

## IMPACT OF NITROGEN AND POTASSIUM NUTRITION ON PAPAYA (PAWPAW) FRUIT QUALITY

### IMPACTO DA NUTRIÇÃO NITROGENADA E POTÁSSICA NA QUALIDADE DE FRUTOS DE MAMOEIRO FORMOSA

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**ABSTRACT:** Pawpaw (*Carica papaya* L.), also known papaya, is a fruit species with economic and social importance for Brazil, the second main world producer. Although this characteristic the relationship between N and K nutrition and papaya fruit quality has been poorly studied. Thus, an objective with this study was to evaluate the effect of nitrogen and potassium for papaya (pawpaw) fruit quality produced in North eastern Brazil. The experimental design consisted of randomised blocks, with treatments distributed in a factorial arrangement (4 x 4), using four nitrogen doses (320, 400, 480 and 560 g of N plant<sup>-1</sup>) and four potassium doses (380, 475, 570 e 665 g of K<sub>2</sub>O plant<sup>-1</sup>), containing with four replications of three plants each. The fruit characteristics, such as fruit mass, titratable acidity, soluble solids, pulp pH and fruit length and width, were recorded. The fruit quality of pawpaw depend on nitrogen and potassium leaf concentration. The higher fruit quality parameters regarding to soluble solids, pH, fruit length and fruit mass are associated to 45.30 g kg<sup>-1</sup> leaf N concentration and 37.55 leaf K concentration.

**KEYWORDS:** *Carica papaya* L., Plant nutrition. Post harvest.

#### INTRODUCTION

Pawpaw (*Carica papaya* L.), also known papaya, is native to Central America but is now distributed throughout the tropical areas of the world (HUI, 2006), including Brazil, where this fruit species present economic and social importance, since it is the second main world producer (FAOSTAT, 2014).

Papaya is a fast and continuously growing plant, which provides fruits all the year round, thus an abundant supply of nutrients at regular intervals is needed to sustain good growth and production (FONTES et al., 2010; SANTOS et al., 2014). In a general form, an adequate supply of nitrogen and phosphorus should be provided during the early stages to ensure optimum foliage, trunk and root development, although, at the fruiting stage, potassium demand should be raised (PAULL; DUARTE, 2011).

Specifically for papaya Hui (2006) observed that fruit quality and yield of papaya fruits are greatly influenced by NK fertilizer application, and nitrogen presents especial hole because almost 23% of all nitrogen absorbed by papaya roots is exported to flowers and fruits (LYRA et al., 2010), thus nitrogen fertilizing with high amounts usually is associated to higher papaya yields and better fruit quality (MARINHO et al., 2008). Regarding to potassium, Römheld and Kirby (2010) argue that

this nutrient is recognized as a quality element which improves major quality parameters of papaya fruits such as pulp thickness, i.e. edible part size of papaya fruits increase; it increases total soluble solids content and it decreases fruit titratable acidity. Additionally, Saure (2005) concluded that N and K<sup>+</sup> are the elements most closely related to papaya fruit quality.

Despite nitrogen is the nutrient more directly correlated to higher increases of papaya yield, its effect on papaya fruit quality has been poorly quantified and, in most studies it is not favourable. Adversely, despite the economic importance of papaya for Brazil, an adequate fertilizing management for nitrogen and potassium has not being defined and accepted by researchers as a standard for high fruit quality and yields.

Hence, the present study aimed to evaluate the effect of nitrogen and potassium for papaya (pawpaw) fruit quality produced in North eastern Brazil.

#### MATERIAL AND METHODS

##### Plant Material and Growth Conditions

Papaya (*Carica papaya* L. pawpaw) plants cv. Caliman 01 propagated by seeds were used in this study. The study was conducted from November 2011 to December 2012 at “Campus

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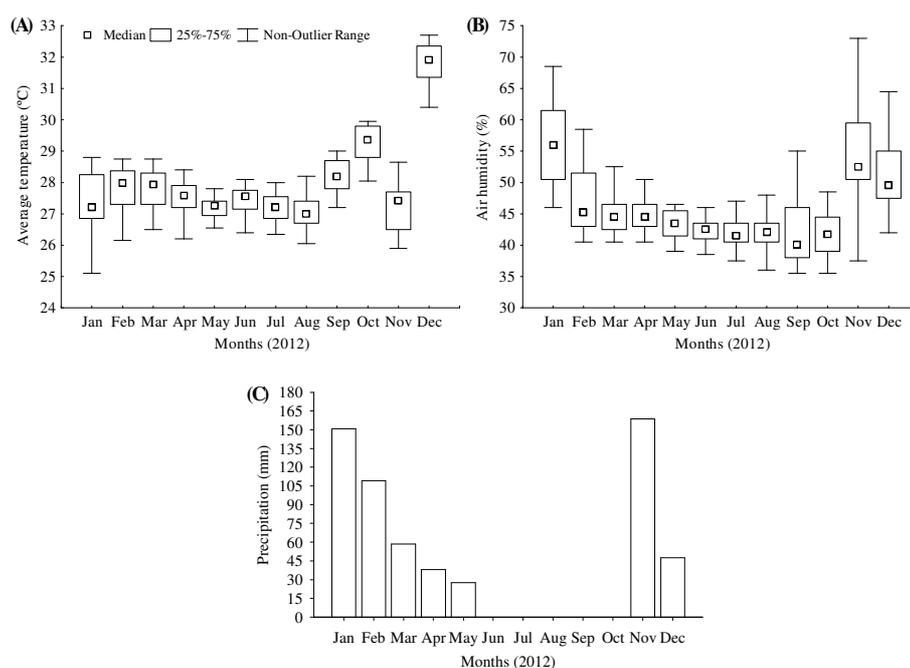
The physical and chemical characteristics of the soil developed for the experiment are shown in Table 1. The climatic data regarding air temperature

and air humidity (thermo-hygrometer Instrutemp<sup>®</sup>, Brazil) and precipitation collected during the experiment are shown in Figure 1.

**Table 1.** Chemical and physical characteristics of the soil (0-20 cm and 20-40 soil depth) where the experiment was carried out.

Soil characteristics	Value	
	0-20 cm	20-40 cm
pH (in water)	5.0	4.8
	cmol <sub>c</sub> dm <sup>-3</sup>	
Ca <sup>2+</sup>	1.6	0.9
Mg <sup>2+</sup>	0.4	0.2
Ca <sup>2+</sup> + Mg <sup>2+</sup>	2.0	1.1
Al <sup>3+</sup>	0.0	0.0
H <sup>+</sup> + Al <sup>3+</sup>	1.7	1.3
K <sup>+</sup>	0.23	0.11
CEC	3.9	2.5
	mg/dm <sup>3</sup>	
P	18.0	14.0
	%	
Organic Matter	1.0	0.4
Al <sup>3+</sup> saturation	0.0	0.0
Basis saturation	57.0	48.0
	g kg <sup>-1</sup>	
Clay	60	60
Silt	20	20
Sand	920	920

P, K: Melich 1; H + Al: calcium acetate (extractor) 0.5M, pH 7; Al, Ca, Mg: KCl 1 M extractor; CEC: cationic exchangeable capacity.



**Figure 1.** Average temperature, air humidity and precipitation during the execution of the experiment.

The plants, spaced with 3.8 m between main rows, 2.0 m between secondary rows and 1.8 m between plants, were daily drip-irrigated with one self-regulating emitter per plant, for a flow of 2.8 L h<sup>-1</sup>, following the Kc defined by Coelho Filho et al. (2006) for papaya. Each hole (40 x 40 x 40 cm) at 60 days before planting received 15L of goat manure (C:N, 17:1) and 169 g of simple superphosphate (18% P<sub>2</sub>O<sub>5</sub>). All experiment area was limed with 1.22 t ha<sup>-1</sup> at 60 days before the beginning of the experiment following soil analysis contained in Table 1.

During the execution of the experiment, all plants were fertilized with 167 g of simple superphosphate (18% P<sub>2</sub>O<sub>5</sub>) at each 90 days. N and K fertilizing, following the treatments, were performed monthly following recommendations of Costa and Costa (2003) using urea (45% of N) and potassium chloride (60% of K<sub>2</sub>O) as N and K sources, respectively.

The cultural practices performed in the experiment followed the instructions of Paull and Duarte (2011).

### Treatments and Experimental Design

The experimental design consisted of randomised blocks with treatments distributed in a factorial arrangement (4 x 4) of four nitrogen doses (320, 400, 480 and 560 g of N plant<sup>-1</sup>) and four potassium doses (380, 475, 570 e 665 g of K<sub>2</sub>O plant<sup>-1</sup>) with four replications of three plants each.

### Data Gathered and Statistical Analysis

For N and K leaf content analysis, leaf samples were taken from normal shoots, at the beginning of each blooming, i.e. at 120 days after planting. According to recommendations of Malavolta et al. (1997), the "F" leaves following papaya plant taxonomy, were collected to perform the nutritional analysis. Leaves were chemically analysed after washing and rinsing with distilled water and drying at 70°C for 48 h. The N contents were determined by the Kjeldahl method (BREMNER, 1965) and K contents were determined by atomic-absorption spectrophotometry (CHAPMAN; PRATT, 1961).

During the fruit harvest time, ten fruits per parcel were manually harvested when they were one-quarter to one-half ripe. The fruits were placed in paper bags and taken to the Food Laboratory at the Federal University of Piauí, Bom Jesus, Brazil. This parameter for fruit selection was recommended by Paull and Duarte (2011) for commercial farms.

The fruit analyses of the papaya (pawpaw) fruits included the usual parameters: i) the fruit mass

was measured using a Sartorius® (Göttingen, Germany) brand precision balance (0.01 g precision) and expressed in g; ii) for the titratable acidity (TA), 20 g of macerated fruit pulp was taken from yellow passion fruits and brought to a final volume of 100 mL by adding distilled water. A 20-mL sample was taken from the mixture, and three to four drops of phthalein were used as an indicator. This suspension was titrated with 0.1 N sodium hydroxide (NaOH). The results were expressed as a percentage of citric acid; iii) the soluble solids (SS), expressed as °Brix, were measured using an Abbe® refractometer (Bausch and Lomb, Rochester, NY, USA); iv) the pulp pH was measured using a Marconi® pH meter; v) fruit width and length (cm); and vi) pulp percentage, obtained through a direct relation of pulp mass with fruit mass. The chemical analyses of fruits followed the methodology described by Instituto Adolfo Lutz (IAL, 2008).

Statistical analyses included analysis of variance (ANOVA) using combined data of two consecutive harvests, regression analysis and correlation analysis between leaf nitrogen concentration, leaf potassium concentration and fruit quality variables. All calculations were performed using the Sigmaplot software (SPSS, version 10.0, Chicago), and the terms were considered significant at  $p \leq 0.01$ .

## RESULTS AND DISCUSSION

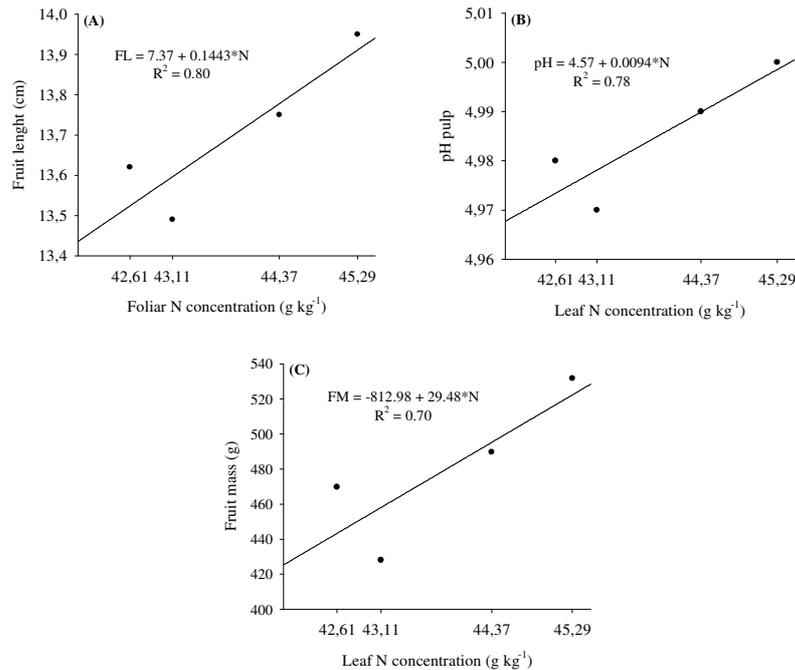
### Nitrogen

In the present study three correlation results were relevant for nitrogen leaf concentration and pawpaw fruit quality. Leaf N concentration was positively and significantly correlated with fruit length, i.e. leaves with higher N concentrations had also fruits with higher length, with a significant ( $p \leq 0.01$ ) correlation coefficient ( $r$ ) of 0.88. This result could be explained by the effects of N on plants, since Pessarakli (2014) argue that nitrogen affects plant growth in two ways: by influencing leaf area; and by affecting the photosynthetic capacity of foliage. Thus, leaf nitrogen can be expected to affect photosynthesis rates and carbohydrate allocation, and consequently promote a higher fruit growth. Accordingly, the results are consistent with the findings Kirimi et al. (2011) who observed that higher leaf nitrogen improved fruit quality by prolonging shelf life, increasing fruit size, colour and taste. However, the degree of association depends on several factors, such as plant species and plant requirement for N, showing that excessive N also could reduce fruit quality such as registered for Aslantas et al. (2007), who reported that nitrogen

application increases growth and leaf nitrogen content, but its excess negatively affects fruit quality.

Fruit length presented a linear adjustment of the data with a minimum fit of 0.80, with a peak at 45.29 Leaf N concentration (Figure 2A). Whether compared with the standardized foliar levels of nitrogen established by Malavolta et al. (1997), it's

possible to infer that adequate N supplied plants (44.38 and 45.30 g of N kg<sup>-1</sup>) presented higher fruit length, results that proves the importance of a balanced N nutritional status for fruit quality and, specifically for fruit length. Pawpaw fruits correlated with leaf N concentration (Figure 2A) presented length shorter than those reported by Souza et al. (2009) and Lima et al. (2009).



**Figure 2A-B-C.** Relationship between leaf N concentration and fruit length (A), pulp pH (B) and fruit mass (C) of pawpaw.

Pulp pH was positively correlated with leaf N concentration ( $r = 0.93$ ,  $p \leq 0.01$ ), a correlation considered by Ferreira (2000) as 'high'. This way, Diehl et al. (2013) reported that some foods are required to be preserved based on their pH levels, e.g. fruits with a pH of 4.6 or less must be preserved because of their acidity. According to the same authors, pulp pH has especial importance for pulp and juice industries because more acid fruits (lower pH) reduce the addition of artificial acid components, and, on the other hand, for consumption as fresh fruit less acid fruits (higher pH) are required.

Fruit pH increased with leaf N concentration increase until 45.30 g kg<sup>-1</sup> losing this tendency and decreasing until 42.61 g kg<sup>-1</sup> (Figure 2B), but, independently, all treatments presented the minimum pulp pH required by food industry, which is 4.0 (Anonymous, 2000).

Although the physicochemical quality of papaya fruits (including pH) is influenced by

various agronomic practices, nitrogen fertilizing and planting time of the year are important parameters (HUI, 2006). However, Marinho et al. (2001) registered no effect of N of papaya fruit quality, result caused by the low nitrogen doses applied, according to author's discussion.

The pH values registered in the present study (Figure 2B) are compatible to those quoted in the scientific literature such as 5.12-5.19 (SOUZA et al., 2009) and 5.06-5.10 (LIMA et al. (2009)). The relatively high pH of papaya fruits is caused by its very low titratable acidity (nearly 0.10%).

Average fruit mass presented a linear adjustment of the data with a minimum fit of 0.70, with a peak at 45.29 leaf N concentration (Figure 2C). This way, it is important to note that lower leaf N concentration promotes lower leaf *a* and *b* chlorophyll concentrations that contributes for decrease the photosynthetic rate and growth of papaya plants (CRUZ et al., 2007). These authors also concluded that leaf area and fruit development

are also dependent of papaya N status, thus in agreement with the present study. In addition, the fruits produced in this study are lighter, on average, than those recorded by Migliaccio et al. (2010) and Lima et al. (2009), but compatible to average of Garcia et al. (2007), all researchers developed with papaya under field conditions.

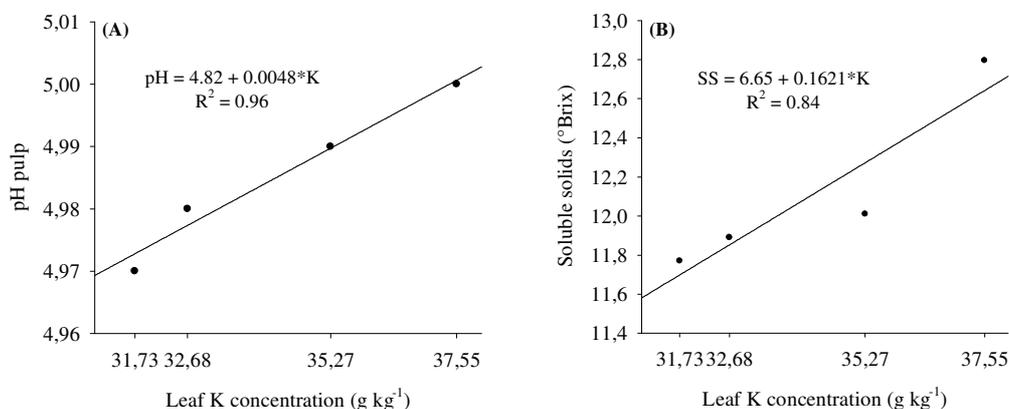
### Potassium

Correlation results between potassium leaf concentration and pawpaw fruit quality revealed that among all variables recorded, only pulp pH and soluble solids were significant.

Soluble solids presented a linear adjustment of the data with a minimum fit of 0.96, with a peak at 37.55 leaf K concentration (Figure 3). This present finding was also reported by Kumar et al.

(2006) who claimed that potash fertilizer use improved major quality parameters of papaya fruits such as the sweetness of papaya (SS), latex yield and its quality; and Campos et al. (2007) registered weightier and sweeter fruits in plants submitted to larger amounts of potassium, agreeing with Marschner (2012), who argue that potassium is known to promote sugar translocation in plants, thus it increases the sugar content as well as soluble solids in fruits, including papaya, as confirmed by Souza et al. (2009) and Kumar et al. (2010).

Indeed, Pessaraki (2014) explains that potassium is recognized as a quality element which improves major quality parameters of papaya fruits such as pulp thickness, i.e. edible part size of papaya fruits increase; it increases total soluble solids content and it decreases fruit titratable acidity.



**Figure 3A-B.** Relationship between leaf K concentration and pulp pH (A) and fruit soluble solids (B) of pawpaw.

Whether compared soluble solids results of the present study with those registered in the scientific literature, it is possible to infer that soluble solids from plants which presented from 37.28 to 37.55 are close to the results reported by Argañosa et al. (2008) and Souza et al. (2009), and higher than average values obtained by Fontes et al. (2012), all of them in studies about papaw. In addition, it is important to note that, independently of the higher soluble solids average of the highest K leaf concentration, all plants presented soluble solids values above the limit of 11°brix required by the industry (ANONYMOUS, 2000) and 11.5°brix required by international market (ALVES et al., 2003).

Fruit pH increased with leaf K concentration increase until 37.55 g kg<sup>-1</sup> losing this tendency and decreasing until 32.59 g kg<sup>-1</sup> (Figure 3). Pulp pH recorded are compatible to those (5.96-5.98) informed by Fontes et al. (2010) and (5.44-5.61)

registered by Argañosa et al. (2008). Plants from all treatments produced fruits with pH average values above the minimum limit of 4.0 required by the industry specifically for papaya (ANONYMOUS, 2000).

Whether compared with the standardized foliar levels of potassium established by Malavolta et al. (1997), it is possible to infer that all treatments promoted leaf K averages above the adequate range, although no visual toxicity symptoms have been registered. This result explains why all treatments reached the minimum average values required by papaya industry for processed fruits, since according to Römheld and Kirby (2010) the physiological basis for the need of adequate K status of plants in quality development of crops is well recognized, i.e. potassium acts in plants increasing photosynthesis as consequence of a more efficient photosynthetic activity, increasing leaf size and number and more effective translocation of photoassimilates and

amino N compounds into reproductive organs via the phloem.

The higher fruit quality parameters regarding to soluble solids, pH, fruit length and fruit mass are associated to 45.29 g kg<sup>-1</sup> leaf N concentration and 37.55 leaf K concentration

## CONCLUSIONS

The fruit quality of pawpaw depend on nitrogen and potassium leaf concentration;

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**RESUMO:** O mamoeiro Formosa (*Carica papaya* L.) é uma espécie frutífera de importância social e econômica para o Brasil, o segundo maior produtor mundial. Apesar dessa característica, a relação entre a nutrição com N e K e a qualidade de frutos têm sido pouco estudada. Assim, objetivou-se com o presente trabalho avaliar o efeito da nutrição nitrogenada e potássica na qualidade de frutos do mamoeiro Formosa no Nordeste brasileiro. Adotou-se o delineamento em blocos casualizados, em esquema fatorial 4 x 4, correspondentes a doses de nitrogênio em cobertura (320, 400, 480 e 560 g planta<sup>-1</sup>) e doses de potássio em cobertura (380, 475, 570 e 665 g planta<sup>-1</sup>), contendo quatro repetições de três plantas por parcela cada. A qualidade dos frutos foi determinada, avaliando-se a massa de fruto, acidez titulável, sólidos solúveis, pH da polpa, diâmetro longitudinal e transversal dos frutos. A qualidade de frutos de mamão formosa depende da concentração foliar de nitrogênio e potássio. Os melhores resultados de sólidos solúveis, pH de polpa, diâmetro longitudinal de frutos estão associados às concentrações foliares de 45,30 g kg<sup>-1</sup> de N e 37,55 g kg<sup>-1</sup> de K.

**PALAVRAS-CHAVE:** *Carica papaya* L. Nutrição de plantas. Pós-colheita.

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