

## Growth of leaf D and productivity of 'Imperial' pineapple as a function of nitrogen and potassium fertilization

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**ABSTRACT:** The cv. Imperial has great commercial potential. Its expansion depends, to a large extent, on the adjustment to the fertilization recommendations proposed in the fertilization and liming recommendation bulletins of the main producing states, in order to have adequate nutritional management. The objective of this study was to verify the growth of leaf D and the productivity of 'Imperial' pineapple cultivated under the presence and levels of fertilization of N and K. The experimental design was a randomized complete block with three replicates and treatments were arranged in a factorial scheme according to the *Plan Plueba* III matrix, with five doses of N (15; 90; 150; 210 and 285 kg ha<sup>-1</sup>) and five doses of K (21.6, 129.6, 216.0, 302.4 and 410.4 kg ha<sup>-1</sup>). Data were submitted to analysis of variance. To evaluate the effect of the interaction of N and K doses and days after planting, the response surface technique was used. The elevation of N doses to 285 kg ha<sup>-1</sup> provided an increase in the median width of leaf D and SPAD index. The dose of 410.4 kg ha<sup>-1</sup> of K<sub>2</sub>O favored the length, basal width, fresh and dry mass of leaf D. There was a correlation of Pearson of fresh leaf D mass (0.63) and leaf D length (0.97), in relation to productivity. The application of 285 kg ha<sup>-1</sup> of N and 410.4 kg ha<sup>-1</sup> K<sub>2</sub>O favors the growth of leaf D, as well as the higher dose of K<sub>2</sub>O (410.4 kg ha<sup>-1</sup>) allows productivity of 26.36 t ha<sup>-1</sup> of 'Imperial' pineapple.

**Key words:** *Ananas comosus* L. var. *comosus*; nutritional relations; SPAD

## Crescimento da folha D e produtividade do abacaxizeiro 'Imperial' em função da adubação nitrogenada e potássica

**RESUMO:** A cv. Imperial possui grande potencial comercial. A sua expansão depende, em grande parte, do ajuste às recomendações de adubação propostas nos boletins de recomendação de adubação e calagem dos principais estados produtores, para se ter o adequado manejo nutricional. Com isso, objetivou-se verificar o crescimento da folha D e a produtividade do abacaxizeiro 'Imperial' cultivado sob presença e níveis de adubação de N e K. O delineamento experimental foi o casualizado em blocos, com três repetições e os tratamentos foram dispostos em esquema fatorial conforme a matriz PlanPlueba III, com cinco doses de N (15; 90; 150; 210 e 285 kg ha<sup>-1</sup>) e cinco doses de K (21,6; 129,6; 216,0; 302,4 e 410,4 kg ha<sup>-1</sup>). Os dados foram submetidos à análise de variância. Para avaliar o efeito da interação das doses de N e K e dias após o plantio, foi utilizada a técnica de superfície de resposta. A elevação das doses de N para 285 kg ha<sup>-1</sup> proporcionou aumento na largura mediana da folha D e índice SPAD. A dose de 410,4 kg ha<sup>-1</sup> de K<sub>2</sub>O favoreceu o comprimento, a largura basal, massa fresca e seca da folha D. Houve correlação de Pearson da massa fresca da folha D (0,63) e do comprimento da folha D (0,97), em relação à produtividade. A aplicação de 285 kg ha<sup>-1</sup> de N e 410,4 kg ha<sup>-1</sup> K<sub>2</sub>O favorecem o crescimento da folha D, assim como a maior dose de K<sub>2</sub>O (410,4 kg ha<sup>-1</sup>) permite produtividade de 26,36 t ha<sup>-1</sup> de abacaxizeiro 'Imperial'.

**Palavras-chave:** *Ananas comosus* L. var. *comosus*; relações nutricionais; SPAD

## Introduction

Pineapple is considered one of the tropical fruits most appreciated worldwide, mainly for its characteristics of flavor, aroma, and color, and as an economically viable activity and social relevance in the regions of exploitation. At the global level, pineapple production is concentrated in five countries (Costa Rica, Brazil, the Philippines, Thailand and Indonesia), with more than 50% of the world's production. Brazil is the second largest producer of pineapple infructescence in Brazil, with approximately 1.6 million infructescences and the average yield of 25.6 t ha<sup>-1</sup> (FAO, 2016). The Northeast region is the main national producer of infructescences (IBGE, 2017).

In this scenario, the state of Paraíba is the second largest national producer with an average yield of 30.023 kg ha<sup>-1</sup> and a production of 283 362 t, corresponding to 16.13% of the national production (IBGE, 2017). However, the producing regions of the state of PB are concentrated in the coastal microregions, in *Tabuleiros Costeiros* areas, which face edaphoclimatic adversities, such as soils with low natural fertility and low technological levels in the productive chain.

Also, the production of pineapple corresponds to the cultivation of almost 100% of the commercial areas with the cv. Pérola, which is the most widespread in the North and Northeast regions (Reinhardt et al., 2002). However, it is susceptible to fusariosis. The introduction of new cultivars of fusariosis-resistant pineapple, such as cv. Imperial, can be promising for the Northeast, as it will allow the diversification of the production system. In this way, it will enable the expansion of the market, generating income and raising the quality of life of family farmers.

The average size of the plants and leaves without spines at the edges stand out among the qualities of the 'Imperial' pineapple. The fruit has great acceptance of the consumers due to the excellent physicochemical characteristics (Viana et al., 2013). However, being a cultivar not yet commercially exploited and without production areas in Paraíba, studies are needed to consolidate information on its nutritional demand and if the recommended doses for pineapple are adequate for their demand.

Nitrogen and potassium are the most required nutrients in this crop because they favor increased productivity and fruit quality. Nitrogen is constituent of amino acids, amides, proteins, nucleic acid, coenzymes, being part of the composition of the chlorophyll molecule (Taiz & Zeiger, 2013). Potassium activates plant enzymes, participates in numerous metabolic processes, including photosynthesis, oxidative mechanisms and protein synthesis, influencing the rate of transport of photoassimilates from the source to the drain, by acting on the loading and transporting of sucrose, and stabilizes the pH in compartments, benefiting most of the enzymatic reactions (Buchanan et al., 2015).

According to Amorim et al. (2011), the application of balanced fertilization is very important to increase the productivity and quality of the fruits. In this sense, in

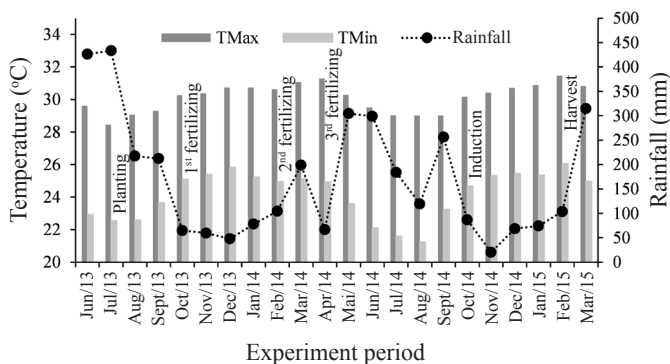
pineapple, the length and fresh mass of leaf D have been used as parameters to estimate plant maturity and productivity in cultivars already established in the market, such as 'Pérola' and 'Smooth Cayenne' (Rodrigues et al., 2010; Marques et al., 2011). Vilela et al. (2015) recommends doing the floral induction in cv. Vitória, when the fresh matter mass of leaf D is around 70 g, aiming at fresh fruit mass equal or greater than 1.2 kg plant<sup>-1</sup>.

However, for the Imperial cultivar, the nutritional demand is still little studied and the fertilization being used is based on the general recommendation for pineapple, and there is no reference for the culture in the Northeast. Thus, the objective of this work was to verify leaf D growth and yield of 'Imperial' pineapple cultivated under N and K fertilization levels.

## Material and Methods

The research was developed in the Jaguarema farm, located in the municipality of Alhandra, in the Zona da Mata, in the state of Paraíba, which is defined by the geographic coordinates of 7°21.9' 43"S and 34°56.1' 93"W and altitude of 49 m. The predominant climate is As', hot and humid. The average annual temperature in 2013 and 2014, period of the experiment, was between 22 and 26 °C, and precipitation of 1.677 and 1.787 mm, respectively (AESAs, 2016).

The soil of the area is classified as Quartzarenic Neosol, according to Embrapa (2013). For the chemical analysis of the soil layer 0-20 cm depth, there were 30 simple samples collected to form a composite sample, which presented the following chemical characteristics: pH in water (1:2,5) – 5.28; P – 21.42 mg dm<sup>3</sup>; K<sup>+</sup> – 22.67 mg dm<sup>3</sup>; Na<sup>+</sup> – 0.03; H<sup>+</sup> + Al<sup>+3</sup> – 3.38; Al<sup>+3</sup> – 0.25; Ca<sup>+2</sup> – 0.40; Mg<sup>+2</sup> – 0.35; SB – 0.84; CTC – 4.22 (All in cmol<sub>c</sub> dm<sup>3</sup>); V – 19.91%; m – 22.94% and m.o – 10.70 g kg<sup>-1</sup>. The granulometric analysis presented 905, 48 and 47 g kg<sup>-1</sup> of sand, silt and clay, respectively, located in the sand textural class (Embrapa, 2013). The rainfall data collected during the conduction of the experiment are shown in Figure 1.



Source: Agência Executiva de Gestão das Águas do Estado da Paraíba – AESAs (2016).

**Figure 1.** Minimum, maximum temperature and precipitation in Alhandra, PB, Brazil, during the experimental period, evidencing the main periods of nutritional management of the plants.

The Imperial pineapple seedlings were grown in vitro. They were acclimatized for one year in the nursery of the Federal University of Paraíba and selected for sanitary aspects and size (30 cm ± 10 cm). During the acclimatization process, leaf fertilization with Ubyverde® mixed mineral fertilizer and Aliette® fungicide applications were performed as a preventive control, in a 30-day interval, for nine months. In July 2013, the planting was carried out under no-tillage conditions in the simple rows system, with spacing of 0.80 x 0.30 m, making a density of 41.666 plants ha<sup>-1</sup>.

The experimental design was the randomized block design, with three replications. The plots were constituted by 70 plants (five rows of 14 plants, considering the 30 central plants useful). The treatments were separated by a strip without plants of 0.50 m and the blocks by 1.50 m. They were arranged in a factorial scheme according to matrix Plan Puebla III (Table 1).

The highest dose of nitrogen (N) and potassium (K) nutrients recommended in the fertilization and liming technical bulletins of the main producers in the Northeast for pineapple were verified to establish the doses to be studied. On top, 20% of the highest dose of recommendation was added, and the mean nutrient dose was calculated to obtain the maximum standard of the matrix. It was then applied to the matrix, obtaining the doses of N and K used in the study. In this way, five doses of N: 15; 90; 150; 210 and 285 kg ha<sup>-1</sup> and five doses of K: 21.6; 129.6; 216.0; 302.4 and 410.4 kg ha<sup>-1</sup> were used.

Phosphate fertilization was applied in a single dose of 80 kg ha<sup>-1</sup> in the soil near the plant base at 65 days after planting (DAP) using single superphosphate (18% P<sub>2</sub>O<sub>5</sub>), doses of N (urea 45 % N) and potassium chloride (60% K<sub>2</sub>O) 65, 195 and 255 DAP were applied. The plants received leaf sprays with micronutrients (B, Zn, Cu and Fe) at 135, 195, 255 and 315 DAP using borax (1.9 kg ha<sup>-1</sup>), zinc sulphate (8 kg ha<sup>-1</sup>), copper sulphate (8 kg ha<sup>-1</sup>) and iron sulphate (16 kg ha<sup>-1</sup>), respectively (Oliveira et al., 2002).

For weed control, manual weeding was done every two months until the sixteenth month after planting and control of cochineal (*Dysmicoccus brevipes*) by application of the insecticide Evidence®, 30 g100 L<sup>-1</sup> of water.

**Table 1.** Matrix Pan Puebla III, where there is the description of the treatments for the doses of urea and potassium chloride, applied in the cultivation of 'Imperial' pineapple.

Treatment	Level		Dose (kg ha <sup>-1</sup> )	
	N	K	N	K
1	-0.4	-0.4	90.0	129.6
2	-0.4	0.4	90.0	302.4
3	0.4	-0.4	210.0	129.6
4	0.4	0.4	210.0	302.4
5	0	0	150.0	216.0
6	-0.9	-0.4	15.0	129.6
7	0.9	0.4	285.0	302.4
8	-0.4	-0.9	90.0	21.6
9	0.4	0.9	210.0	410.4
10	-0.9	-0.9	15.0	21.6

The floral induction was carried out at 14 months after planting by applying 50 ml plant<sup>-1</sup> floral rosette, Ethrel® solution, adding 2% urea. Plant growth assessments were performed by measuring leaf D. At 135, 195, 255, 315 and 375 DAP, there were seven leaves D collected from each experimental plot.

The leaves' length (LENGTH), basal width (LARBAS) and medium width (LARMED) (cm), mass of fresh matter (MF) and dry matter (MS) were measured (g) and SPAD index was evaluated. The productivity was calculated following the formula proposed by Marques et al. (2011).

Data were submitted to analysis of variance. The response surface technique was used to evaluate the effect of the interaction of the N and K doses and days after planting, performing a polynomial regression analysis for the main effect, testing to quadratic level. The significance of up to 5% of probability and coefficient of determination (R<sup>2</sup>) above 60% was considered. Pearson's linear correlation coefficients were also calculated; and also their significance was tested by the t-test, at 5% probability, aiming at evidencing the level of association between growth variables, nutrients (N, P, K) and pineapple productivity. The analyses were performed with the help of SAS 9.3 software (Cody, 2015).

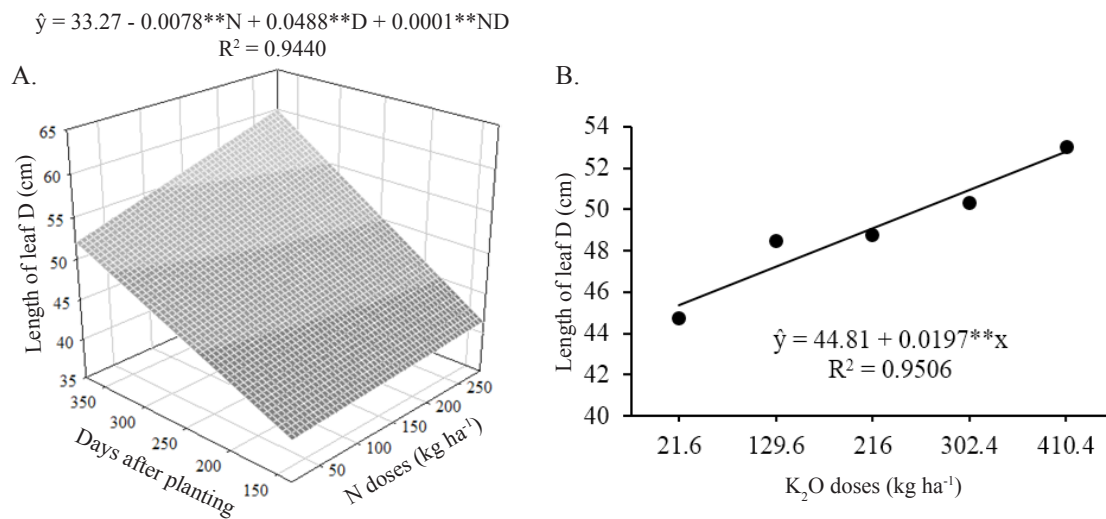
## Results and Discussion

For all variables analyzed, there was no significant interaction between the N and K<sub>2</sub>O doses, but there was interaction between N doses and days after planting and, for the isolated factors. Based on the results obtained, leaf D length was positively influenced by the interaction between N doses and days after planting (Figure 2A). At 135 and 375 DAP, the lowest (15 kg ha<sup>-1</sup>) and higher N doses (285 kg ha<sup>-1</sup>) increased 13.36% in leaf D length. Besides to N, increasing doses of K<sub>2</sub>O linearly increased leaf D length, with a 14.48% increase from lowest to highest dose (Figure 2B).

The increase of leaf D length with N application has been reported by several authors in different varieties of pineapple (Arshad & Armanto, 2012; Silva et al., 2012; Omotoso & Akinrinde, 2013), demonstrating the nutritional requirement of pineapple. Studying the Imperial cultivar in a hydroponic system, Ramos et al. (2013) verified leaf length D of 66.2 cm with the complete solution, a value close to this study. Studying the same cultivar, under dry conditions, Oliveira et al. (2015b) reported mean leaf D length of 75.15 cm but found no effect of N and K doses.

The length and/or the fresh mass of leaf D in pineapple are considered reference estimates to define the moment of floral induction, as it generally presents a positive correlation with the mass and length of the infructescence at harvest (Rodrigues et al., 2010; Marques et al., 2011).

In this study, it was verified that at the maximum dose of N (285 kg ha<sup>-1</sup>), leaf D length at 375 DAP was 60.03 cm, being below the 70 cm length required for floral induction of cv. Smooth Cayenne, which according to Reinhardt et al. (1987) would result in infructescence with mass greater than 1.5



\*\* and \*: significant at 1% and 5% of probability by the F test, respectively.

**Figure 2.** Length of leaf D of 'Imperial' pineapple in relation to nitrogen doses (N) and days after planting (D) (A) and in relation to the doses of K<sub>2</sub>O (B).

kg. This cultivar is one of the 'Imperial' relatives. The lowest growth of 'Imperial' leaf D at 375 DAP may be related to the amount of fertilizers applied, indicating that the crop has a higher requirement level than the doses (Figure 1) during the growing period, which may have contributed to the lower absorption of nutrients. The fact of using meristematic seedlings and being the first cycle may have also influenced the lower growth of plants. Silva et al. (2012) observed slow growth of cv. Vitória, and attributed the low capacity of N utilization, reflecting in reduction of the mass and length of leaf D.

The basal width of leaf D increased with greater doses of K<sub>2</sub>O (Figure 3A), representing an increase of 16.24% from the lowest to the highest dose. Elevation of N and K doses provided greater basal width of leaf D (Figure 3B). For the median width of leaf D, the effects of the isolated factors can be verified (Figure 3C, D, E). N doses were adjusted to the linear regression model, with an increase of 13.22% (Figure 3C). The doses of K<sub>2</sub>O and days after planting (DAP) were adjusted to the quadratic regression model. From the adjusted equation, it was verified that the median width of the maximum D-sheet estimated was 4.23 cm, with the application of 412.5 kg ha<sup>-1</sup> of K<sub>2</sub>O (Figure 3D). Regarding the days after planting, the median width had a minimum point at 238 DAP, with 3.58 cm, increasing from this point (Figure 3E).

The length and width of leaf D are important because they are correlated with the leaf area of the plant. The leaf area is directly related to the use of solar energy, which is transformed into chemical energy during the process of photosynthesis (Taiz & Zeiger, 2013). Thus, the leaf area reflects on the ability of the plant to intercept the radiation and to effect the gas exchange, being an indication of the productivity of the plant (Francisco et al., 2014). In this process, the increase in basal length and width with the application of increasing doses of potassium are justified by their function as activator of several enzymes

during photosynthesis, respiration, stomata opening and maintenance of cellular turgidity (Guarçoni & Ventura, 2011; Oliveira et al., 2015a).

Working with the 'Imperial' pineapple, Ramos et al. (2006) verified the leaf width D of 5.27 cm at 12 months after planting, with the application of the solution containing all the nutrients, and in the absence of N and K<sub>2</sub>O, verified a width of 4.02 and 4.68 cm, respectively. These results are close to those found in this study, showing that even when linear responses occur with the applications of increasing doses of N and K<sub>2</sub>O, it is an indication that the doses used were not sufficient to produce maximum leaf D growth that according to Malezieux and Bartholomew (2003), it depends on the cultivar and the ecological conditions being able to reach 7 cm in width.

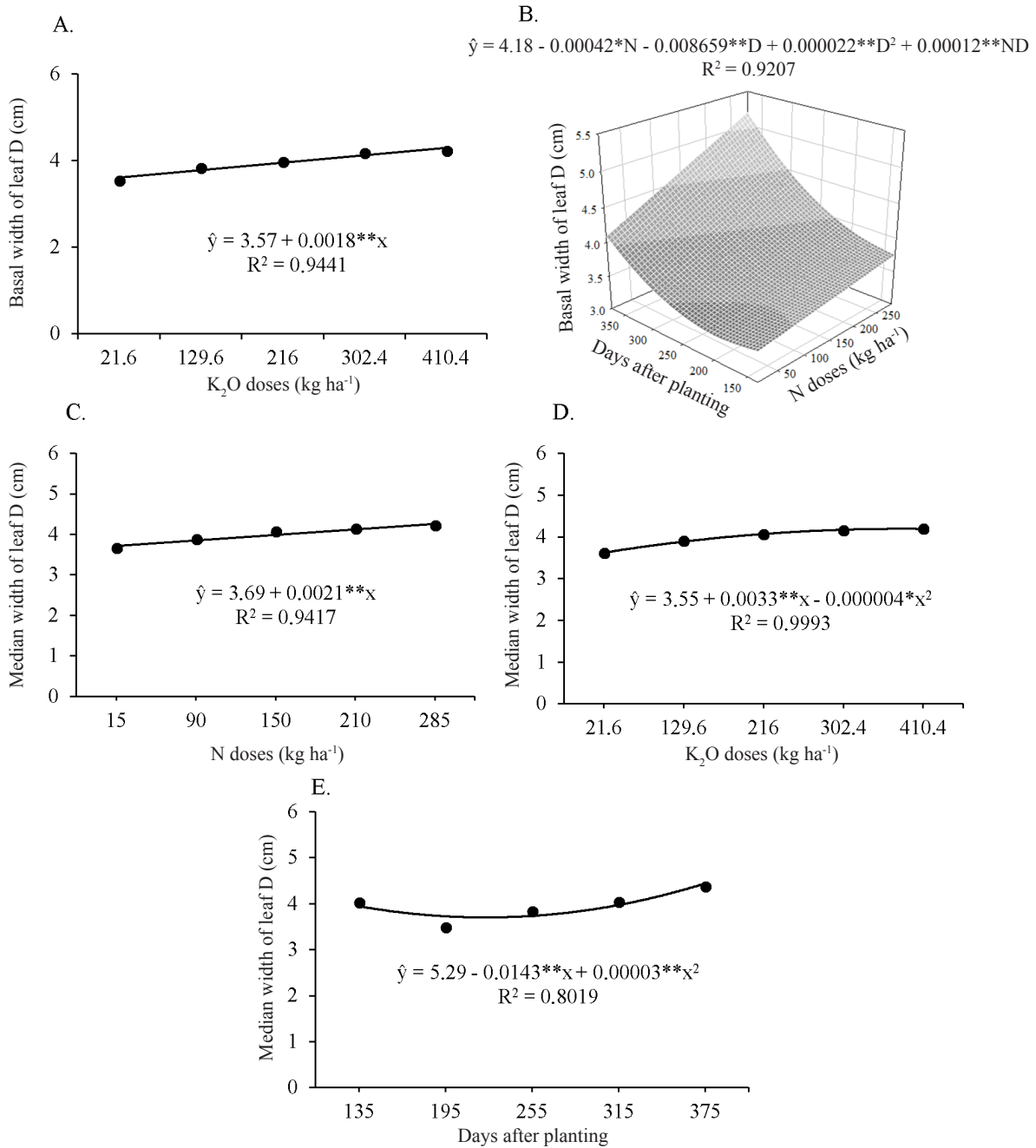
Nitrogen is involved in the process of photosynthesis, being necessary for the synthesis of chlorophyll; in the limitation of N, the plant decreases the photosynthetic efficiency and with that, it affects the absorption of nutrients and the production of carbohydrates for its development (Taiz & Zeiger, 2013), which may justify the results found.

The fertilization with K<sub>2</sub>O linearly increased the fresh mass of leaf D of pineapple cv. Imperial (Figure 4A), showing an increase of 29%. The dry mass of the leaf D was also influenced linearly by the K<sub>2</sub>O doses, obtaining an increase of 68.66%, from the lowest to the highest dose (Figure 4B).

The fresh mass of leaf D also increased with N doses and the days after planting (Figure 4C). At 135 and 375 days after planting, the lowest and highest dose of N increased 29.11 and 47.39%, respectively. Similar behavior was observed for the accumulation of dry mass of leaf D, presenting an increase of 37.95% considering the lowest and highest dose of N.

For the Vitória cultivar, from meristematic molt, Silva et al. (2012) also verified positive linear responses with the application of N in the fresh mass of leaf D, at 420 DAP registered, for the doses of 100 and 600 kg ha<sup>-1</sup>, fresh mass





\*\* and \* significant at 1% and 5% of probability by the F test, respectively.

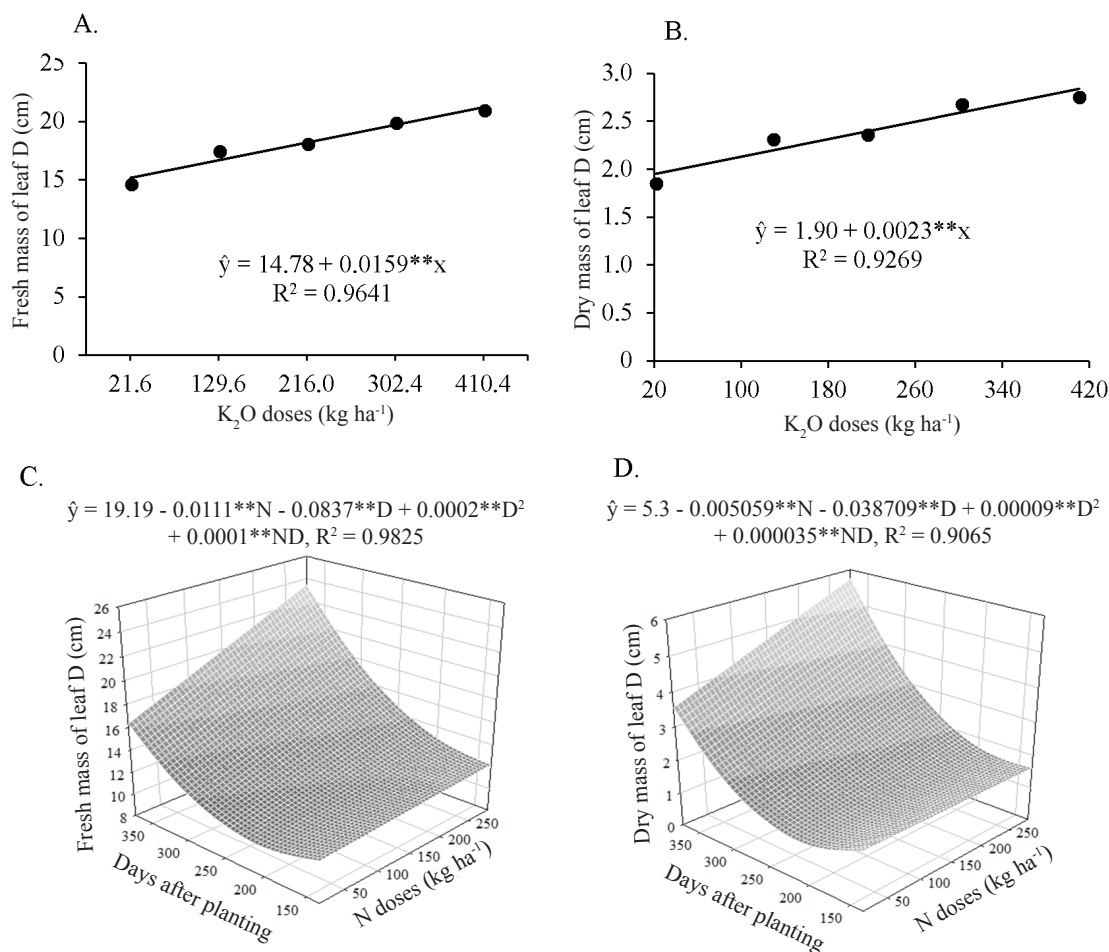
**Figure 3.** Basal width of leaf D of pineapple plants in relation to potassium doses (A); in relation to the days after planting and nitrogen (B) and median width of leaf D in relation to nitrogen doses (C), potassium (D) and the days after planting (E).

of 35.9 and 47.1 g, respectively. In pineapple cv. Imperial, Sampaio et al. (2011) obtained a mass of 34 g at 14 months after planting, corresponding to the mass of the fruit with 670 g crown. Vilela et al. (2015) recommended doing floral induction in cv. Vitória, when the fresh mass of leaf D is equal or greater than 70 g or diameter of the minimum stem of 8.5 cm, with a fruit mass equal or greater than 1.2 kg plant<sup>-1</sup>.

Some authors such as Silva et al. (2012); Caetano et al. (2013) and Rodrigues et al. (2013) reported an effect on the dry and fresh mass of leaf D, using fertilizations with N and/or K. Oliveira et al. (2015b), under dry conditions, verified maximum leaf mass D in 'Imperial' pineapple of 56 g,

obtaining fruits of 1,086 g, with the application of 364 kg ha<sup>-1</sup> of N and 600 kg ha<sup>-1</sup> of K<sub>2</sub>O, and recommended a minimum mass of 44 g of leaf D for the accomplishment of floral induction in 'Imperial' pineapple to obtain fruits with mass greater or equal to 900 g, and to obtain average (1,200 g) and large fruits (1,800 g), it is necessary to have fresh sheet D mass of 62 and 99 g, respectively. Guarçoni & Ventura (2011) verified in cv. Gold, estimated maximum value of 6.84 g, with application of 638.0 kg ha<sup>-1</sup> of N and 571.9 kg ha<sup>-1</sup> of dry mass of leaf D.

The results of this study indicate that the application of the Imperial cultivar is much higher than the available



\*\* significant at 1% probability by F test.

**Figure 4.** Fresh (A) and dry (B) mass of leaf D of 'Imperial' pineapple in relation to potassium and fresh (C) and dry (D) mass doses of leaf D in relation to nitrogen doses and days after planting.

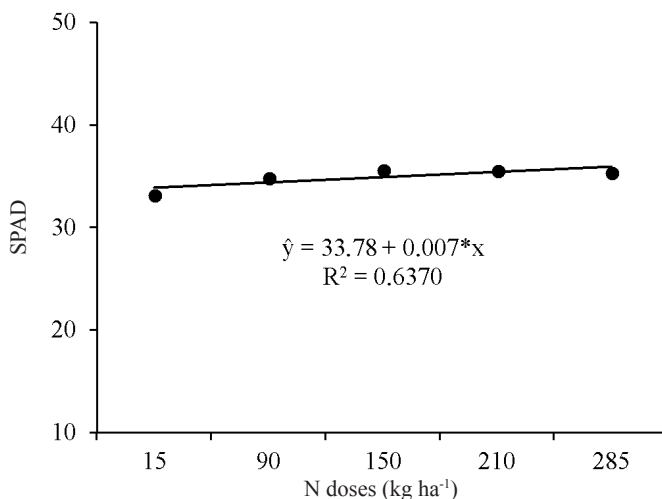
with the fertilization. Also, the low mass accumulation can be justified by the use of seedlings from the in vitro culture in the first cycle; even though they had gone through the acclimatization process, the plants presented slow growth. Probably the demand of the plant was not supplied by the applied nutrient doses, evidencing that the cultivar needs a greater demand than the generic recommendation for pineapple by the state bulletins. Despite the management, the low natural fertility of the soil and the fact that it is sandy texture may have contributed to this result.

Figure 5 shows a linear increase of the SPAD index in the leaf with increasing doses of N indicating an increase of 5.28% of the lowest for the highest dose of N.

For pineapple cv. Imperial, Ramos et al. (2013) verified that with the solution containing all the nutrients, the SPAD index and the foliar concentration of N presented 75.7 units and 14.8 g kg<sup>-1</sup>, respectively, and in the deficient treatment of N, 36.6 units of the SPAD index and 9.7 g kg<sup>-1</sup> of N in the leaf was obtained, besides they observed a reduction in leaf D length with N deficiency and positive linear correlation of the SPAD reading with leaf D width. In this study, the SPAD index value (35.77 units) of the highest N dose (285 kg ha<sup>-1</sup>) are close to those reported by the authors in plants with N deficiency, indicating that the plants presented nutrient

restriction during vegetative growth and require higher doses of N to reach high yields.

Table 2 shows that there is a higher Pearson correlation between plant growth parameters and productivity, in detriment to N, P, K leaf levels, showing that to achieve



\*significant at 5% probability by F test.

**Figure 5.** SPAD index in leaf D of 'Imperial' pineapple in relation to nitrogen doses.

**Table 2.** Pearson's linear correlation between productivity (PROD), leaf level of nitrogen (N), phosphorus (P), potassium (K) and length (LENGTH) and fresh mass of leaf D (FML) and, fruit mass with crown (FMC) of pineapple plants, Areia, PB, Brazil.

	PROD	N	P	K	LENGTH	FML
N	-0.4834**					
P	-0.3789*	0.0591 <sup>ns</sup>				
K	0.2905 <sup>ns</sup>	-0.3514 <sup>ns</sup>	0.0884 <sup>ns</sup>			
LENGTH	0.5595**	-0.0815 <sup>ns</sup>	-0.2728 <sup>ns</sup>	0.1170 <sup>ns</sup>		
FML	0.6324**	-0.1305 <sup>ns</sup>	-0.2779 <sup>ns</sup>	0.1662 <sup>ns</sup>	0.9723**	
FMC	1.0000**	-0.4834**	-0.3789*	0.2905 <sup>ns</sup>	0.5595**	0.6324**

<sup>ns</sup>, \*\* and \*: not significant and significant at 1% and 5% probability by the t-test, respectively.

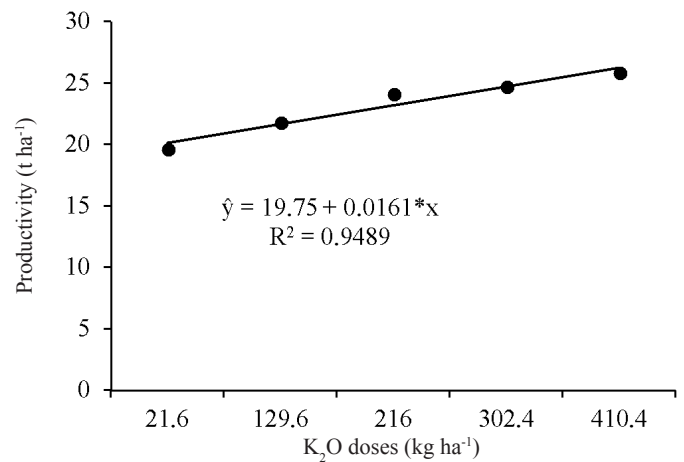
high productivity, it is necessary to verify the aspects that interfere in the vegetative growth of the pineapple. The highest correlation was found between fruit yield and crown mass (1.0), followed by fresh leaf D mass and leaf D length (0.97). There was correlation of the fruit mass with crown of 0.55 and 0.63 in relation to the length and fresh mass of leaf D, respectively.

Similar results were found by Oliveira et al. (2015b) where for cv. Imperial they reported correlation between the mass of the fruit and the mass of leaf D, being 56 g the maximum mass observed in leaf D. For this mass, the fruit mass of 1,096 g was estimated. To obtain fruits with 900 g, which is the minimum mass for commercialization of pineapple, 44 g was estimated for the mass of leaf D. Also, a correlation of 0.80 between the length and the mass of leaf D was verified. In cv. MD-2, Guarçoni & Ventura, (2011) showed a positive correlation between the mass of the fruit with and without crown and the variables length and mass of leaf D. However, they reported that the levels of N and K in leaf D, at the time of floral induction showed a correlation with fruit development, which was not verified in 'Imperial' pineapple.

These results suggest that the fresh mass and leaf D length at the moment of artificial induction can be used as parameters to obtain maximum yield of 'Imperial' pineapple.

The positive effect of the potassium doses can also be verified for the productivity of cv. Imperial, so the increasing the doses have linearly increased the fruit yield, with the maximum productivity of 26.36 t ha<sup>-1</sup>, with the highest dose (410.4 kg ha<sup>-1</sup>) of K<sub>2</sub>O, representing an increase of 23.75% in the productivity of the lowest to the highest dose of K<sub>2</sub>O (Figure 6).

The maximum productivity (26.36 t ha<sup>-1</sup>) in this study is close to the national productivity average (25.6 t ha<sup>-1</sup>) (FAO, 2016), but below the average productivity in Paraíba state. Although increasing doses of K<sub>2</sub>O favor productivity, they were not sufficient for the expression of the maximum productive capacity of cv. Imperial. Oliveira et al. (2015c) working with the same cv., reported an estimated yield of 42 t ha<sup>-1</sup> and fruit weight with and without crown of 1086 g and 967 g, respectively, at the maximum physical doses of 365 and 374 kg ha<sup>-1</sup> of N. For Pineapple Gold, the expression of maximum capacity according to Guarçoni & Ventura (2011), yields of 650.6 and 735.9 kg ha<sup>-1</sup> of N and K<sub>2</sub>O, respectively, with yield of 65.4 t ha<sup>-1</sup> were obtained.



\*significant at 5% probability by F test.

**Figure 6.** Productivity of inflorescences of 'Imperial' pineapples in relation to potassium doses.

The potassium provided by the fertilizer can occupy the available farms for the exchange of cations when the soil presents low saturation in calcium and magnesium, allowing rapid absorption by the plant, which probably could have happened in this study, where values of Ca<sup>+2</sup> and Mg<sup>+2</sup> of 0.40 and 0.35 cmol<sub>c</sub> dm<sup>3</sup> were obtained respectively, at the time of culture implantation.

Also, according to Malezieux & Bartholomew (2003), the adequate K level in the soil before planting pineapple is 150 mg dm<sup>3</sup>, much higher than the soil analysis level of this study before the experiment was installed (22.67 mg dm<sup>3</sup>). Thus, low K<sub>2</sub>O values in the soil, the application of insufficient doses to suppress the demand for 'Imperial' pineapple and precipitation irregularity (Figure 1) may have contributed to low productivity.

According to Sampaio et al. (2011) seedlings from in vitro cultivation may show slow growing vegetative growth in the first cycle and the results may be better in the next cycle conducted with seedlings. Thus, the lower results in this study may be related to the fact that they are seedlings from in vitro cultivation, in the first production, which usually results in smaller inflorescence. The incorporation of cultural remains and evaluation in subsequent cultivation as well as the elevation of nutrient doses can increase these values.

The results show that the same pineapple growing from in vitro cultivation is responsive to fertilization. In this sense, the application of higher concentrations with favorable

climatic factors could have provided higher productivity. Therefore, it is of utmost importance to work with this cultivar using higher doses of N and K, besides to seedlings from subsequent crops.

## Conclusions

The elevation of N doses to 285 kg ha<sup>-1</sup> provided an increase in the median width of leaf D and SPAD index.

The dose of 410.4 kg ha<sup>-1</sup> of K<sub>2</sub>O favored the length, basal width, fresh and dry mass of the leaf D.

At the moment of artificial induction, the fresh mass and the length of leaf D can be used as parameters to infer about the productivity of 'Imperial' pineapple.

The dose of 410.4 kg ha<sup>-1</sup> of potassium provided higher productivity in the infructescences of 'Imperial' pineapple.

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