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Production of 'Pacovan Ken' banana fertigated under different doses of potassium and nitrogen

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Abstract

The objective of this study was to evaluate the fruit productivity of 'Pacovan Ken' banana under different nitrogen and potassium doses. The experiment was carried out in a randomized complete block design with four replicates in the factorial scheme, with four nitrogen doses (200, 400, 600 and 800 kg ha^{-1} of N) and four potassium (300, 600, 900 and 1200 kg ha^{-1} of K_2O), via fertigation. The vegetative and production characteristics evaluated were: mean mass of the leaves, yield, number of leaves, total length and mass of the rachis, leaf spacing, mean diameter of two fruits of each hand, total and commercial fruit length, circumference and height of the pseudostem. Both yield and mean mass of the leaves was greatest when applied 780 kg ha^{-1} of K_2O. The production variables decreased linearly with increased nitrogen doses via fertigation. Dose of 487.5 kg ha^{-1} of N and provides less spacing between shoots, and dose of 530 kg ha^{-1} of N provides greater length and mass of the rachis. Dose of 700 kg ha^{-1} of K_2O provided less spacing between leaves and length of the rachis.

Keywords: *Musa* spp., productivity, nutrition, irrigation

Introduction

The banana (*Musa* spp.) is a fruit grown in most tropical and subtropical regions, since banana cultivation moves the economy and generates both direct and indirect jobs and represents an important source of income for the less capitalized farmers due to the low cost, as well as good taste, easy consumption, good source of energy, vitamins and minerals, (Costa et al., 2016; Salomão et al., 2016; Ramos et al., 2018).

In Brazil, banana is the second most important fruit in terms of area planted, quantity produced and value of production. The states of São Paulo, Bahia, Santa Catarina and Minas Gerais are the main national producers of this fruit, which accounted for 50.18% of the total produced in 2017 (IBGE, 2019). The state of Espírito Santo, with its privileged location and with the characteristics of climate and soil that it possesses, allows the cultivation of the banana tree and supply in a period that coincides with low yield in the north of Minas Gerais, can become a great producer and give new opportunity to farmers (Nascimento et al., 2018).

The introduction of new banana cultivars that present desirable yield and phytosanitary characteristics in growing areas, studies that characterize the productive and vegetative behavior in different edaphoclimatic conditions are necessary; this is needed because the nutritional requirements of these materials are not always the same as those of the traditionally grown bananas (Nomura et al., 2017; Borges & Silva et al., 2017).

However, part of the absorbed potassium is exported by the fruits and part is returned to the soil by the pseudostem and leaves (Brito et al., 2017). The amount of nitrogen and potassium extracted is growing till the flowering phase, decreasing in the flowering phase the fruiting, the quantities of potassium extracted being higher than the values of nitrogen (Conceição et al., 2017).

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In addition to the nutritional aspects, the banana tree is a demanding crop also in water, requiring a continuous supply of water for its adequate production and growth. Fertigation, which is the application of fertilizers with irrigation water, allowed the optimization of the use of inputs in different irrigated crops, both in yield and in product quality. (Andrade Neto et al., 2017). Although, fertigation can increase banana yield, nutrient dosage requires adjustments based on reliable diagnostic tools (Deus et al., 2018).

Before the exposed, it was aimed to evaluate the yield of 'Pacovan Ken' banana fruits under different nitrogen and potassium doses, applied via fertigation in the north of the state of Espirito Santo.

Material and Methods

The experiment was carried out at the Experimental Farm of the Federal University of Espírito Santo - UFES/CEUNES, located in the municipality of São Mateus, northern Espírito Santo. Featuring latitude of 18°40'32 "S, longitude of 39°51'39"W and altitude of 37.7 m. The region is of tropical climate with dry winter, type Aw (Köppen), according to Pezzopane et al. (2010), with annual mean air temperature of 23.8 °C and rainfall of 1,212 mm.

The meteorological conditions during the period of carrying out of the experiments were recorded by means of an automatic meteorological station, located about 200 meters away from the experimental area. The soil of the place is a Yellow Argisol, sandy loam texture, typical of coastal boards. Table 1 shows the physical-hydric characteristics of the soil of the area where the experiment was implemented.

Table 1. Soil chemical and phyisical characterization in the experimental area.

Layer (m)	Sand (g kg^{-1})	Silt (g kg^{-1})	Clay (g kg^{-1})	Equation of the water retention curve[1]
0.00-0.20	887	21	92	$\theta = 0.049+((0.456-0.049)/(1+(3.6268\Psi)^{1,5112})^{0,3383})$
0.20-0.40	822	33	145	$\theta = 0.070+((0.255-0.070)/(1+(0.3656\Psi)^{1,6097})^{0.3656}$

Note: [1] θ = gravimetric humidity ($cm^3\ cm^{-3}$); Ψ = matrix tension (kPa).

The experiment was established in November of 2016, in an area where the preparation of the soil was done with plowing, harrowing and subsoiling in the planting row. Seedlings propagated by tissue culture were used and the banana variety (*Musa* spp.) 'Pacovan Ken' was used at the spacing of 3 x 2 meters.

The soil was previously amended by means of liming, raising the base saturation to 70%. At planting, the plants received mineral fertilization in the furrow, with the application of all P_2O_5. For the nutritional supply of the crop, the following macronutrient sources were used: nitrogen (urea, 45% N), phosphorus (single superphosphate, with 18% P_2O_5) and potassium (potassium chloride, 60% K_2O). In relation to micronutrients, pit fertilization with 50 g of FTE BR 12 and the maintenance done by fertigation every 15 days with iron, zinc, copper and boron were carried out.

The experimental design was a randomized complete block design (DBC), with four replications, in the 4 x 4 factorial scheme, whose treatments consisted of four nitrogen doses (200; 400, 600 and 800 kg ha^{-1} of N) and four potassium doses (300, 600, 900 and 1200 kg ha^{-1} K_2O), via weekly fertigation, the crop cycle being divided into three phases according to Borges and Costa (2002): establishment phase from December to February (applied 10% N and 5 % K_2O of the total dose); rapid growth phase (pre-inflorescence) from March to August (applied 75% N and 65% K_2O of the total dose); and fruiting phase from September to December (applied 15% N and 30% K_2O of the total dose).

The irrigation system employed in the conduction of the experiment was an automated micro-sprinkling, the injection of the fertilizers being done by means of flow bypass tank type injectors, locally built by the executing team from segments of DN 150 PVC pipes, cap and connectors.

The application of the irrigation water depth was based on the replacement of crop evapotranspiration (ETc) estimated by means of soil water balance (Bernardo et al., 2008) in a control volume corresponding to a depth of 0.40 m and evapotranspiration of reference by the Penmann-Monteith.

The number of days from planting to flowering, number of days from flowering to harvest and number of days from planting to harvest (cicle total), in addition to circumference and height do pseudostem and leaf numbers active in the inflorescence emergence were evaluated.

For the production characteristics, four hands bunches of the useful plot were harvested and the hands of female rachis separated by performing the following evaluations: average mass of the hands (g); average yield per hectare (kg ha^{-1}); number of leaves; total length of the female rachis (cm), measured between the insertion point of the first hand to the last hand, hand spacing (cm), obtained by dividing the total length of the female rachis by the number of hands minus 1; Mass

of the rachis (g); average diameter of two fruits of each hand (mm), measured from the median region of the fruit perpendicularly to its largest axis; total fruit length (cm), fruit insertion point in the crown to the end of the fruit on its convex face and commercial fruit length (cm), measured from the length of the pulp, parallel to the largest axis of the fruit according to Cavatte (2007). The evaluations were performed by using a semi analytical balance, semi flexible measuring tape and a caliper.

The results were submitted to analysis of variance, with unfolding of the effects, according to their significance. The choice of the regression model was based on the greatest significant degree model by the test F, whose deviation of the regression has been not significant.

Results and Discussion

The results of the analysis of variance showed that for the variables, number of days from planting to flowering and planting to harvest, average productivity, average mass of clumps and rachis, spacing between clumps, total length of female rachis, average diameter of fruits, total and commercial length of fruits, showed significance in different doses of nitrogen and potassium applied via fertigation. The other variables were not significant for N and K_2O, just as interaction was not significant for all variables.

The total cycle was influenced by the different doses of potassium via fertigation in the 'Pacovan Ken' banana, having a linear behavior, the same behavior found for the planting to emergence of inflorescence, and both cycles were not affected by the different nitrogen doses, presenting, on average, 435 and 306 days for the total and planting to emergence of inflorescence, respectively (Figure 1D).

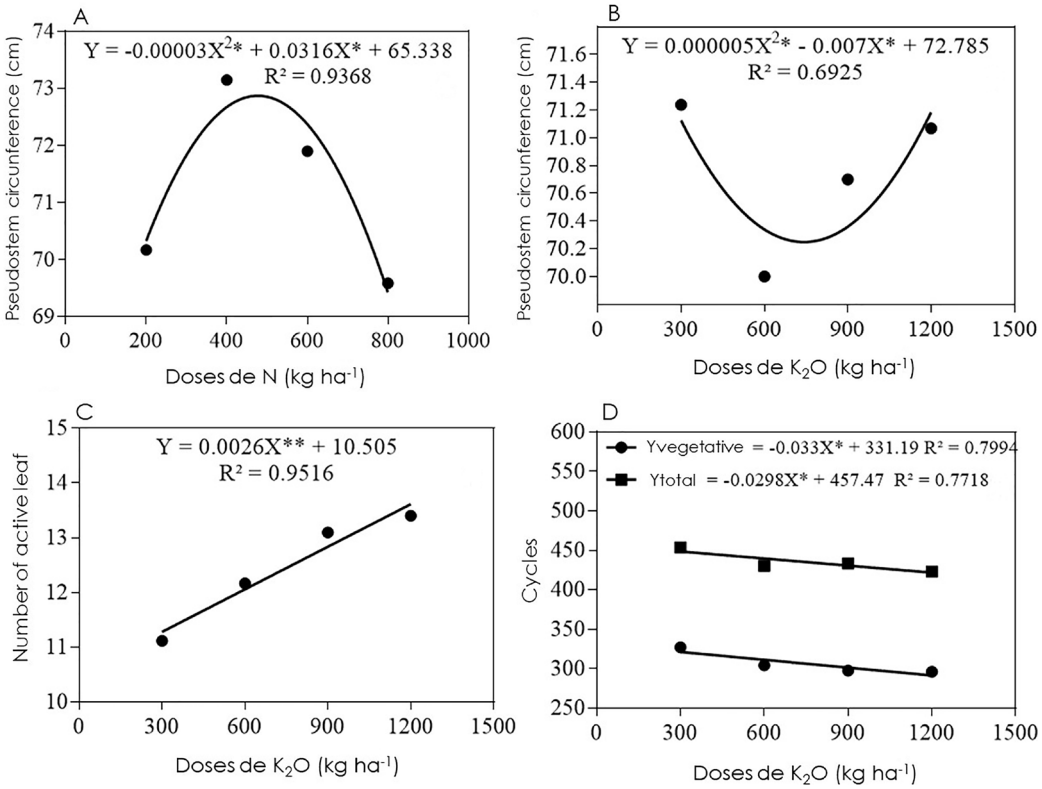

Figure 1. Circumference of the pseudostem at different doses of nitrogen (A) and potassium (B) and active leaf numbers (C) total and planting to emergence of inflorescence (D) of the 'Pacovan Ken' banana at different doses of potassium via fertigation.
* **significant regression coefficient at 5% or 1% respectively by t test.

These results are important since the earliness of flowering is an important characteristic, for it reduces the time of exposure of the plants to the pathogens, being able to increase the number of leaves at the moment of the floral differentiation and to favor a greater amount of feminine flowers during the inflorescence (Robinson & Galán Saúco, 2010), resulting in bunches with higher number of hands. On the other hand, the flowering to harvest of the 'Pacovan Ken' banana tree was not influenced by the nitrogen and potassium doses via fertigation, presenting a mean of 133 days.

The height of the banana on the inflorescence emission did not undergo change when submitted to nitrogen and potassium doses, presenting a mean of 3.33

m, a result lower than that found by Arantes et al. (2017) evaluating the agronomic characteristics of the banana cultivars in three production cycles in the southwest of Bahia, they found for Pacovan Ken cultivar, plant height in the first cycle of 3.75 m.

The circumference of the pseudostem showed a quadratic behavior in the different nitrogen and potassium doses, presenting for nitrogen a maximum point of 526 kg of N ha^{-1} and a minimum point in the application of 700 kg of K_2O ha^{-1} (Figure 1A and 1B), a similar result was found by Nascimento et al. (2018) that evaluating the 'Pacovan Ken' banana verified that the growth rate of the circumference of the banana pseudostem decreases with increasing dose of potassium applied by fertigation.

The number of active leaves in the inflorescence did not present any influence under the doses of nitrogen applied, however, the potassium doses showed a linear increase with the increase of the doses (Figure 1C), with a mean of active leaves of 12.44; number greater than that recommended by Soto-Ballestero (2008), which is at least eight leaves. These results are also superior to the work by Silva Júnior et al. (2012) in the Siriji River Valley in Pernambuco where 10 living leaves were found for 'Pacovan Ken'.

The yield of banana 'Pacovan Ken' presented a linear decreasing behavior in relation to the increase of the nitrogen doses, fact that, can be related to the nitrogen targeting to the vegetative growth in detriment to yield. The average yield obtained for the nitrogen doses, 200; 400; 600 and 800 kg ha^{-1} were 28.25; 28.72; 23.70; and 24.38 ton $ha^{-1,}$ respectively (Figure 2A).

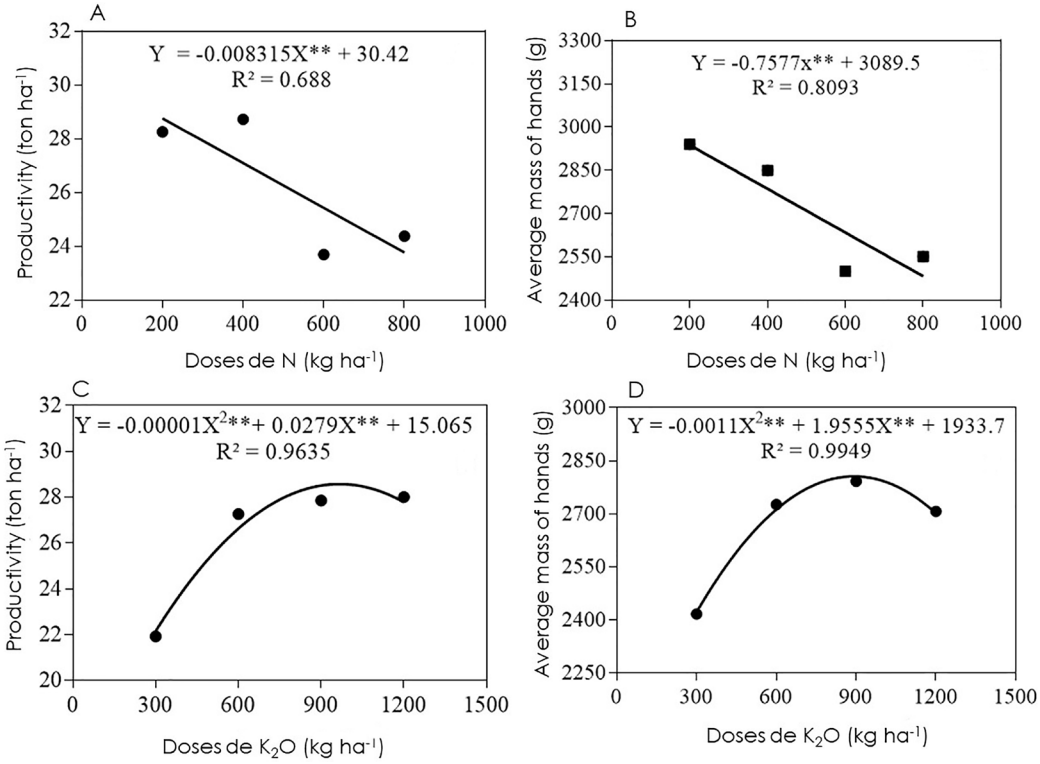

Figure 2. Yield and average mass of the hands of 'Pacovan Ken' bananas submitted to different doses of nitrogen (A and B) and potassium (C and D) via fertigation.
* **significant regression coefficient at 5% or 1% respectively by t test.

Results that differ from that found by Pinto et al. (2005), who studied the yield of the Pacovan variety of the AAB group, verified a quadratic behavior in which the maximum yield was with the dose of 340 kg ha^{-1} of N for a yield of 17.43 t ha^{-1}, which was lower than the yield found in this study when the average yield was found when the dose of 200 kg ha^{-1} was applied. It is also worth mentioning that the doses that presented higher average yield are within the range of fertilization recommendation for Brazil that varies from 90 to 400 kg of N according to Borges et al. (2007). On the other hand, in the work developed by Sousa et al. (2004), they did no obtain response in the characteristics evaluated with different doses of nitrogen. (2007).

On the other hand, for the results concerning the doses of potassium, the yield of the "Pacovan Ken" banana presented a quadratic behavior in which a maximum yield of 26.40 tons ha^{-1} was reached from the dose of 777 kg ha^{-1} of K_2O (Figure 2C), a result similar to that found by Pinto et al. (2005) who found maximum

yield at the dose of 790 kg ha^{-1} of K_2O in the second cycle of banana cultivation, a result within the range of K_2O recommendation in the world that ranges from 228 to 1600 kg ha^{-1} year and above the range in Brazil that ranges from 0 to 750 kg ha^{-1} year, and the recommendation takes into account the high potassium requirement of the plant that is mainly used in the growth and production of the banana tree and soil fertility Borges et al. (2007).

The mean mass of the hands (Figure 2B) presented the same behavior of the variable yield with the increase of the nitrogen doses, a result that differs from that obtained by Maia et al. (2003) and Brazil et al. (2000), who worked evaluating the components of the production of banana "Prata Anã" and cultivar "Pioneira" in the District of Jaiba - MG and in the Municipality of Capitão Poço - PA, respectively, where they also adopted the micro-sprinkler irrigation system and the results did not show significant effects of the nitrogen doses for any of the evaluated variables.

Taking into consideration, the mean mass of the leaves, this variable presented a quadratic behavior where maximum mass of 2734.10 g with the dose of 780 kg ha^{-1} of K_2O was obtained (Figure 2D), a result different from that shown by Pinto et al. (2005) and Costa et al. (2009), in which also conducting fertilization via fertigation with different doses of potassium presented no significant effect for the mass of hands.

Regarding the mean diameter of the two central fruits of each hand, the results presented significance for nitrogen application with decreasing linear behavior with increase of the nitrogen doses (Figure 3A), results also found for the variables: total and commercial length of the fruits (Figure 3B).

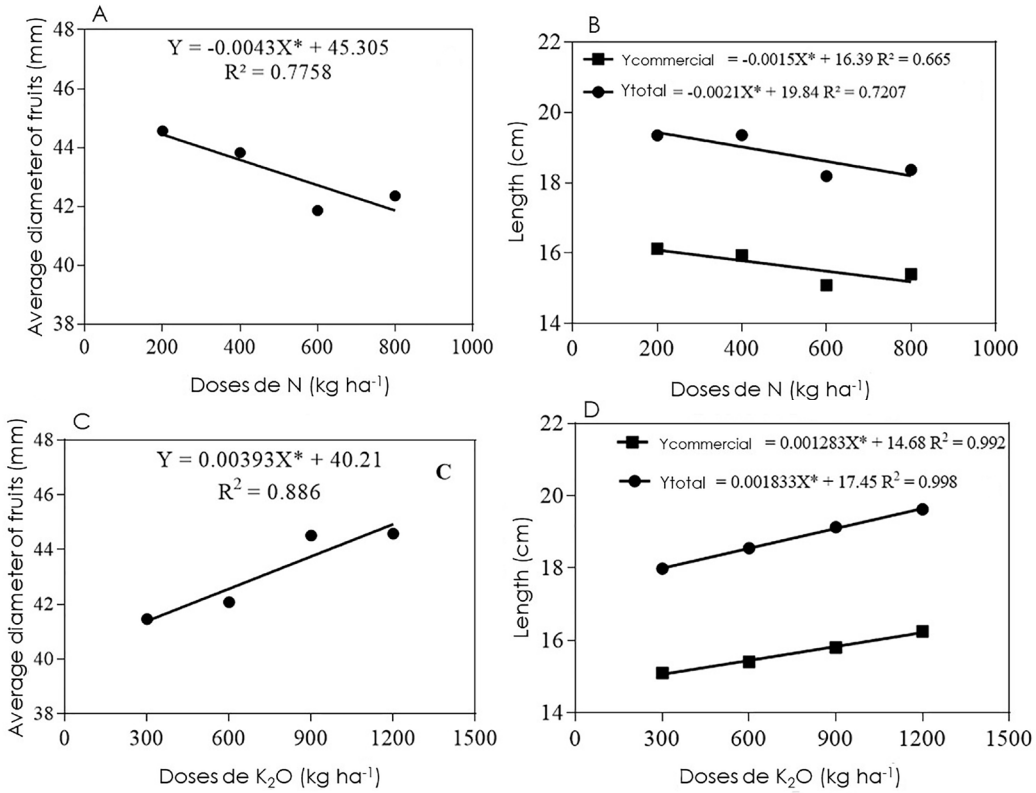

Figure 3. Mean diameter and total and commercial length of 'Pacovan Ken' banana fruits at different doses of nitrogen (A and B) and potassium (C and D) via fertigation.
* **significant regression coefficient at 5% or 1% respectively by t test.

Potassium provided a significant linear increase for the variable fruit diameter (Figure 3C), a result that differs from the work developed by Maia et al. (2003), who found no effect of potassium. However, for total and commercial length of the fruit, potassium resulted in increasing linear growth (Figure 3D), a result similar to that found by Maia et al. (2003).

Result that can be explained since with the increase of the doses, an increase in the number of leaves occurred (Figure 1C), providing increased active photosynthetic area, improving the physiological activities of the plant, which in turn, results into fruits of larger size, according to Castricini et al. (2012), who report that the size of the fruits is, among other factors, dependent on the rhythm of leaf emission and the size of the plant, besides, a plant that does not undergo water

stress (or other stress) is more likely to produce larger and better fruits, since the beginning of the growth of these takes place still in the phase of flowering.

Further, according to Jesus et al. (2004) and Viviani and Leal (2007), the physical characteristics of diameter and length are important characteristics in the export banana-producing regions, since these variables are used in fruit classification, both for fresh fruit and for dehydration process, influencing the drying process.

Corroborating this result, Borges et al. (2007) report that potassium is present in high amount in banana, corresponding to 62% of the total macronutrients in the plant, and 35% of potassium are exported by the fruits, a fact that is evident in the results presented here with improvement of the physical quality of the fruit, contributing to the resistance to transportation. In addition, the fruits presented average length (18.82 cm) and diameter (43.16 mm), which allows them to be classified as export type, according to Frutiséries (2000).

Nitrogen and potassium in the characteristic hand spacing were adjusted by a quadratic equation, where the minimum spacing between hands was obtained with the dose of 487.50 kg ha^{-1} of N (Figure 4A) and 700.00 kg ha^{-1} of K_2O (Figure 4B), the same behavior found for the variable female rachis length, in which a minimum length of 30.13 cm with the dose of 532.50 kg ha^{-1} of N (Figure 4C) and 31.03 cm at the dose of 712.5 kg ha^{-1} of K_2O was obtained (Figure 4D). This fact favors the estimation of the best doses, since a very compact bunch makes the dropping difficult, increases the chance of fruit injuries, decreases the quality by increasing the bunch deformation, can increase the incidence of pests and diseases, besides influencing the marketing price, as reported by Cavatte (2007).

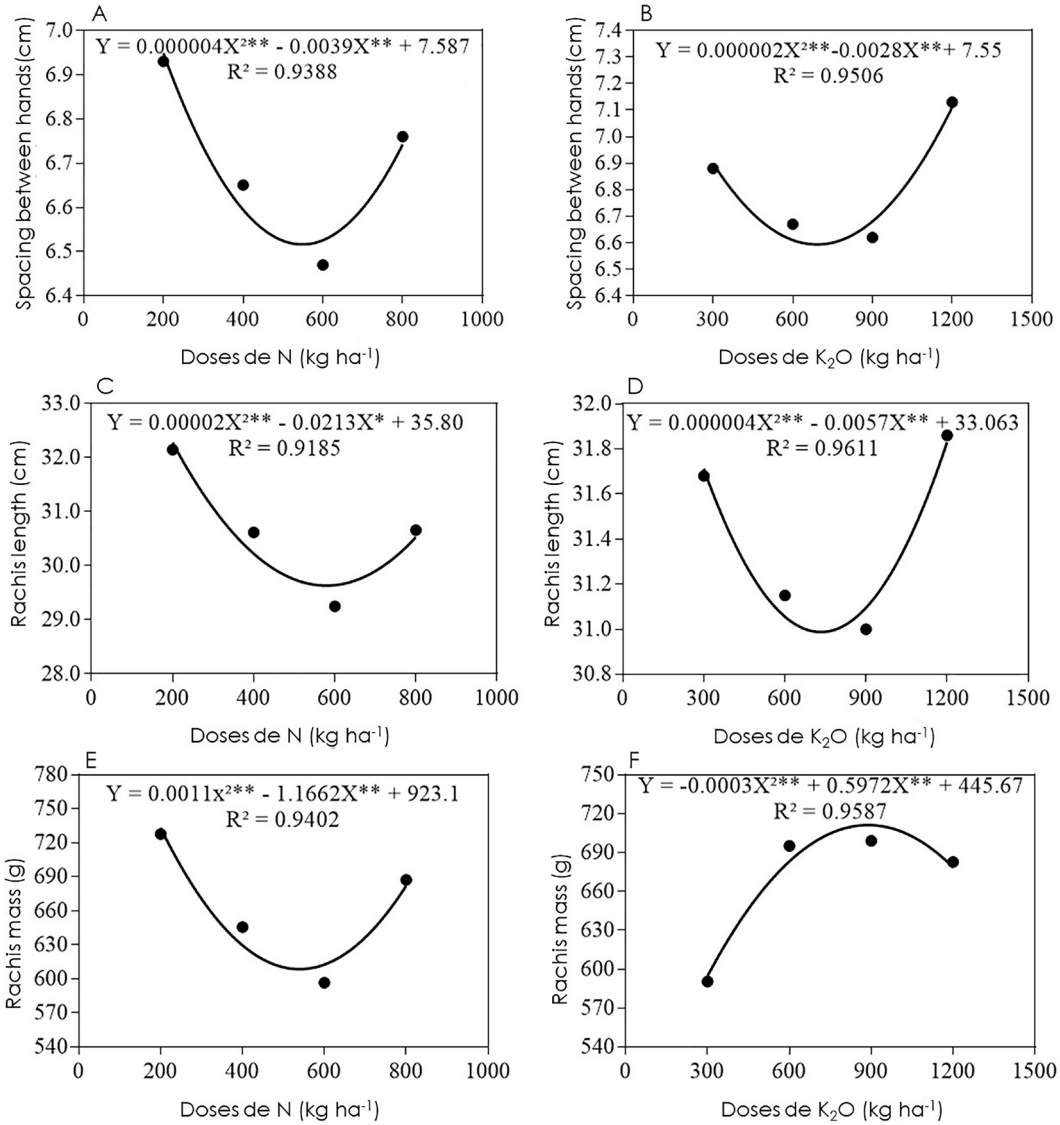

Figure 4. Hand spacing, length of rachis and mass of the rachis of the 'Pacovan Ken' banana tree at different doses of nitrogen (A, C and E) and potassium (B D and F) via fertigation.
* **significant regression coefficient at 5% or 1% respectively by t test.

The rachis mass was adjusted by a quadratic regression analysis, in which a minimum mass of 614.00 g was obtained when using the dose of 530.09 kg ha^{-1} of N (Figure 4E) and the mean maximum mass of 742.88 g when using the dose of 995.33 kg ha^{-1} of K_2O (Figure 4F). Being the female rachis component of the bunch and an important variable in the quantification of total nutrients exported in the harvest period. This fact is important in estimating of how much restitution via fertilization should be, according to Borges et al. (2007).

Conclusions

The yield and average mass of the hands of the banana 'Pacovan Ken', was maximum when applied 780 kg ha^{-1} of K_2O.

The production variables of the 'Pacovan Ken' banana declined linearly with increasing doses of nitrogen via fertigation.

Dose of 487.5 kg ha^{-1} of N and provides less spacing between the hands and dose of 530 kg ha^{-1} of N provides greater length and mass of the rachis.

Dose of 700 kg ha^{-1} of K_2O provided less spacing between hands and length of the rachis.

The increase of the doses of potassium reduced the period from planting to emergence of the inflorescence and planting to harvest and increased the numbers of leaves of the "Pacovan Ken" banana.

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