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Vegetative Performance of Two Cultivars and Four Hybrids of Pineapple in Côte d'Ivoire

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Authors' contributions

This work was carried out in collaboration among all authors. Author NA designed the study and lead the experiments. Authors AN and NA performed the statistical analysis. Author NA wrote the first draft of the manuscript. Authors KKCG, AGJO and TS criticized the analyses and the manuscript. All authors read and approved the final manuscript.

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ABSTRACT

Since the early 2000s, pineapple from Côte d'Ivoire has suffered a discount in its marketing due to the heterogeneity of the quality of its fruit and the arrival of MD2 on the international market. In order to help pineapple from Côte d'Ivoire once again win back the international market, Ananas comosus hybrids with an early natural coloring have been developed at the CNRA. The agronomic performances of these hybrids were tested at the research station of Anguédédou. Vegetative characteristics such as plant fresh mass, stem fresh and dry mass, number of leaves generated and leaf D fresh mass of these hybrids H1, H2, H3 and H4 were compared to those of cultivars Smooth Cayenne and MD2 at 2, 4 and 6 months. The results obtained showed no statistically significant difference in plant mass between hybrid H4 (2675 g) and cultivars MD2 (2645 g) and Smooth Cayenne (2763 g) after 6 months of planting. The fresh and dry mass of the stems of these three varieties were also statistically identical. Hybrid H4 leaf D fresh mass was very low (55 g) at six months of planting compared to the two cultivars (73 g each). Hybrids H2 and H3 at this same period gave leaf masses of over 80 g. Regarding the characteristics assessed, hybrids H4 and H3 had much more conformity with cultivars Smooth Cayenne and MD2.

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1. INTRODUCTION

Pineapple is one of the agricultural enterprises which have experienced spectacular development in Côte d'Ivoire. From 1 800 tons in 1950, pineapple yield reached 200 000 tons in the 1970s and represented 97% of the European market in 1987 [1-3]. Pineapple contributed 1.6% to the Agricultural Gross Domestic Product (GDP) and 0.6% to the national GDP in 2000. In 2001, the yield rose to 272 000 tons and Côte d'Ivoire was ranked second largest exporting country of fresh fruit in the world behind Costa Rica [4]. However, in recent years, the sector has faced a drastic drop in its revenues; which has already prompted some producers to turn to other enterprises. The yield has considerably fallen, reaching 60 000 tons in 2008 [5]. In 2014, only 33 976 tons of fruit were exported [6]. This drop is the drawback of monovarietal cultivation of Smooth Cayenne which since then has suffered setbacks against the Latin American variety, MD2 (Extra-sweet). The latter having more popularity with European consumers because of its sweeter taste, long shelf life and cylindrical shape [7]. To this is added a great qualitative heterogeneity of Smooth Cayenne fruit, the excessive use of ethephon which caused the problem of maximum residue limits (MRL) set by the European legislation of July 2001. All these constraints made roll back pineapple from Côte d'Ivoire on the European market.

Faced with these different problems that plague the pineapple sector, the National Center for Agronomic Research (CNRA) has deemed it important to look for cultivars that are hardier and can be appreciated on the international market. The pineapple genetic improvement program implemented since 1978 at the research station of Anguédédou has resulted in the selection by the CNRA of hybrids with organoleptic (firm flesh, sweet juice and higher vitamin C content) and agronomic (early, natural orange color, thornless, early production of suckers) qualities clearly superior to Smooth Cayenne ones. These hybrids appear as an opportunity to help Côte d'Ivoire regain its position on the European market. For this purpose, these hybrids must first be subject to studies both at agronomic level and fruit quality. It is in this context that this study proposes to compare the vegetative performance of these hybrids.

2. MATERIALS AND METHODS

2.1 Material

2.1.1 Area of study

The experiment took place in Anguédédou, on the site of the National Center for Agronomic Research. This site is located in Southern Côte d'Ivoire, 25 km west of Abidjan. The geographic coordinates are 5°25 north latitude, 4°08 west longitude and 30 m altitude. The climate of the area, of the Attiéen type (equatorial transition climate), has two rainy seasons, the most abundant of which is centered on the month of June and the other on the months of October-November. The two rainy seasons are separated by two dry seasons. The average annual rainfall is around 2000 mm. The average temperature is 26 °C, with monthly minimum and maximum values of 21 °C and 32 °C. The average minimum humidity is 59% for the driest month, which is January. The site belongs to the ombrophilous sector of the Guinean forest domain characterized by dense humid evergreen forests. The soil is highly desaturated ferralitic (CPCS classification) or Ferralsol drastic (WBR classification) from tertiary sands. The texture is predominantly sandy, with a high proportion of coarse sand. The pH is strongly acidic (4.1 to 4.5). This type of soil is suitable for growing pineapples, which prefers loose and airy soil.

2.2 Plant Material

Suckers of Smooth Cayenne, MD2, H1, H2, H3 and H4 used for planting were of the cayeux type (basal suckers), collected on the AGRO A plot (trial plot) of the CNRA. The weight of the suckers was 400 ± 30 g.

Smooth Cayenne is the most cultivated variety in Côte d'Ivoire and MD2 was introduced from Costa Rica. It is more colorful, has a longer shelf life and low acidity than Smooth Cayenne [8]. hybrid H1 is derived from an intervarietal cross Cayenne x Perolera; hybrid H2 is derived from an intravarietal cross Cayenne x Cayenne; hybrid H3 is the result of an intravarietalcross Perolera x Perolera; and hybrid H4 is from an intervarietal cross Cayenne x Perolera.

2.3 Pesticides and Fertilizers

Pesticides, Trimangol (ai: maneb), Callidim (ai: dimethoate), Rugby 10G (ai: cadusaphos), were used to disinfect the plant material before

planting. Dolomite and tricalcium phosphate fertilizers were used as a basic manure. Urea, potassium chloride and potassium sulphate were used as maintenance manure.

2.4 Method

2.4.1 Experimental plan

The plot was arranged in twenty-four (24)7-m long and 0.5-m wide ridges. The ridges were separated from each other by 0.9 m. The plants were arranged on the ridges in twin rows at a spacing of 0.40 m between rows and 0.30 m between plants on the same row. This spacing corresponded to a planting density of 51 200 plantha^{-1}. The treatments assessed were six genotypes, pineapple cultivars Smooth Cayenne and MD2, and hybrids H1, H2, H3 and H4. One ridge hosted one genotype. The design was therefore randomized single block with 4 repetitions.

2.4.2 Land preparation and planting

The plot was plowed using a disc plow followed by ridge making. Mineral fertilizers dolomite and tricalcium phosphate were applied at a dose of 350 kgha^{-1} and 750 kgha^{-1}, respectively. In order to limit the effect of parasites, in particular nematodes, the nematicide rugby (ai:Cadusaphos 10 G) was also applied at the rate of 40 kgha^{-1}. The ridges were then covered with black polyethylene film.

The pineapple suckers selected for planting were trimmed and then disinfected in a solution made up of fungicide (Trimangol: maneb) and insecticide (Callidim: dimethoate) at the respective dose of 400 g and 100 cc in 100 L of water. The suckers were planted 24 hours after disinfection.

2.4.3 Trial maintenance

During vegetative growth, urea and potassium sulphate fertilizers were applied monthly to plant base, at the level old leaves' axils at the respective rate of 2.5 g and 3.5 g per plant. In the sixth month after planting, potassium sulfate was replaced by potassium chloride.

2.4.4 Parameters assessed

The trial was destructive. The vegetative parameters, plant fresh mass, stem fresh and dry mass, leaf D fresh and dry mass, were assessed at 2, 4 and 6 months. These parameters were determined on ten plants per plot and per variety. The number of leaves generated by the varieties was counted monthly from two to six months. These plants were first uprooted and cleared of the soil before being weighed using a scale. They were then stripped of their roots and leaves for stem fresh mass determination. They were dried in an oven at 70 °C for 72 hours and then weighed to get the dry mass. Leaf D from ten plants of each variety was cut with a knife and weighed to determine their fresh mass. Leaf D is the longest leaf of pineapple.

2.5 Statistical Analysis

The collected data was subjected to an analysis of variance (ANOVA) using XLSTAT software. When the analyses were significant at $\alpha<0.05$ threshold, the averages were compared by the Newmann and Keuls student test.

3. RESULTS AND DISCUSSION

3.1 Plant Fresh Mass

The comparison between pineapple genotypes, two months after planting, showed no significant difference ($P>0.05$) (Table 1). In contrast, from four to six months, the six genotypes had different fresh masses ($P=0.05$). The cultivars Smooth Cayenne, MD2 and hybrid H4 were the heaviest with fresh masses of 2763.3 g; 2645 g and 2675 g in the 6thmonth, respectively. At the same date, the lowest fresh mass was recorded on H2 plants (1436.7 g). The variation between the genotypes observed from the fourth month indicated that the plants might express their own potentials. According to [9]), at this age, pineapple plants no longer experience the depressive effects of sucker separation. Fruit from Smooth Cayenne, MD2, and H4 plants might be of higher mass at harvest than hybrid H2 ones. Indeed, there is a correlation ($r=0.75$) between the fresh mass of the plant and that of the fruit at the time of flower induction [10,11]. The similar development between varieties Smooth Cayenne and MD2 is consistent with the observations of [12] in Côte d'Ivoire.

3.1.1 Stem fresh and dry mass

Over the three observation phases, stem fresh mass of hybrids H2 and H3 was the lowest compared to the other pineapple genotypes (Table 2). The values varied from 38 to 121.7 g and from 44 to 186 g, respectively. Smooth

Cayenne, MD2 and H4 genotypes recorded the highest fresh masses and were statistically identical at 2, 4 and 6 months. They also had the highest dry masses and those of hybrids H1, H2 and H3 were the lowest (P=0.05). The high fresh matter mass of varieties Smooth Cayenne, MD2 and H4 might be the result of a greater accumulation of reserves in the stems. These plants might therefore be more resistant to adverse conditions than hybrids H1, H2 and H3. Hybrid H4 might have a higher filling capacity compared to the other hybrids.

3.1.2 Number of leaves generated

Leaf generation was linear over time and varied from one genotype to another (Fig. 1). This observation was in agreement with the results the monthly monitoring of leaf emergence occurring on cayeux (basal suckers) and crowns of Smooth Cayenne cultivated in the field by [13]. Leaf generation was relatively high for hybrids H4 and H1and variety Smooth Cayenne with a monthly rate of around 7 leaves. Six months after planting, each of these varieties generated around 40 leaves. The different values of leaf generation rate shown by the genotypes might be due to a difference in the leaf generation potential level of each of them. MD2 generated fewer leaves than Smooth Cayenne. After six months the number of leaves generated was 33 leaves. This value remains lower than the one observed by [14] at this age. This difference may be related to the nutritional status of soils. They used a Sandy Loam that retains soil nutrients compared to Sandy soil. In hybrid H3, leaf generation averages were about 5 leaves per month and 29 leaves in total. Hybrid H2 had the lowest leaf generation rate; about 4 leaves per month and 22 leaves over the duration of the observations.

3.1.3 Leaf D fresh mass

Leaf D mass increased steadily from 10 to 20 g /month in all genotypes except hybrid H4 in which less than 5 g was obtained per month (Fig. 2). Its mass was 55 g after six months. Hybrids H2 and H3 had the heaviest leaf D after six months of cultivation.

These two hybrids recorded at this age a leaf D mass of more than 80 g, indicated for the Floral Induction Treatment (FIT).Leaf D mass is a criterion for flower induction and 80 g is generally the standard set for varieties Smooth Cayenne and MD2 [12]. Varieties Smooth Cayenne, MD2 and H1 had a mass of about 73 g at six months. Leaf D of the first two ones reached 80 g at 7 or 8 months. However, [15] indicates that from a mass of 60 g of leaf D, flower induction treatment can be carried out.

Table 1. Plant fresh mass of cultivars Smooth Cayenne and MD2 and hybrids H1, H2, H3 and H4

	Month		
	(2)	(4)	(6)
Varieties	**PFM (g)**	**PFM (g)**	**PFM (g)**
Smooth Cayenne	839.3 a	1515.0 a	2763.3 a
MD2	675.0 a	1352 ab	2645 a
H1	770.3 a	1267.7 ab	2166.7 ab
H2	654.7 a	860.0 b	1436.7 b
H3	687.0 a	1212.0 ab	1986.7 ab
H4	871.0 a	1615.7 a	2675.0 a

In the same column, the values followed by the same letter are not significantly different (NEWMAN and KEULS test at 5% threshold); PFM: Plant Fresh Mass

Table 2. Stem fresh and dry mass of cultivars Smooth Cayenne and MD2 and hybrids H1, H2, H3 and H4

	Month					
Genotypes	**2**		**4**		**6**	
	SFM (g)	**SDM (g)**	**SFM (g)**	**SDM (g)**	**SFM (g)**	**SDM (g)**
Smooth Cayenne	65.0 ab	8.3 ab	152.1 ab	19.8 a	354.7 a	50.0 a
MD2	60.9 ab	8.4 ab	148.2 ab	16.8 ab	361.1 a	51.4 a
H1	60.7 b	8.9 ab	130.5 ab	19.8 a	258.6 b	32.1 bc
H2	38.0 c	6.7 b	83.3 c	10.0 b	121.7 c	18.7 c
H3	44.0 c	7.1 b	95.8 c	13.6 ab	186.0 bc	27.9 bc
H4	80.0 a	9.3 a	179.1 a	18.9 a	390.7 a	44.4 ab

In the same column, the values followed by the same letter are not significantly different (NEWMAN and KEULS test at 5% threshold); SFM: Stem fresh mass; SDM: Stem dry mass

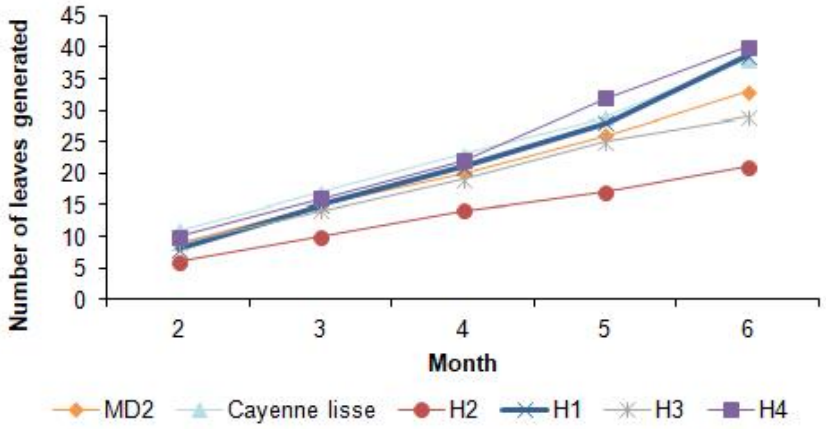

Fig. 1. Evolution of the number of leaves generated in pineapple varieties

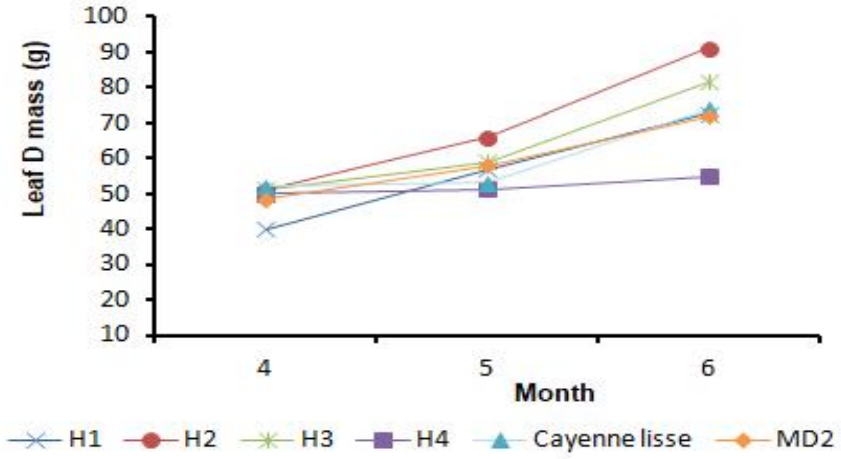

Fig. 2. Leaf D Mass Variability with Month

Plate 1. Hybrid H1: spread out habit, "piping" leaves, reddish-green

Plate 2. Hybrid H2: upright habit, "piping" leaves, dark green

Plate 3. Hybrid H3: upright habit, "piping" leaves, pale green

Plate 4. Hybrid H4: very spread out habit, thorny leaves, reddish-green

4. CONCLUSION

Apart from stem fresh mass and leaf D mass, respectively, Hybrids H3 (44 g) and H4 (55 g) showed vegetative characteristics statistically identical to Smooth Cayenne and MD2. The mass of leaf D in hybrid H4 at six months is 55 g. Leaf D mass might therefore not be the indicator for FIT start in hybrid H4. If followed properly, these two hybrids (H3 and H4) could validly be exploited on a large scale to overcome the shortcomings and constraints linked to Smooth Cayenne exploitation. For this purpose, studies must continue, in particular the organoleptic quality of the fruit of these genotypes.

ETHICAL APPROVAL

We conducted our research after obtaining proper IEC approval.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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