significantly different at the 5%

Effect of Herbagreen® on development parameters of banana trees at flowering

Plantation and Flowering Interval (IPF)

The average time between planting and flowering (IPF) of control bananas (26.40 weeks) is slightly higher than those of bananas treated with different amounts of Herbagren® T1 (26.35 weeks); T2 (26.05 weeks); T3 (26.25 weeks). However, the statistical analysis of the flowering planting interval of the subjects treated with the Herbagren® doses showed no significant difference with that of the control bananas (Table 3).

Number of Functional leaves (NFL)

The number of functional leaves of control bananas (10.35) is lower than that of banana trees in treatment T1 (10.19) but lower than those of T2 (10.84) and T3 (10.45) Herbagren®. The analysis of the number of live leaves of bananas treated with the doses of Herbagren® did not reveal any significant differences with that of the control bananas (Table 3).

Bananas girth

The mean circumference of the control bananas (59.55 cm) is practically identical to that of bananas treated with the Herbagren® T1 dose (59.65 cm), and is superior to that of the banana trees treated with the Herbagren® T2 dose (58.45 cm), and less than the thickness growth of bananas treated with the Herbagreen® T3 dose (60.55 cm).

However, statistical analysis of the circumference of the pseudo-trunk of bananas treated with Herbagren doses did not reveal any significant differences from that of control bananas (Table 3).

Height of banana pseudo-stem

The average height of banana trees treated with the different doses of Herbagren ® (T3: 2.55 m, T1: 2.52 m, T2: 2.50 m) is slightly higher than that of the control bananas (2.49 m). However, the variance analysis carried out on the height of the pseudo-stem showed no significant difference at the threshold of 0.05 between the doses of Herbagren® and that of the control banana (Table 3).

Table 3. Evolution of the development parameters of bananas dessert at flowering according to Herbagren® treatments.

Treatments	Parameters						
	IPF (Weeks)	NL	CB (cm)	HF (m)	DH (m)	NH	NF
T0	26.40 a (± 0.21)	10.35 a (±0.18)	59.55 a (± 0.88)	2.49 a (±0.02)	1.31 a (±0.02)	10.3a (±0.16)	199.05 a (± 4.21)
T1	26.35 a (± 0.20)	10.19 a (±0.21)	59.65 a (± 0.53)	2.52 a (± 0.017)	1.26a (±0.037)	10.40 a (±0.15)	196.15 a (± 4.38)
T2	26.05 a (± 0.13)	10.84 a (±0.23)	58.45 a (± 0.77)	2.50 a (± 0.022)	1.25 a (± 0.036)	10.10 a (±0.06)	187.05 a (± 2.88)
T3	26.25 a (± 0.09)	10.45 a (±0.18)	60.55 a (± 0.92)	2.55 a (± 0.023)	1.32 a (± 0.051)	10.20 a (±0.11)	190.45 a (± 3.78)

In a column the means followed by the same letter are not significantly different from the comparison test of the Newman-Keuls means at the threshold of 0.05. (Mean ± standard error).

Flowering and Planting Interval (IPF); Number of Leaves (NL); Circumference (CB); Height of bananas (HR); Discharge height (DH); Number of hands of diets (NH); Number of fingers (NF)

(T0 : 0g + 0ml ; T1 : 400g + 20ml ; T2 : 800g + 40ml ; T3 : 1200g + 60ml).

Height of succeeding releases

Comparison of the means of the height of the discharge did not give any significant effect (Table 3) between the discharges of bananas treated with Herbagren® doses (T1: 1.26 m, T2: 1.25 m, T3: 1.32 m) and that of the control releases (1.31 m).

Number of hands of banana diets

The number of hands of banana diets treated with Herbagren® doses (T1: 10.40, T2: 10.10, T3: 10.20) is similar to that of the control banana diets (10.35) Analysis of the number of hands of banana diets treated with the Herbagren® doses did not reveal any significant differences with that of the control bananas (Table 3).

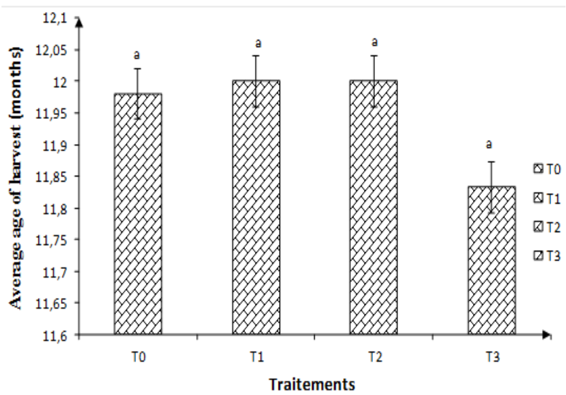
Number of fingers per banana diets

The number of diet fingers of control bananas (199.05) is higher than those of bananas treated with Herbagren® doses (T1: 196.15, T2: 187.05, T3: 190.45). However, the analysis of the number of fingers of the banana diets treated with the Herbagren® doses did not reveal any significant differences with that of the control banana diets (Table 3).

Effect of Herbagren® on dessert banana yields

Average harvest time (AHT)

The mean age of harvesting of banana diets treated with Herbagren® did not reveal any significant differences from that of the control banana diets (Fig. 6).



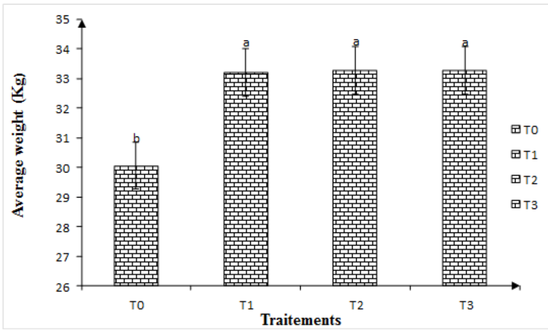
T0 : 0g + 0ml; T1: 400g + 20ml; T2: 800g + 40ml; T3: 1200g + 60ml;

Fig. 6. Average harvest time of banana diets served by Herbagreen® treatments.

The Fig. followed by the same letter are not significantly different at the 5%

Average bananas diet weights

The average weights of banana diets treated with Herbagren® doses (T1: 33.211 Kg, T2: 33.266 Kg, T3: 32.311) are much higher than those of the control bananas (30.053 Kg). The statistical analysis showed significant differences between the weights of the banana diets treated with the quantities of Herbagren® and those of the untreated banana diets (Fig. 7).



T0: 0 g + 0 ml; T1: 400 g + 20 ml; T2: 800 g + 40 ml; T3: 1200 g + 60 ml;

Fig. 7. Mean weight of banana diets served by Herbagreen®

The Fig. followed by the same letter are not significantly different at the 5%

Discussion

The number of leaves evolved positively during the three months of growth of the banana plant Grande Naine. Banana plants treated with the Herbagreen® T2 dose had a faster foliar growth than the untreated plants on a weekly basis. These results could be explained by the fact that the use of Herbagreen® at the T2 content (2 Kg + 100 ml/ha) was effective in stimulating cell division in treated banana plants. This has favored the growth of the banana tree and consequently increases the number of leaves. These results are similar to those obtained by Akin (2011). According to this, the foliar spraying of the vine plants with Herbagreen® increases the number of vine leaves. These results are also in agreement with those obtained by Addam *et al.* (2013). These authors showed after spraying of salad and cabbage feet by Oekomineral which has the same characteristics as Herbagreen® that the volume of the leaves of these plants has increased.

The height growth of bananas does not have the same characteristics as the foliar growth. The different doses of Herbagreen® applied have no significant effect on the pseudostem height growth of banana plants. These results could be explained by the primary function of Herbagreen®; In fact the fertilizer is sprayed on the leaves and contributes to the development of all the aerial parts of the plant.

Banana plants treated with Herbagreen® doses (T1, T2, and T3) showed high levels of chlorophylls compared to T0. These results could be explained by the action of the foliar fertilizer. In fact, after spraying, the mineral elements are mobilized in the leaves, especially calcium. The latter oxidizes to give calcium oxide and carbon dioxide; this had the effect of increasing the rate of photosynthesis in the leaves. Thus carbohydrates are produced in abundance in plants by the increase in sugar synthesis due to high levels of chlorophylls. Similar results were obtained by Addam *et al.* (2013). These authors have shown, after spraying of salad and cabbage plants by Oekomineral foliar fertilizer, that the average chlorophyll rate in the treated salad is 10% higher than that of the untreated salad and the average chlorophyll rate on cabbage was 59% for treated feet versus 41% for untreated plants. A high amount of Herbagreen® would be toxic or inhibitory for the synthesis of chlorophylls. This would explain the low content of this substance in these T3-treated plants.

The observation of Sigatoka (YLA and YLN) on the leaf rows of bananas showed that there were no significant differences between the different doses of Herbagreen® (T1, T2, and T3) used and control (T0); This could be explained by the time interval between leaf treatments (one month after each treatment). As a result, doses of Herbagreen® had no long-term effect on the disease. This could also be explained by the action of rain during the months of banana treatment (August, September, October). Indeed, the rain leached the product just after the treatment, which did not allow having the expected effect on the development of the disease. These results are consistent with those obtained in 2009 by Wilson and Guilo. These authors have shown that the rainy period favors the proliferation of microorganisms, which increases the index of the disease in the field. The regression of the mean leaf ranks of the youngest leaf infected (YLA) and the youngest leaf necrotic (YLN) in the second month indicates the evolution of the disease towards the leaves that are close to the cigar.

At the time of flowering, the foliar release of bananas treated with the Herbagreen® T2 dose stopped at about 26 weeks compared to the control bananas (26 weeks and 3 days). This result could be explained by the effect of the T2 dose of Herbagreen®. It has promoted the growth and reduction of the vegetative cycle of banana. This made it possible to slightly increase the number of functional leaves with the T2 dose (10.84) as against 10.35 for the control bananas. The different quantities of Herbagreen® brought in have no significant effect on the growth in thickness, the height of the banana pseudostem and the height of successive rejections of dessert bananas. These results could be explained by the application of the different Herbagreen® solutions. Spraying was done only on the foliage of the banana trees; thus the mineral elements contained in the slurry are difficult to reach at the base of the banana trees

The application of Herbagreen® doses in the vegetative cycle also did not have a significant effect on the number of diet hands, the number of fingers of diets and the age of harvest of dessert banana diets; But the effect was significant on the weight of banana diets. Bananas treated with the T2 dose of Herbagreen® had an average regime of 33.266 kg compared to 30.053 kg for the control banana plants; which corresponds to a difference of 3.213 kg in favor of bananas treated with the T2 dose.

These results could be explained by the effectiveness of the use of the T2 content of Herbagreen®. It allowed the development of the banana and the increase of the leaves during the vegetative phase. The increase in the number of functional leaves at the time of the inflorescence of the banana trees, led to a correct filling of the diets. These results are similar to those obtained by N'Guessan *et al.* (2000).

These authors showed a positive correlation between the number of leaves at flowering and the mass of the fingers of plantain.

Conclusion

At the end of this study, we were able to establish that the foliar contribution of the different doses of Herbagreen® on the banana plants favored a good vegetative phase of the plant. Thus, the T2 dose (2 kg + 100 ml/ha) produced better leaf emission. Doses of Herbagreen® also positively influence chlorophyll levels in the leaves. The highest chlorophyll content was obtained with the dose (T2). On the other hand, the effects of the doses of Herbagreen® were quite low on the height growth of the pseudostem. The effect of different doses of Herbagreen® on Sigatoka was also low due to the rainy season during the months of treatment. At the time of flowering, the effects of Herbagreen® doses were also quite low on the number of functional leaves, circumference, height growth of the pseudostem, height of successive rejections, number of hands, number of fingers of diets and the harvesting time of dessert banana diets. But the doses of Herbagreen® had quite positive effects on the weight of banana diets dessert. Dose (T2) was the highest diet weight. The objectives assigned to this work have been partially achieved, we suggest that further studies be undertaken to check the effect of different doses of Herbagreen® on pests (weevils); The rate of nematodes in the roots and on the simultaneous treatment of the leaves and soil (the base) of the dessert bananas. In addition to these studies we hope that in vitro tests will be carried out to evaluate the effect of different doses of Herbagreen® on Black Sigatoka.

References

Addam KS, Aboubacar I, Boukary H. 2013. Rapport/résultat préliminaires du test de complément minéral foliaire sur le riz au niveau de l'aménagement hydro-agricole de Saga et sur les cultures maraîchères sur les sites de Gamkalé et Yantala corniche, Institut national de la recherche agronomique du Niger 10 p.

Akin A. 2011. Effects of Cluster Tip Reduction and Some Growth Regulating Applications on Grape Yield and Quality of the Müşküle Grape Variety. YuzuncuYil University Journal of Agricultural Sciences **21(2),** 134-139.

Anonyme 1. 2014. Agence de Presse Africaine, consulté le 21 Août 2015, La filière banane dessert contribue à 3% au PIB ivoirien, selon le PM Kablan Ducan, en ligne: http://fr.africatime.com

Anonyme 3. 2011. Agence Belge de Développement, la banane un fruit en sursis 48 p.

Chillet M, Castelan FP, Abadie C, Hubert O, Chilin-Charles Y, De Lapeyre de Bellaire L. 2014. Effect of different levels of Sigatoka disease severity on banana pulp colour and early ripening. Canadian Journal of plant pathology **36(1),** 48-53.

De Lapeyre De Bellaire L, Fouré E, Abadie C, Carlier J. 2010. Black Leaf Streak Disease is challenging the banana industry. Fruits **65(6),** 327-342.

Dumancic D. 2010. Herbagreen (Practical information), consulted 10 September 2015 on http://5k.web.tr/dokuman/Prof_Dr_Dumancic_Herbagreen_Article.doc, 18 p.

Ganry J, Fouré´ E, De Lapeyre De Bellaire L, Lescot T. 2012. An Integrated Approach to Control the Black Leaf Streak Disease (BLSD) of Bananas, while Reducing Fungicide Use and Environmental Impact, Fungicides for Plant and Animal Diseases, Dr. Dharumadurai Dhanasekaran (Ed.), ISBN: 978-953-307-804-5, InTech, Available from: www.intechopen.com/books/fungicides-for-plant-and-animaldiseases/an-integrated-approach.

Kassi FM, Badou OJ, Tonzibo ZF, Salah Z, Amari L-NDGE Koné D. 2014. Action du fongicide naturel NECO contre la cercosporiose noire (*Mycosphaerella fijiensis* Morelet) chez le bananier plantain (AAB) en Côte d'Ivoire. Journal of Applied Biosciences **75,** 6183-6191.

Lassois L, Busogorox JP, Jijaki H. 2009. La banane: de son origine à sa Commercialisation. Biotechnologie, Agronomie, Société et Environnement **13(4),** 575-586.

Lassoudière A. 2007. Le bananier et sa culture, versaille, France: Editions Quae, 384 p.

Loeillet D. 2005. Le commerce international de la banane entre évolution et révolution. Fruit Trop **129,** 2-19.

Mckinney G. 1941. Absorption of light by chlorophyll solution. J. Biol. Chem **140,** 315-322.

N'Guessan AEB, Koné D, Kobenan K, Aké S, Tenkouano A. 2000. Caractéristiques agronomiques et comportement de quelques hybrides tétraploides de bananiers plantain dans le sud de la Côte d'Ivoire. BIOTERRE. Rev. Inter. Sci. De la Vie et de la Terre **1(1),** 6-21.

Tripathi L, Tripathi JN, Vroh-Bi I. 2007. Bananas and Plantains (*Musa* spp.): Transgenics and Biotechnology. Transgenic Plant Journal **1(1),** 185-201.

Tuo S, Amari L-N'DGE, Chérif M, Ouédraogo SL, Kassi F, Kouamé KG, Camara B, Koné D. 2017. Agronomic performance of plantain cultivars (*Musa* spp.) in efficient mixing situation for the control of Black Sigatoka in Southern Côte d'Ivoire. Asian Journal of Plant Pathology **11(1),** 1-9.

Velkov N, Petkova V. 2014. Influence of Herbagreen® mineral fertilizer on seed production of cucumber, melon and Zucchini. Agricultural science and technology **6(1),** 63-67.