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Effect of Different Types of Fertilizers on the Growth of Vivo MD2 Pineapple Plants in Nursery

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Abstract: The supply of pineapple rejects is a constraint for pineapple producers. However, pineapple has several techniques for the production of sprouts. The in vivo production technique is accessible to farmers and allows to produce homogeneous plants. However, the time required to grow the vivo plants is long and does not allow farmers to have the plants within a short period of time. The present study was initiated to improve the growth of MD2 pineapple live plants in the nursery. Thus, the effect of fertilizers on the growth of pineapple live plants in the nursery was evaluated with four types of fertilizers, F0: the neutral control; F1: biofeed base (solid biological fertilizer); F2: solid urea; F3: liquefied urea and F4: nutrigofol (foliar fertilizer). The trials were set up in a Fisher block design with three replications. The results obtained showed that the growth of vivo plants is influenced by the type of fertilizer tested. The F1 fertilizer gave the best results for all the parameters studied. Thus with F1, an average height of 40 cm was obtained at the 12th month of the experiment. The number of living leaves was 45. The leaf emission was 6 leaves. The mass of the plants and their roots was respectively 428 and 60 g. The survival rate was 100%. The lowest values were obtained in the untreated plants (F0). There was a strong correlation between the mass and the number of leaves possessed by the reject with R = 0.79. At the end of this study, organic fertilizers in solid form should be recommended and the approximate determination of the mass of the shoot ready to be transplanted in the field will be done by simple counting of the number of living leaves, that is between 40 and 50 leaves.

Keywords: Pineapple MD2, Vivo Plants, Manure, Organic Fertilizer

1. Introduction

Pineapple (Ananas comosus (L.) Merr [18] is a Bromeliaceae, mainly cultivated in the humid tropics. Its fruit is consumed fresh or canned (slices, pieces, juice). The leaves can be used for their fibers or in livestock feed. It is one of the major tropical fruits whose demand on the international market is increasing nowadays. Pineapple cultivation is an important source of income for rural populations [6]. Pineapple is generally planted on low ridges or beds that promote drainage and can be grown throughout the year. In 2018, its production was estimated at 27.92 million tons [1] and ranked second in global tropical fruit production [7] after banana. The leading producer is Costa Rica with a production of 3.42 million tons. In Africa, Nigeria (1.66 million tons in 2018) is the leading producer [1]. However, Ghana, Benin, Cameroon, and Kenya with 677,112; 360,257; 351,574; and 204,850 tons respectively in 2017 are major producers on the African continent. In 2018, African production was 5.50 million tons on an area of 408,648 ha [8].

Pineapple contributes 1.6 percent to agricultural GDP and 0.6 percent to the national GDP of Côte d'Ivoire [14]. However, intensive pineapple production requires a large number of releases of homogeneous mass. In vivo techniques available to farmers have increased the number of plants per strain [11]. However, the plants produced are small in size and the mass varies between 10 and 20 g [16]. As the

recommended mass of offspring for pineapple cultivation varies between 350 and 450 g, growing or enlarging small-caliber vivo plants (10 to 20 g) in the nursery within a short period of time therefore becomes a priority for farmers.

The general objective of this study is to determine the fertilizers that can make vivo plants grow from 10 g to 350 or 450 g in a short period of time and more specifically to:

1) evaluate the effect of 4 types of fertilizers on the growth of vivo plants.
2) define the relationship between the mass of shoots from vivo plants and the number of leaves at the end of the vivo plant growth phase.

2. Materials

2.1. Study Site

The study was carried out on an experimental plot of the University Nangui Abrogoua (UNA) in Abidjan, located in the south of Côte d'Ivoire at 4° W; 5°23 W and 100 m altitude. The soils of the study site are deeper with a sandy to sandy clay texture [17]. The vegetation of the UNA is that of the ombrophilous sector. It is the continuation of the Banco National Park [5]. The ombrophilous sector shelters hydrophilic or ombrophilous forests that are rich in lianas and epiphytes [2]. The climate is subdivided into four seasons: a long and short rainy season from March to July and October to November, respectively, and a long and short dry season from December to April and August to September, respectively. Average annual temperatures in the city of Abidjan are between 25 and 29°C.

2.2. Plant Material

The study used MD2 pineapple vivo plants derived from the strain fragmentation technique.

3. Methods

3.1. Production Phase of Vivo Plants

Harvested MD2 pineapple strains were split longitudinally from the insertion of the stalk on the stem to the base of the strain (Figure 1). The resulting fragments were soaked in a fungicidal solution (Mancozan 80 wp, Mancozeb 800g/kg; 80 to 100g per 15 liters of water) for 30 min. Then, they were sown in germinators.

Figure 1. *MD2 pineapple strain split longitudinally in two.*

3.2. Weaning of Vivo Plants

Beginning in the sixth week after sowing the pineapple strain fragments, all growing plants on the fragments (Figure 2) bearing at least 5 leaves were weaned (Figure 3).

Figure 2. *Vivo pineapple plants grown on substrate in germinator after seeding of strains.*

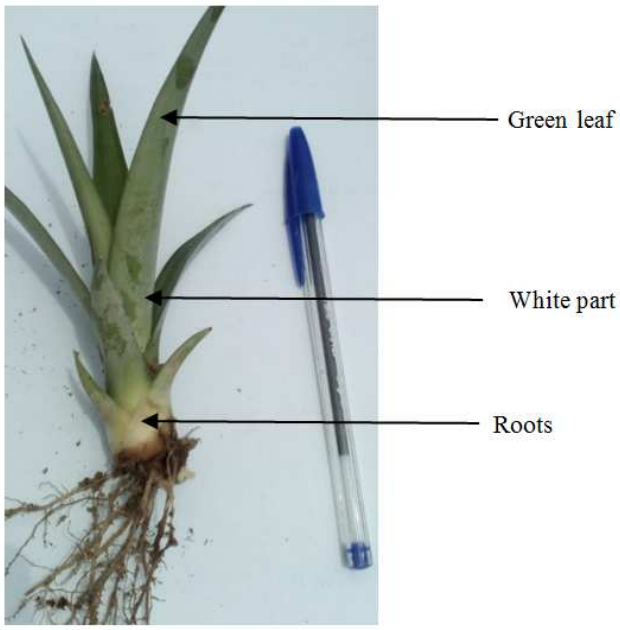

Figure 3. *Vivo pineapple plant weaned to grow in nursery.*

3.3. Growth of Vivo Plants in Nursery

The weaned plants were grown in the open air in nursery bags of 1865 cm3 volume in order to obtain plants of 350 to 450 g. During this growth phase, four types of manures or fertilizers were used. These were:

1) F0: untreated control plants;
2) F1: an organic fertilizer (biofeed base) NPK 8.8-2.5-5 (63% dry organic matter) at the rate of 1.5 g per plant;
3) F2: solid urea (46%): the dose was 0.25 g per plant. It was applied in solid form;
4) F3: solid liquefied urea (46%): the dose was 0.25 g per plant. It was applied in liquid form;
5) F4: nutrigofol NPK 8-8-8 (foliar fertilizer), applied at the rate of 1.5 ml of solution per plant. The dilution was.

Urea was applied in two forms. The first one was liquid. The required amount of urea was diluted with water at a rate of 6 kg per 200 liters of water. This slurry was sprayed on the

surface of the leaves. The second was in solid form. The granules were deposited in the axil of the last leaf at the base of the plant and was buried in the substrate.

The application of the organic fertilizer was solid and followed the same principle of application as the urea applied in solid form.

The contribution of nutrigofol was liquid (100 ml of solution for 10 liters of water) and respected the same principle of application as that of urea applied in liquid form.

The applications of organic fertilizer, urea and nutrigofol were made every two weeks. The growth medium was made up solely of black soil sterilized with firewood. The experiment was conducted over a 12-month period with 28 applications of each fertilizer. The vivo plants put in the nursery had an average mass of 10 g.

The experimental set-up (Figure 4) adopted for the implementation of the trials was a Fisher block with three replications. The length of the blocks was 7 m and 6.4 m for the width. The distance between blocks was 1.5 m and 1 m between sub-blocks. The distance between plants was 0.2 m. The number of plants per treatment was 75.

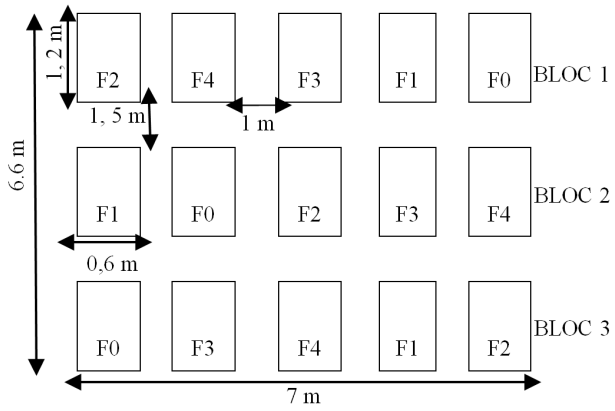

Figure 4. *Experimental setup for the growth of vivo plants.*

F0: control with no manure application; F1: organic fertilizer (biofeed base); F2: solid urea; F3: liquefied urea; F4: foliar fertilizer (nutrigofol)

3.4. Relationship Between Mass of Vivo Plants and Number of Leaves

This study was considered in order to find another alternative parameter to the mass of fresh material measured at the end of the growth phase when the seedling had reached at least 350 g.

4. Evaluation of Agrophysiological Parameters

During the grow-out period, survival or recovery rate, number of total leaves, monthly leaf emission frequency, plant height, vivo plant and root mass were assessed each month after the vivo plants were bagged.

4.1. Survival or Recovery Rate

The recovery rate concerned the number of plants that survived 3 months after transplanting into bags. A plant will have survived if this one was able to preserve the green coloring of its leaves and that an uprooting of the given plant poses a certain resistance which translates the emission of new roots, thus the resumption of its growth.

$$\text{Recovery rate} = \frac{\text{Number of surviving plants} \times 100}{\text{Number of plants bagged}}$$

4.2. Leaf Emission Rate and Number of Living Leaves

The last visible leaf in the heart of the plant was identified and marked with indelible ink as the leaf emission marker. Newly emitted leaves were those leaves that emerged after the marked leaf and allowed assessment of the rate of leaf emission. All leaves with green coloration were counted and constituted the total number of leaves borne by the shoot or the number of live leaves.

4.3. Measurement of Shoot Height

To measure plant height, a tape measure attached to a stick was used. Leaves were grouped together lengthwise. The height of the plant was measured from the base (substrate surface) to the tip of the longest leaf. The measurement of the latter constituted the height of the plant.

4.4. Determination of Shoot and Root Mass

The mass of the freshly cut roots and the mass of the vivo plant were evaluated by weighing on a digital scale. The mass displayed was recorded in grams. The quotient of the mass of a shoot over the total mass of the harvested plant was used to obtain an average of the plants.

$$\text{Average plant or root mass} = \frac{\text{Sum of individual mass}}{\text{Total number of plants or root harvested}}$$

4.5. Data Analysis

An analysis of variance was applied to the collected data and the comparison of the means was performed using the Newman-Keuls test (post-hoc ANOVA) at the 5% significance level using STATISTICA 7.1 software.

5. Results

5.1. Effect of Fertilizers on Plant Height

The evolutionary curve of the effect of fertilizers on plant height as a function of time (Figure 5) shows that all treatments had a greater effect than the F0 control. From the 6th month, the action of F1 fertilizer (organic fertilizer) on plant height is very remarkable and more important than the other fertilizers. The application of F1 allows to have plants with an average height of 40 cm at the 12th month. The action of F4 (nutrigofol) on the height of the plants is particularly different from F0, F2 and F3, only from the 9th month to reach 28 cm at the 12th month. The plants that received the treatments F0 (neutral control), F2 (solid urea) and F3 (liquefied urea) had a height between 17 and 21 cm at the 12th month.

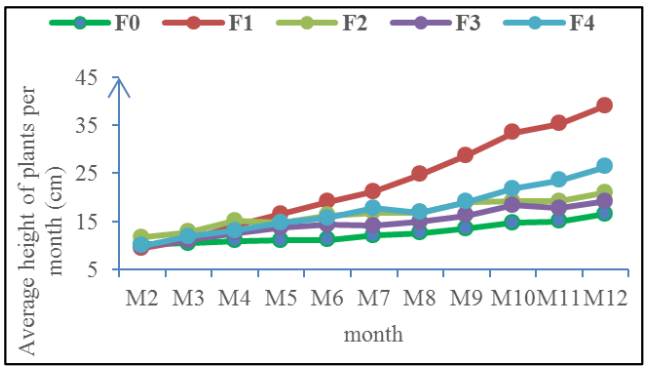

Figure 5. *Effect of manuring on the height of vivo plants.*

M2, M3..., M12: month 2, month 3..., month 12; F0: neutral control; F1: organic fertilizer; F2: solid urea; F3: liquefied urea; F4: foliar fertilizer.

5.2. Influence of Manures on the Number of Living Leaves Per Month

The number of living leaves (Figure 6) varied with different treatments from month 6 onwards. The F1 treatment gave the best results with an average of 45 leaves per plant at month 12. However, the control treatment (F0) gave poor results with an average of 23 leaves. With F4, we note an average of 34 leaves. The F3, and F2 fertilizers generated an average of 28 leaves.

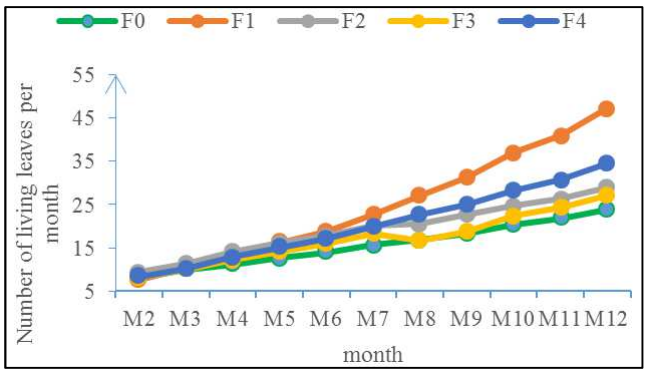

Figure 6. *Influence of fertilization on the number of living leaves of vivo plants.*

M2, M3..., M12: month 2, month 3..., month 12; F0: neutral control; F1: organic fertilizer; F2: solid urea; F3: liquefied urea; F4: foliar fertilizer.

5.3. Effect of Fertilizers on Monthly Leaf Emission Rate

The effect of F1 fertilizer on the monthly leaf emission rate remained higher than the action of other types of fertilizers from the 4th month, it varied between 2.78 and 6.28 between the 5th and 12th month. With the F4 manure, it reached 3.72 leaves on average at month 12. The rate was lower with the other treatments (F0, F2, and F3), averaging between 1.94 and 2.56 leaves per month (Figure 7).

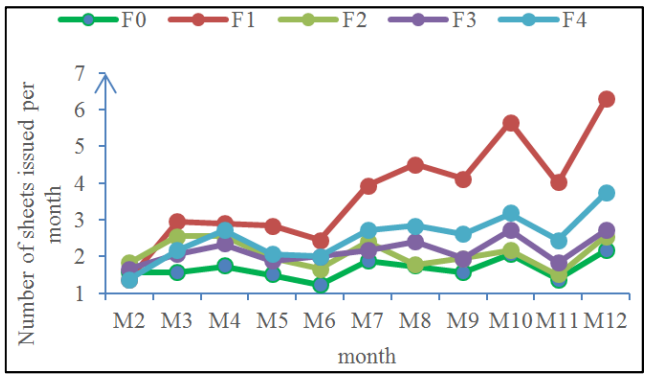

Figure 7. *Impact of fertilization on the number of leaves emitted from vivo plants.*

M2, M3..., M12: month 2, month 3..., month 12; F0: neutral control; F1: organic fertilizer; F2: solid urea; F3: liquefied urea; F4: foliar fertilizer

5.4. Effects of Manures on Plant Mass, Root Mass and Survival Rate

Table 1 shows the results of the effect of the fertilizers on the mass of the plants, roots and survival rate after 12 months of cultivation. The results obtained showed that the plants that received the F1 fertilizer had the best results (Figure 8). The highest mass of plants after 12 months of culture was obtained with the F1 fertilizer (428 g) followed by the plants having received the F4 fertilizer (225 g). The masses of 44.33, 67 g and 82.39 were obtained respectively with F0, F2 and F3. In terms of root mass, the highest masses were obtained with F1 (60.39 g). On the other hand, with the other fertilizers, the average root mass was 8.44; 16; 23 and 39 g respectively with F0, F2, F3 and F4. Survival rate was 100% for all treatments.

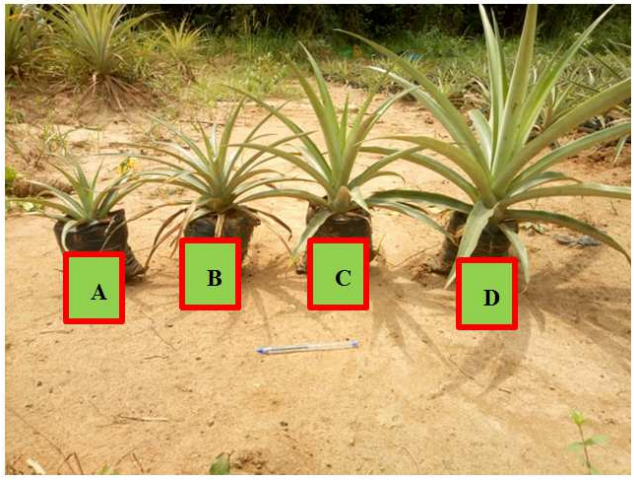

Figure 8. *Vivo Pineapple Plants After 12 Months of Growth with Different Manures.*

A: Vivo plant that received no fertilizer (F0, Control)
B: Vivo plant having received solid or liquid urea (F2, and F3)
C: Vivo plant having received foliar fertilizer (nutrigofol) (F4)
D: Vivo plant having received the organic fertilizer (biofeed base) (F1)

Table 1. *Effect of manures on plant mass, root mass and survival rate after 12 months of cultivation.*

Type of manure	Average mass of vivo plants (g)	Average root mass of vivo plants (g)	Survival rate (%)
F0	44,33 d	8,44 d	100
F1	428,11 a	60,39 a	100
F2	67,00 c	16,00 cd	100
F3	82,39 c	23,00 c	100
F4	225,00 b	39,00 b	100
CV (%)	15	20	
P	0,000	0,000	

In the same column, numbers followed by the same letter are statistically identical at the α = 5% threshold (Newman-keuls test); CV: Coefficient of Variation; P: Probability; F0: neutral control; F1: organic fertilizer; F2: solid urea; F3: liquefied urea; F4: foliar fertilizer.

5.5. Relationship Between Mass of Vivo Seedlings and Number of Leaves at the End of the Growth Phase of Vivo Pineapple Plants md2 After 12 Months of Culture

The relationship between the parameters mass of shoots from vivo plants and number of leaves at the end of the growth phase of MD2 pineapple plants (Figure 9) is characterized by the linear equation y = 0.0509x + 24.353. The tests revealed that the two parameters studied, are strongly and positively correlated. The correlation coefficient established was R = 0.79. The number of living leaves at least equal to 350 g, determined from the prediction line (y = 0.0509x + 24.353) was 42 leaves.

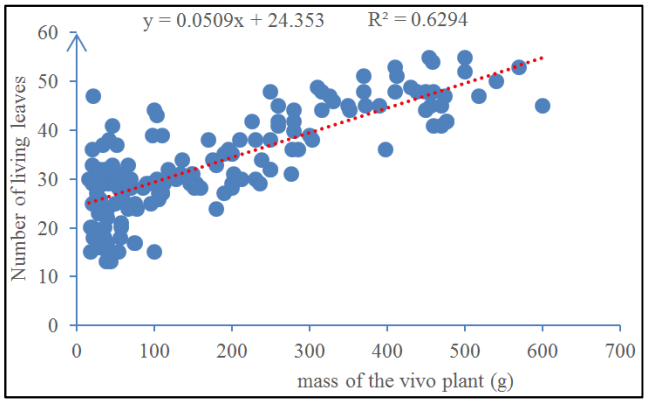

Figure 9. *Relationship Between Mass of and Number of Leaves at the End of the Magnification Phase of MD2 Pineapple Plants.*

6. Discussion

The results obtained show that the F1 fertilizer (biofeed base), which is an organic fertilizer, gave the best results, with plants growing more than 400 g in 12 months. Such a result is explained by the fact that this organic fertilizer is composed of 63% of dry organic matter, contains in its core very soluble nitrogen and directly assimilable by the plant. This richness in organic matter will improve the physicochemical properties and biological activity of the soil [9, 3], which promotes plant growth. Similar results were obtained by Meddich et al. [13]. Indeed, these authors showed that Bacteriosol® which is an organic fertilizer was beneficial for date palm biomass compared to the use of organic and chemical amendment. Urea which is a fertilizer prized for its positive action on plant growth did not give a better result. This could be due to the frequency of application or the quantity or the fact that it is a very volatile mineral fertilizer. The vivo plants are too fragile and very young and do not have an adequate root system to quickly draw the nutrients provided. This could explain the lesser effect of urea on the growth of vivo plants. The results obtained are in agreement by Maurice, 2017 [12]. Our results are contrary to those of many authors who have shown the beneficial effect of urea on seedling growth [10, 15]. The results obtained show a strong positive correlation between vivo plant mass and number of leaves at the end of the growth phase of MD2 pineapple vivo plants. It should be noted that shoot biomass is conditioned by stem mass and leaf mass. At this stage of the development of the shoot, the stem being less developed carries many leaves with a sufficient leaf area, this would explain this positive correlation that exists between the parameters mass of shoots and number of living leaves. Codjo, 2016 [4] obtained similar results. Indeed, during his studies on the production of shoots in situ, he was able to show that the treatments provided that gave shoots of greater mass had respectively a number of living leaves also higher than the others. The results of this work therefore showed a proportionality between the mass of the shoot and the number of living leaves.

7. Conclusion and Perspective

At the end of this study, it appears that the growth of vivo pineapple plants in nursery was influenced by the tested fertilizers. The best growth result was obtained with the F1 fertilizer (biofeed base) which is an organic fertilizer. Moreover, a strong correlation was shown between the mass and number of living leaves on the shoot. In order to deepen the research on the growth of pineapple live plants in nursery, in another trial, it seems appropriate to study:

1) The effect of several substrates on the growth of vivo plants in nursery.
2) The agronomic performances of vivo plants (vegetative growth, yield and organoleptic quality of fruits).

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