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Research Article

Effectiveness of Biostimulant Banzaï in Productivity of Cocoa in Côte D'ivoire

Hermann-Désiré Lallie[1*], Mohamed Doumbouya[2] and Franck Zokou Oro[2]

[1]Peleforo GON COULIBALY University, Training and Research Unit of Biological Sciences, Department of Biochemistry-Genetics, BP 1328 Korhogo, Côte d'Ivoire: [2]Peleforo GON COULIBALY University, Training and Research Unit of Biological Sciences, Department of Plant Biology, BP 1328 Korhogo, Côte d'Ivoire.

***Corresponding author:** hermannlallie@hotmail.com

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ABSTRACT

Côte d'Ivoire, West African country, is the world's largest producer of cocoa. However, cocoa diseases and pests are prevalent in all regions and can cause production losses of up to 60%. In order to minimize production losses, several varieties of natural products have been developed. The objective of this study is to find out the effectiveness of the Banzaï biostimulant on cocoa productivity. Carried out in the department of Toumodi precisely in the locality of Kouaméfla, this study took place according to two devices. A device comprising a cocoa field that has received a fertilizer input during the last three years (DAE) and another which has not received any fertilizer input during the last three years (DSE). Data collection and analysis focused on the number of cherries and pods produced by treatment and by device. The Kruskal-Walli's test made it possible to compare the treatments between them and to classify them according to their effectiveness in productivity. The results show that the plots that have undergone the application of Banzaï have produced significantly more cherries and pods than the control plots without application of the biostimulant. Indeed, compared to controls, the rate of progression of cherries is between 19 to 52% in plots without precedent fertilizer and between 5 to 65% in plots with previous fertilizer. Pod production also has a growth rate of between 6 to 65% in plots without unprecedented fertilizer and between 9 to 64% in plots with previous fertilizer. In conclusion, the banzaï biostimulant has a positive effect on the yield in the cocoa culture. It could therefore strongly compensate for yield losses due to pests and diseases of the cocoa tree in Côte d'Ivoire.

Key words: Banzaï, Biostimulant, Cocoa, Productivity, Côte d'Ivoire

INTRODUCTION

The cocoa tree, *Theobroma cacao*, is a tree that is 10 to 15 meters tall, usually pruned to 6 or 8 meters, cauliflorous and evergreen (Barel, 2017). It blooms from 3 years old and gives flowers, fruits and leaves throughout the year. It reaches its full yield 6-7 years after planting and lives up to 40 years. On the trunk, many rejects or greedy people normally develop that must be regularly suppressed (Pokou, 2015).

Cocoa occupies a prominent place in the socio-economic fabric of Côte d'Ivoire, which produces about 1,600,000 tons annually, or 40% of the world supply, making this country the world's leading producer (Koua, *et al.*, 2018). However, cocoa diseases (Figure 1A) and pests (Figure 1B) are prevalent in all regions and can cause production losses of up to 60% (Coulibaly, *et al.*, 2017).

Although cocoa-specific fertilizers exist, producers in Côte d'Ivoire generally do not use mineral elements when growing cocoa, which does not allow trees to express their full potential (N'goran, 1998). In order to minimize production losses, several varieties of natural products have been implemented (Flood, *et al.*, 2004): These are biostimulants.

Biostimulants are defined as substances or microorganisms whose function, when applied to plants or the rhizosphere, is to stimulate natural processes that promote and improve nutrient absorption or utilization, tolerance to abiotic stress, crop quality or yield, regardless of the presence of nutrients (EBIC, 2014; Faessel, *et al.*, 2014). They provide fertilization and crop protection solutions by acting on the ability of biological systems to adapt to attacks by bio-aggressors or nutrient availability problems (Faessel, *et al.*, 2014). Of various origins, biostimulants have very varied modes of action.

The biostimulant Banzaï (Figure 2) is a bio-fungicide that promotes flowering, limits the fall of flowers and cherries, and stimulates the vigor of pods against external diseases and stresses (Callivoire, 2017). It is a new category

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of agricultural inputs that complements crop protection products and fertilizers. It comes in the form of two canisters that mix just before application.

The general objective of this study was to know the effectiveness of the biostimulant Banzaï on the productivity of cocoa trees in Côte d'Ivoire.

MATERIALS AND METHODS

Study Site

Our study was carried out in Kouaméfla, Toumodi department. With an area of about 2,837 km² with 127,825 inhabitants (RGPH, 2015), the department of Toumodi is located 198 km from Abidjan, the economic capital and 34 km from Yamoussoukro, the political and administrative capital of Côte d'Ivoire (AIP, 2013). Indeed, Toumodi is one of the departments whose cocoa production rate is high. For the 2012 season, this department produced about 8,727 tons of cocoa (AIP, 2013).

Materials

The plant material consisted of cocoa trees at least 10 years old of the Forastero type. The technical equipment used are: the reference product to be tested Banzaï; fertilizers adopted for cocoa production; an atomizer to apply the Banzaï biostimulant to cocoa trees; a decameter to delimit experimental blocks; ribbons and paints to mark trees.

Methods

In this study area, there are two devices selected. A device with previous fertilizer-free (DSE) and another device with previous fertilizer (DSE). The previous without fertilizer consists of a cocoa field that has not received any fertilizer input in the last three years, while the previous fertilizer consists of a cocoa field that has received a fertilizer input in the last three years.

The devices consisted of three Fischer blocks. Each block is composed of six (6) randomized plots rated T01, T02, T1, T2, T3 and T4. Each experimental plot is composed of twenty (20) cocoa tests trees.

o T01 represents the control without application of Banzaï but with a contribution of fertilizer.

o T02 represents the control without application of Banzaï without fertilizer input.

o T1 is a plot that has received three applications of Banzaï with a fertilizer input.

o T2 is a plot that has received four applications of Banzaï without fertilizer input.

o T3 is a plot that has received three applications of Banzaï without fertilizer input

o T4 is a plot that has received four applications of Banzaï with fertilizer input.

The observations were made during nine months (from July to February). The total number of cherries (immature pod less than 6 cm in length) is first counted per tree. The pods (size greater than 6 cm in length) produced since the first treatment of Banzaï was counted, then marked by strings at the peduncle. The cherries and the counted pods are not cumulative.

The statistical analysis was performed using SPSS version 20 software and R 3.2.5 software. For this purpose, several statistical tests were used: the Shapiro-Wilk test used for the verification of normality and the Levene test was used to verify the homogeneity of variances. For homogeneous variances, one-way analysis of variance (Anova) was applied. While the non-homogeneous variances and non-normal distributions the nonparametric Kruskall-Walli's test were applied. Then a classification of treatments according to the levels of differences in treatment was made.

RESULTS

Figure 3 shows a variation in the number of cherries produced as a function of the observation period in the DSE device. The highest production of cherries is observed in August with 2,755 cherries produced. Over the entire observation period, the T2 treatment produces the largest number of cherries (2,405). In general, the plots treated by Banzaï have a production of cherries higher than that of the controls in the unprecedented fertilizer device.

Figure 4 shows boxplots of the number of cherries according to the treatments in the DSE device. The Kruskal-Walli's test, used to compare the average production of cherries, shows that there is a significant difference ($p<0.05$) between treatments. The cherries produced are higher in plots with Banzai treatment than in control plots in the unprecedented fertilizer system.

The Kruskal-Walli's test grouped the treatments into three descending classes A, B and C. The T1, T2, T3 and T4 treatments of classes A and B represent the largest averages of cherries production while the controls (T01 and T02) of class C have the lowest averages of cherries produced per treatment (Table I). The most important production is at the level of T2 treatments. Figure 5 shows a variation in the number of cherries produced as a function of the observation period in the DAE device. The highest production of cherries is observed in August and January with an average production of 3,519 cherries. The months of September and March show a low production of cherries (860). T1 treatment produced the highest number of cherries (3,613), followed by T2 treatment (3,385). In general, the plots treated by Banzaï produced a greater number of cherries than the control plots on each month of observation omitted the months of February and March in the device with previous fertilizer.

Figure 6 shows boxplots of the number of cherries by treatment in the DAE device. The Kruskal-Walli's test used to compare the average production of cherries shows that there is a significant difference ($p<0.05$) between treatments. The cherries produced are higher in plots with Banzai treatment than in control plots in the device with previous fertilizer.

The Kruskal-Walli's test grouped the treatments into three descending classes A, B and C. The T1, T2, T3 and T4 treatments of class A and B represent the largest averages of cherries production while the controls (T01 and T02) of class C have the lowest averages of cherries produced (Table II). The most important production is at the level of T1 and T2 treatments.

Figure 7 shows boxplots of the number of cherries depending on the devices. The Kruskal-Walli's test used to compare cherries production averages shows that there is a significant difference ($p<0.05$) between devices. The average cherries produced are twice as high on the plots of the device with previous fertilizer (DAE) than on the plots of the unprecedented fertilizer device (DSE).

Table I: Classification of treatments according to the average production of cherries in the DSE device

Treatments	Average cherries produced	Classification
T2	40,08	A
T1	34,27	
T4	33,38	B
T3	33,33	
T02	28,10	C
T01	26,33	

Table II: Classification of treatments according to the average production of cherries in DAE device

Treatments	Average cherries produced	Classification
T1	60,22	
T2	56,42	A
T3	48,10	
T4	42,78	B
T02	40,82	
T01	36,47	C

Table III: Classification of treatments according to the average production of pods in the DSE device

Treatments	Average pods produced	Classification
T2	30,00	
T1	26,45	A
T4	25,35	
T3	23,88	
T02	20,15	B
T01	18,15	

Table IV: Classification of treatments according to the average production of pods in the DAE device

Treatments	Average pods produced	Classification
T2	39,90	
T1	38,58	A
T3	36,40	
T4	28,07	B
T01	25,73	
T02	24,32	C

Figure 8 shows that there is a variation in the number of pods from one treatment to another over the entire observation period in the DSE device. The largest numbers of pods produced are observed in September (1,987) and January (1,957). The month of March records the lowest number of pods (52). Over the entire observation period, the pod production of the plots treated with Banzaï is higher than that of the controls (T01 and T02) in the unprecedented fertilizer system.

Figure 9 shows boxplots of the number of pods as a function of the treatment in the DSE device. The Kruskal-Walli's test used to compare pod production averages shows that there is a significant difference ($p<0.05$) between treatments. The pods produced are higher in plots with Banzaï treatment than control plots in the DSE device.

The Kruskal-Walli's test grouped the treatments into two descending classes A and B. Class A with T1, T2 and T4 treatments represent the largest average pod production while controls (T01 and T02) and T3 treatment represent the Class B, the lowest class of average pods produced (Table III). The most important production is at the T2 processing level.

Figure 10 shows the evolution of pod production during the observation period in the DAE device. The first pods were recorded in September with a number of 2,442.

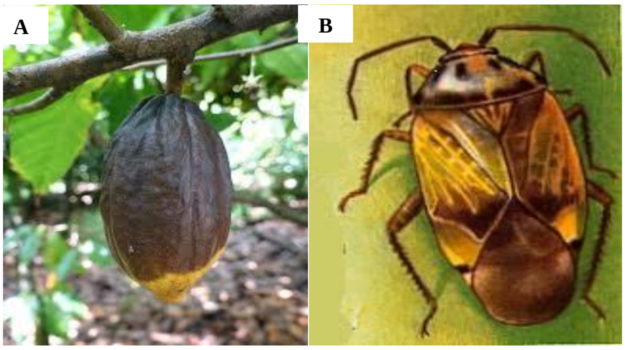

Fig. 1: Pod Rot Brown Disease (A); Cocoa pest mirid (B).

Fig. 2: Banzaï biostimulant (Callivoire, 2017).

The month of January presents the largest production of pods (2,466). In general, plots treated with Banzaï produced a greater number of pods compared to controls in the device with previous fertilizer.

Figure 11 shows boxplots of the number of pods as a function of the treatment in the DAE device. The Kruskal-Walli's test used to compare the average production of pod shows that there is a significant difference ($p<0.05$) between treatments. The pods produced are higher in plots with Banzaï treatment than in control plots in the device with previous fertilizer.

The Kruskal-Walli's test grouped the treatments into three descending classes A, B and C. Class A and B treatments T1, T2, T3 and T4 represent the largest average pod production while controls (T01 and T02) of class C have the lowest average pods produced per treatment (Table IV). The most important production is at the level of T2 and T1 treatments.

Figure 12 shows boxplots of the number of pods produced depending on the treatment. The Kruskal-Wallis test used to compare pod production averages shows that there is a significant difference ($p<0.05$) between devices. The average pods produced are twice as high on the plots of the device with previous fertilizer (DAE) than on the plots of the unprecedented fertilizer device (DSE).

DISCUSSION

The evolution of the number of cherries per treatment during the months of observation showed that the peak of production occurred in the month of August. This can be explained by the rainy season from April to June,

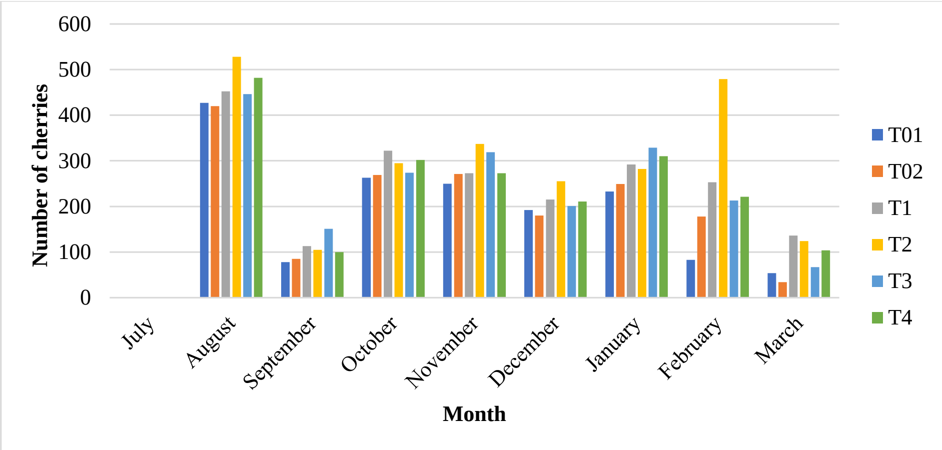

Fig. 3: Evolution of the number of cherries by treatment and per month of observation in the DSE device.

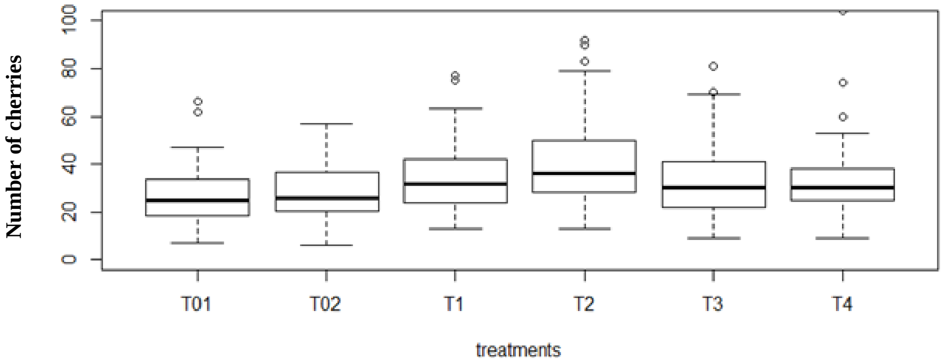

Fig. 4: Boxplots of the number of cherries produced by treatment in the DSE device.

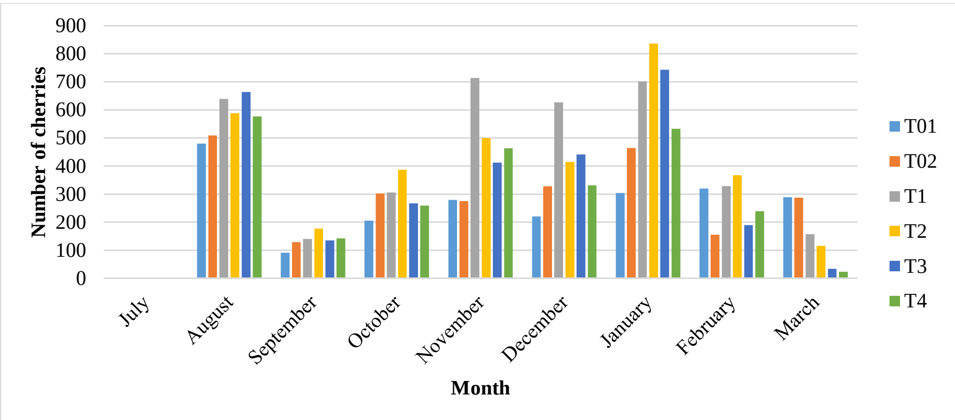

Fig. 5: Evolution of the number of cherries by treatment and per month of observation in the DAE device.

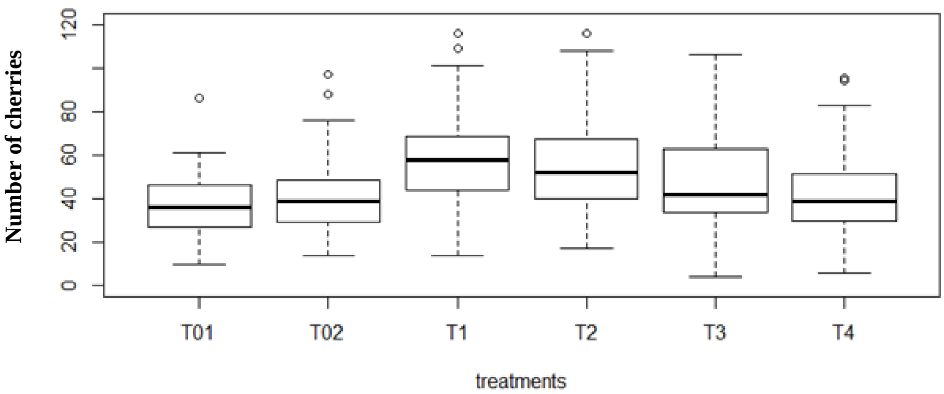

Fig. 6: Boxplots of the number of cherries produced in the DAE device.

which favored the production of cherries. Indeed, according to the CNRA report, the production of cherries reaches a sharp increase after rainy periods (CNRA, 2009).

The production of cherries by treatment and device showed a significant difference. Indeed, the plots that have undergone the application of Banzaï have produced significantly more cherries than the control plots that are without the application of the biostimulant. This is in line with the results of Mannino, who claims that biostimulants extracted from seaweed or yeast fungi on tomato plants leaded to improve the fruit quality as well as given a better nutritional value for human health when compared to untreated plants (2020).

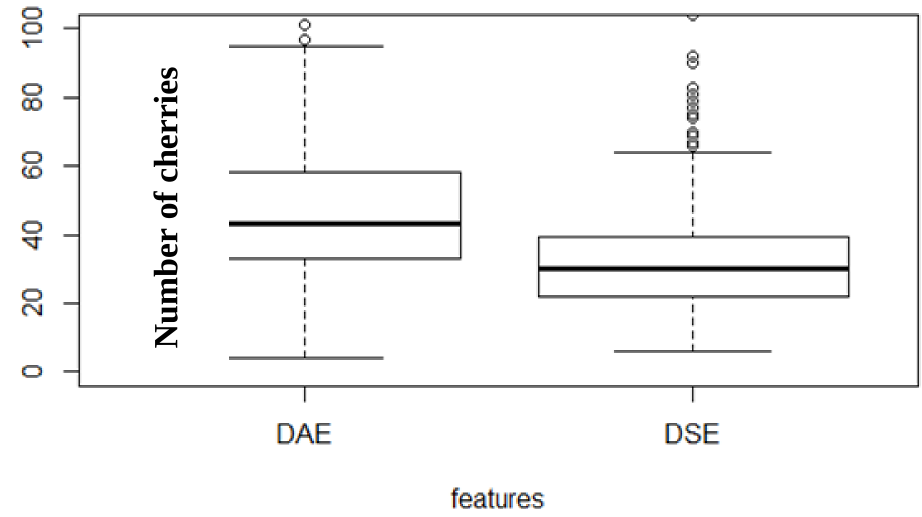

Fig. 7: Boxplots of the number of cherries produced by device.

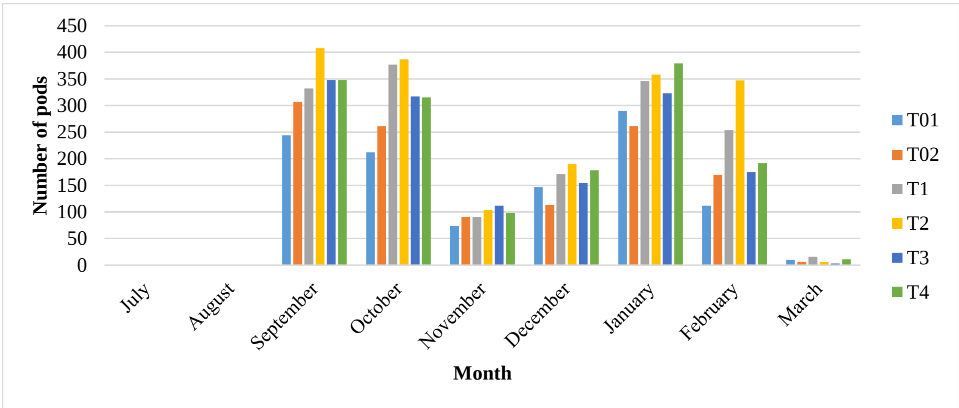

Fig. 8: Evolution of the number of pods by treatment during the months of observation in the DSE device.

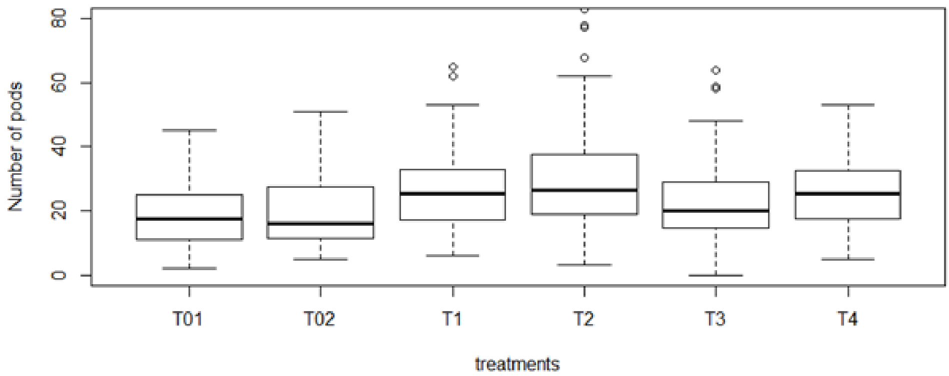

Fig. 9: Boxplots of the number of pods produced by treatment in the DSE device.

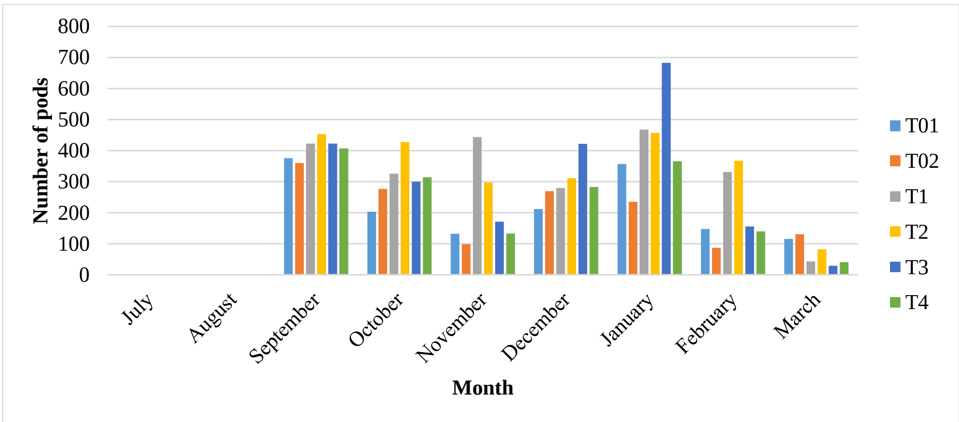

Fig. 10: Evolution of the number of pods produced by treatment and per month of observation in the DAE device.

The evolution of the number of pods per treatment during the months of observation showed that the peak of pod production occurred in the month of September. This can be explained by the high production of cherries in August which turned into a pod. Indeed the fruit called cherries becomes a pod only when it has reached about ten centimeters in length (more than 6 cm). The processing time from cherries to pod can last two to four weeks (Barel, 2017).

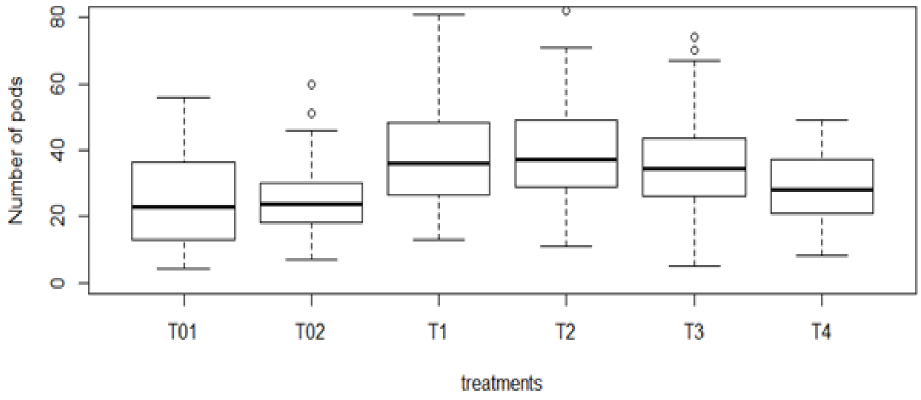

Fig. 11: Boxplots of number of pods produced in the DAE device.

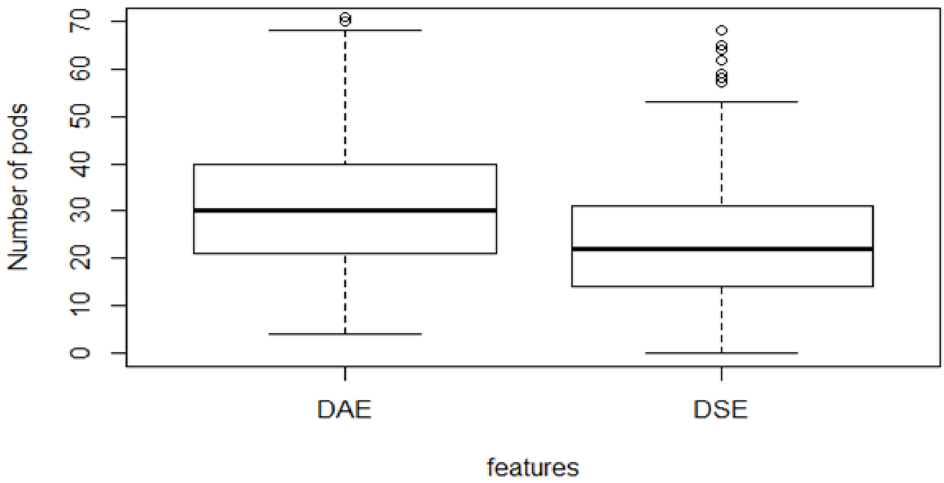

Fig. 12: Boxplots of the number of pods by device.

The production of pods per treatment showed a significant difference. Indeed, the plots with Banzaï application have produced significantly more pods than the control plots which are without application of the biostimulant. This is in line with the results of Faessel and EBIC (2014), who claim that biostimulants improve the biological functioning of the plant by promoting flowering, thus stimulating the vigor of fruits against external diseases and stresses (Faessel, *et al.*, 2014).

These precedent results are in agreement with Oro and his collaborators that shown the Banzaï biostimulant improves the production on cherries and pods, stimulates the vigor of cocoa trees against diseases and pests (2020A, 2020B, 2020C and 2020D).

The production of cherries and pods in the devices without prior fertilizer (DSE) and with previous fertilizer (DAE) showed a significant difference. Indeed the plots with previous fertilizer have a production of cherries and pods significantly higher than that of the plots without previous fertilizer. This can be explained by an accumulation of fertilizer in the soil that improves the yield of productivity. Our results are consistent with those of Goulet, which shows that the accumulation of fertilizers in the soil improves the production yield of cherries and pods (Goulet, *et al.*, 1997).

Conclusion: At the end of this study, it emerges that the application of Banzaï on plots has a significant effect on the production of cherries with a rate of progression between 19 to 52% in plots without unprecedented fertilizer and between 5 to 65% in plots with previous fertilizer compared to controls. At the same, this biostimulant has a significant effect on pod production with a margin of progression of between 6 to 65% in plots without unprecedented fertilizer and between 9 to 64% in plots with previous fertilizer compared to controls. It should be noted that plots with previous fertilizer capitalize more soil fertilization thus improving the production yield of cherries and pods of the cocoa tree. We can conclude that the Banzaï biostimulant has a positive effect on the yield of the cocoa tree.

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