ISSN 0100-2945
DOI: http://dx.doi.org /10.1590/0100-29452018034
Revista Brasileira de Fruticultura
Soil and plant nutrition

Production and quality of mango fruits cv. Tommy atkins fertigated with potassium in semi-arid region

Marcio Alves Carneiro[1], Augusto Miguel Nascimento Lima[2], Ítalo Herbert Lucena Cavalcante[2], Karla dos Santos Melo de Sousa[2], Fernanda Campos Alencar Oldoni[3], Karine da Silva Barbosa[2]

Abstract-Correct management of potassium (K) fertilization is of fundamental importance for mango orchards, and K is one of the most exported and yield-limiting nutrients. Thus, an experiment was carried out to evaluate the production and physical-chemical characteristics of Tommy Atkins mango fruits under fertigation with different doses of potassium chloride and potassium sulfate in the semi-arid region. The experimental design was randomized blocks in split plots, using five K doses (50, 75, 100, 125 and 150% of the recommended dose) in the plots and two sources of K (potassium chloride – KCl and potassium sulfate – K_2SO_4) in the subplots, with four replicates. The following characteristics were evaluated: transverse and longitudinal diameters, skin thickness, fruit weight, production per plant, pulp percentage, hydrogen potential (pH), soluble solid (SS), ascorbic acid (VIT C), titratable acidity (TA) and SS/TA ratio. The doses and sources of K applied through fertigation caused significant effect on fruit physical-chemical characteristics and production per plant in Tommy Atkins mango, particularly at the dose of 349 g plant^{-1} of K_2SO_4, which led to higher production per plant and guaranteed the minimum quality required for fruit physical-chemical characteristics.
Index terms: *Mangifera indica* L., soil fertility, physical-chemical characteristics.

Produção e qualidade de frutos de mangueira cv. Tommy atkins fertirrigada com potássio no semiárido

Resumo - O correto manejo da fertilização potássica é de fundamental importância para os pomares de mangueira, sendo o potássio (K) um dos nutrientes mais exportados e que mais limita a produtividade. Nesse sentido, um experimento foi desenvolvido com o objetivo de avaliar a produção e as características físico-químicas dos frutos da mangueira 'Tommy Atkins' fertirrigada com diferentes doses de cloreto e sulfato de potássio no Semiárido. O delineamento experimental adotado foi o em blocos casualizados, em esquema de parcelas subdivididas, utilizando cinco doses de potássio (50; 75; 100; 125 e 150% da dose recomendada) nas parcelas e duas fontes de potássio: cloreto de potássio (KCl) e sulfato de potássio (K_2SO_4) nas subparcelas, com quatro repetições. As características avaliadas foram: diâmetros transversal e longitudinal, espessura da casca, peso do fruto, produção por planta, percentual da polpa, potencial hidrogeniônico (pH), sólidos solúveis (SS), ácido ascórbico (VIT C), acidez titulável (AT) e relação SS/AT. As doses e fontes de K aplicadas via fertirrigação promoveram efeito significativo para as características físico-químicas e produção por planta dos frutos da mangueira 'Tommy Atkins', sendo destacada a dose de 349 g/planta^{-1} de K_2SO_4, a qual apresentou maior produção por planta e garantiu a qualidade mínima exigida para as características físico-químicas dos frutos.
Termos para indexação: *Mangifera indica* L., fertilidade do solo, características físico-químicas.

Corresponding author:
augusto.lima@univasf.edu.br

Received: March 27, 2018.
Accepted: July 05, 2018.

[1]Instituto Federal de Educação, Ciência e Tecnologia do Maranhão. São Raimundo das Mangabeiras-MA. Brasil. E-mail: marcio.carneiro@ifma.edu.br
[2]Universidade Federal do Vale do São Francisco. Petrolina-PE. Brasil. E-mails: augusto.lima@univasf.edu.br; italo.cavalcante@univasf.edu.br; karla.smsousa@univasf.edu.br; karynebosa@hotmail.com
[3]Universidade Estadual Paulista "Júlio de Mesquita Filho" - Câmpus Araraquara. Araraquara-SP. Brasil. E-mail: fernandac.alencar2010@gmail.com

Introduction

The Sub-middle São Francisco River Valley, located in the northeastern semi-arid region, accounts for more than 93% of the Brazilian exports of mango, especially the cv. Tommy Atkins, considered as the most planted in the region (OLIVEIRA et al., 2014).

Despite the economic importance of mango for the São Francisco River Valley and for Brazil, potassium fertilization management in this crop is not yet a consensus in the scientific literature and, commercially, is not performed according to cultivar, despite the differences in the demand especially for 'Keitt' (ALMEIDA et al., 2015), 'Palmer' (CAVALCANTE et al., 2016) and Tommy Atkins (CARNEIRO et al., 2017).

Potassium (K) is one of the most exported nutrients by mango trees (PINTO et al., 2010) and, in a study conducted with the cv. Tommy Atkins in the São Francisco River Valley, the authors found that, in high-yielding orchards, K is the second most limiting nutrient for fruit yield and quality. K application influences fruit size, appearance, color, and acceptance by consumers, besides leading to high contents of juice, vitamin C and to their uniformity (GANESHAMURTHY et al., 2011). Several studies have been conducted aiming to correlate the effect of different doses and sources of K with fruit yield and quality in 'Amrapali' mango (DUTTA et al., 2011), 'Vitória' pineapple (CAETANO et al., 2013) and 'Paluma' guava (AMORIM et al., 2015). Mango post-harvest quality depends on various factors, particularly on nutrient balance (AULAR; NATALE, 2013; COSTA et al., 2011).

Given the above, the present study aimed to evaluate the production and physical-chemical characteristics of mango fruits cv. Tommy Atkins fertigated with different doses of potassium chloride and potassium sulfate.

Material and methods

Mango plants and growth conditions

Eleven-year-old plants of mango (*Mangifera indica* L.), cv. Tommy Atkins, with uniform size and vigor were used in the study.

The study was carried out in a commercial mango orchard at the *Fazenda Herculano Agrícola* farm, in two production cycles (First cycle: January to March 2014; Second cycle: January to March 2015), located in the municipality of Casa Nova – Bahia, Brazil, at geographic coordinates 9º 11' 43.5'' S, 41º 01' 59.2''W and altitude of 400.3 m. According to Köppen's classification, the local climate is Bswh' (semi-arid). Along the experiment, the mean values of air temperature and relative humidity ranged from 23.48 ºC to 31.26 ºC (2014) and 24.54 ºC to 30.80 ºC (2015) and from 44.5 % to 87.75 % (2014) and 39.75 % to 90.00 % (2015), respectively, with accumulated precipitation of 304.2 mm (2014) and 189.86 mm (2015). The soil of the area is classified as Quartzipsamments (SANTOS et al., 2013).

Before the experiment, under the crown projection of the mango trees, 20 simple soil samples were collected in the 0.0-0.04 m layer to form a composite sample in order to characterize soil fertility and determine soil texture, according to the methodology of Silva (2009) (Table 1).

Mango plants, spaced by 10 m between rows and 7 m between plants, were daily irrigated by micro-sprinklers, with one emitter per plant at 60 L h^{-1} flow rate. All management practices, such as pruning, control of weeds, pests and diseases, application of gibberellin-inhibitor growth regulators (Cultar®) and dormancy breaking (calcium nitrate), were carried out by following the instructions of Genú & Pinto (2002). Fertilization was applied through a fertigation system, based on soil analysis (Table 1) and plant requirement (GENÚ; PINTO, 2002).

Experimental design and treatments

The experimental was set up in a randomized block design in split plots, with four replicates, using five K doses (50, 75, 100, 125 and 150% of the recommended dose) in the plots and two K sources (KCl and K_2SO_4, with respective K_2O concentrations of 60 and 50%) in the subplots. The recommended dose of K_2O was 180 g $plant^{-1}$, according to soil analysis (Table 1) and recommendations of Genú & Pinto (2002). Each experimental plot comprised five plants, and the central plant was used for evaluation. K doses were split and applied by fertigation: 45% before induction, 20% at flowering, 20% after fruit setting and 15% fifty days after fruit setting, as recommended by Genú & Pinto (2002).

Parameters evaluated and statistical analysis

Production of fruits per plant was determined by using a Filizola® CF15 precision scale (0.5 g precision) and expressed in kilograms per plant (kg $plant^{-1}$). Marketable fruits were harvested by hand in a single day when they reached minimum size of 15 cm and physiological maturity, characterized by pulp color (creamy yellow), according to the parameter of fruit selection recommended by the Brazilian Program for Horticulture Modernization (Programa Brasileiro para a Modernização da Horticultura, 2004) for commercial farms.

Then, the fruits were washed, sanitized with sodium hypochlorite solution (200 mg L^{-1}), washed again in running water to remove the excess solution, and stored under refrigeration at 10 ºC for 30 days to complete their maturation cycle. Analyses of mango fruits followed the instructions of Zenebon et al. (2008), including the usual parameters: i) total fruit weight (FW) and pulp weight, determined on precision scale (0.1 g precision) and expressed in g; ii) pulp percentage (P), obtained by the ratio between pulp weight and total fruit weight; iii) transverse diameter (TD, region of fruit shoulder), longitudinal diameter (LD, region between peduncle and apex) and skin thickness (ST), measured using a digital caliper (0.01 mm - 300 mm) with 0.01 mm precision and expressed in mm.

For physical-chemical analyses, fruit pulp was analyzed in triplicates for the following parameters: i) pH, determined by potentiometry; ii) soluble solids (SS), in an Abbe-type refractometer, with results expressed in °Brix; iii) titratable acidity (TA), expressed in grams of citric acid per 100 g of pulp, determined by titration with sodium hydroxide (0.1 N) using 1% phenolphthalein as indicator, according to the methodology of Zenebon et al. (2008); iv) the soluble solids/titratable acidity ratio (SS/TA) was also calculated; v) ascorbic acid (VIT C), determined according the AOAC method, modified by Benassi & Antunes (1988), and expressed in mg 100 g^{-1}.

The combined data of both production cycles were subjected to analysis of variance by F test to find significant effects between the sources of K, whereas K doses were subjected to quantitative analysis by polynomial regression.

Results and discussion

According to Table 2, for the physical characteristics, the interaction between K doses and sources was significant only for fruit weight (FW) and production per plant (PP). For all variables evaluated, expect pulp percentage, there were individual effects of K sources and doses. KCl led to the highest values of fruit weight, transverse diameter, longitudinal diameter and skin thickness, whereas K_2SO_4 caused highest values of production per plant (Table 2).

As observed in Figures 1A and 1B, the maximum estimated values of fruit weight were 572.3 g (94.2% of the recommended K dose for KCl) and 532.3 g (84.3% of the recommended K dose for K_2SO_4).

The response of fruit weight as a function of doses of potassium chloride (KCl) and potassium sulfate (K_2SO_4) applied through fertigation can be explained by the active participation of K in metabolic activities relative to the synthesis and transport of carbohydrates and water to the fruits, thus favoring the increase in weight (RÖMHELD; KIRBY, 2010). At doses higher than the estimated ones, this variable decreased, with possible occurrence of 'luxury consumption', that is, increments in fertilization do not result in increased production by the crop.

Considering the norms of classification for mango fruits with respect to weight (PBMH, 2004), it can be noted that fruits produced by plants fertilized with the maximum estimated dose of K_2SO_4 fitted in the class 350 (351 to 550 g), whereas those produced under fertilization with KCl fitted in the class 550 (551 to 800 g).

For the production of fruits per plant (PP), K_2SO_4 at estimated dose of 97.7% of the recommendation led to maximum production of 116.4 kg $plant^{-1}$, which was 13.7% higher than the maximum production caused by KCl (100.4 kg $plant^{-1}$), at 100% of the recommendation (Figures 1C and 1D). The superiority of K_2SO_4 for the production per plant is related to the functions of sulfur in the plant, which participates in chlorophyll synthesis and formation of ferredoxin, an electron carrier in photosynthesis, which then favors the accumulation of carbohydrates and other nitrogen compounds (LESTER et al., 2005), preponderant factors in the increase of production per plant. Dutta et al. (2011) observed for 'Amrapali' mango in India that K_2SO_4 caused 5% gain in the number of fruits, compared with KCl.

According to Table 3, it can be observed that there was interaction between K doses and sources for all physical-chemical variables evaluated, as well as individual effects of the factors, except on SS/TA ratio. Application of KCl as source of K led to the highest values of ascorbic acid (VIT C) and soluble solids (SS), whereas K_2SO_4 increased the values of pH and titratable acidity (TA).

Ganeshamurthy et al. (2011) state that fruit quality with respect to size, appearance, color, soluble solids (SS), titratable acidity (TA), vitamin C content, taste (SS/TA ratio) and post-harvest longevity are significantly influenced by the adequate supply of K due to the direct relationship of this nutrient with processes of photosynthesis, translocation of photosynthates, regulation of stomatal opening and closure and activation of enzymes.

The increase in K doses applied through fertigation caused different effects on the ascorbic acid content (VIT C), depending on the source of K. Increasing doses of KCl led to linear increase in ascorbic acid production (Figure 2A), whereas K_2SO_4 doses caused a Gaussian effect on this variable. Thus, it is possible to observe maximum ascorbic acid content of 6.5 mg 100 g^{-1} at the KCl dose of 150% of the recommendation (Figure 2A), whereas for K_2SO_4 the highest mean of 6.3 mg 100 g^{-1} was found at dose equivalent to 71.4% of the recommendation (Figure 2B). Therefore, K_2SO_4 at doses lower than the recommended led to ascorbic acid contents very close to those caused by KCl at maximum dose (150%). The effect of K_2SO_4 on this variable can be explained by the fact that S participates in chlorophyll synthesis and formation of ferredoxin, which acts as electron carrier in photosynthesis, thus favoring the accumulation of carbohydrates and other nitrogen compounds (LESTER et al., 2005), since ascorbic acid is synthesized from sugars produced in the photosynthesis.

Increase in K_2SO_4 doses resulted in a linear reduction in pulp pH (Figure 2C). The values shown in

Figure 2C were superior to those presented by Motta et al. (2015), who recorded pulp pH variation of 3.15-3.88. The studied doses of K_2SO_4 led to fruit pulp pH within the range recommended by Brasil (2000), from 3.3 to 4.5.

Titratable acidity as a function of KCl and K_2SO_4 doses showed interaction and fitted to a Gaussian regression model with four parameters, reaching estimated peaks of 0.43 and 0.47 g of citric acid /100 g of pulp for KCl and K_2SO_4, respectively, at doses of 74.6 and 74.2% of the recommendation (Figures 3A and 3B). Hunsche et al. (2003) explained that the increment in K doses results in accumulation of acidifying substances, possibly related to the contents of organic acids present in the fruits, which depend on plant nutritional balance. Dutta et al. (2011) observed mean values of titratable acidity of 0.24 and 0.27 g of citric acid/100 g of pulp caused by KCl and K_2SO_4, respectively. According to the standards of identity and quality of mango fruits established by Brasil (2000), the values of titratable acidity for the maximum estimated doses of KCl and K_2SO_4 (0.43 and 0.47 g of citric acid /100 g of pulp, respectively) in the present study are at the minimum standard of quality established (0.32% of citric acid).

The interaction between the different sources and doses of K fertilizers was significant for the content of soluble solids (Table 3), but the data did not fit any regression model. KCl led to mean of 13.6 ºBrix and K_2SO_4 resulted in mean of 12.8 ºBrix. The contents of soluble solids caused by the doses and sources are within the quality standards, since the minimum value established is 11 ºBrix, according to the norms of Brasil (2000).

Silva et al. (2014) stated that the contents soluble solids in Tommy Atkins mango can vary from 8.2 to 14.7 °Brix, depending on pre-harvest factors. The determination of this parameter is of great importance in fruits, for both fresh consumption and industrial processing, since high contents of these constituents in the raw material lead to lower addition of sugars, shorter time of water evaporation, lower expenditure of energy and high agro-industrial yield, resulting in greater saving in the processing (AULAR; NATALE, 2013).

For the ratio between soluble solids and titratable acidity (SS/TA) there was interaction between K sources and doses, and the data fitted to a quadratic model. The maximum points in the curves were estimated at doses of 102.7% for KCl and 80.4% for K_2SO_4, with SS/TA ratios of 39.4 and 39.43, respectively (Figures 3 C and 3 D). With lower dose of K_2SO_4 (80.4%) it was possible to obtain a result similar to that obtained with KCl (102.7%). The anion SO_4^{2-} is less leached in the soil than Cl^-, so there is higher possibility of absorption, increasing the efficiency of K_2SO_4 in comparison with KCl. The use of K_2SO_4 reduces K losses by leaching, increasing the efficiency of the fertilizer (CECÍLIO FILHO; GRANGEIRO, 2004), which may contribute to fruit quality.

Table 1. Chemical characteristics and texture of the soil under irrigated mango cultivation in the 0.0 – 0.4 m layer before the experiment.

EC	OM	pH	P	K^+	Ca^{2+}	Mg^{2+}	Na^+	H+Al	CEC
($dS\ m^{-1}$)	($g\ kg^{-1}$)	(H_2O)	($mg\ dm^{-3}$)	--------------------($cmol_c\ dm^{-3}$)--------------------					($dS\ m^{-1}$)
0.18	11.0	6.8	41	0.63	4.3	1.7	0.04	0.80	7,47
Al^{3+}	V	Cu	Fe	Mn	Zn	Sand		Silt	Clay
($cmol_c\ dm^{-3}$)	(%)	--------------$mg\ dm^{-3}$--------------				------------$dag\ kg^{-1}$-------------			
0.00	89.00	2.0	39.4	51.7	18.9	65		14	21

EC: electrical conductivity of the saturation extract; P, K^+: Mehlich-1; H +Al: 0.5 M calcium acetate at pH 7.0; Al^{3+}, Ca^{2+}, Mg^{2+}: 1 mol L^{-1} KCl; CEC: cation exchange capacity; OM: soil organic matter; V: Base saturation

Table 2. Summary of analysis of variance for physical characteristics of Tommy Atkins mango fruits as a function of potassium sources and doses.

	FW	PP	TD	LD	ST	P
	— g —	$kg\ plant^{-1}$	———	mm	———	— % —
Source of K (F value)	10.41^{**}	185.0^{**}	7.52^{*}	8.09^{*}	38.06^{**}	0.27^{ns}
KCl	524.7 a	88.20 b	92.85 a	120.4 a	1.89 a	66.63 a
K_2SO_4	507.9 b	106.3 a	90.89 b	118.0 b	1.61 b	66.26 a
Doses of K (F value)	17.07^{**}	52.12^{**}	10.61^{**}	4.44^{**}	5.22^{**}	2.20^{ns}
Interaction (S x D)	3.54^{*}	6.87^{**}	0.60^{ns}	2.57^{ns}	1.56^{ns}	0.57^{ns}
CV (%)	6.24	4.33	3.01	2.70	13.58	6.34

^{ns} Not significant; **, *Significant at 0.01 and 0.05 probability levels by F test; fruit weight (FW); production per plant (PP); transverse diameter (TD); longitudinal diameter (LD); skin thickness (ST); and pulp percentage (P).

Table 3. Summary of analysis of variance for physical-chemical characteristics of Tommy Atkins mango fruits as a function of potassium sources and doses.

	VIT C	pH	TA	SS	SS/TA
	mg 100 g^{-1}		g 100 g^{-1}	(ºBrix)	
Source of K (F value)	9.88*	72.2**	11.4*	394.7**	5.52^{ns}
KCl	5.83 a	4.00 b	0.41 b	13.6 a	37.90 a
K_2SO_4	5.49 b	4.11 a	0.42 a	12.8 b	36.90 a
Doses of K (F value)	7.39**	9.80**	7.78**	47.2**	12.26**
Interaction (S x D)	14.2**	19.3**	7.74**	137.1**	16.74**
CV (%)	5.29	1.03	4.19	0.80	3.97

^{ns} Not significant; **, *Significant at 0.01 and 0.05 probability levels by F test; vitamin C (VIT C); titratable acidity (TA); soluble solids (SS); SS/TA ratio.

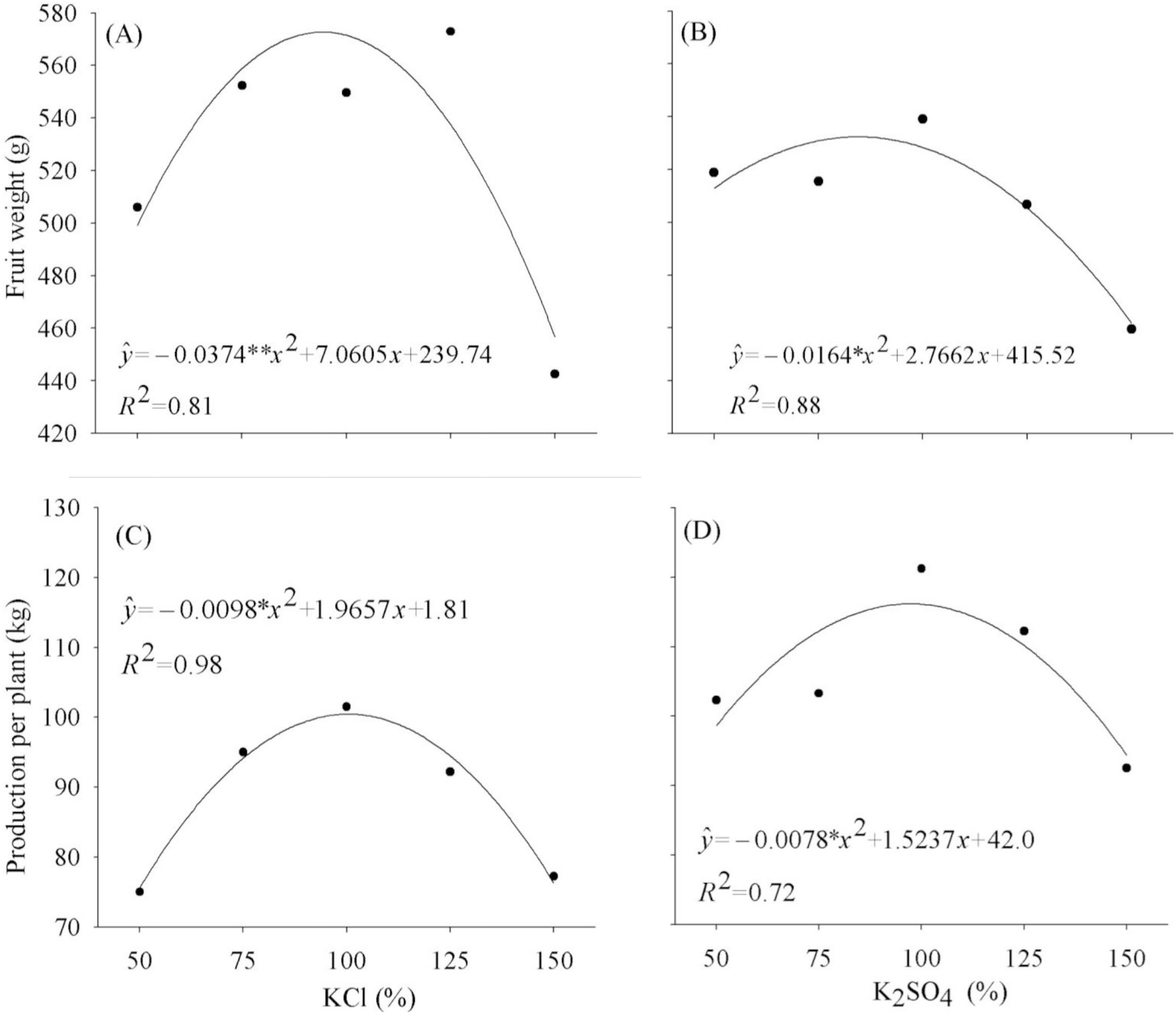

Figure 1. Fruit weight and production of Tommy Atkins mango under fertigation with difference sources (KCl and K_2SO_4) and doses of potassium.

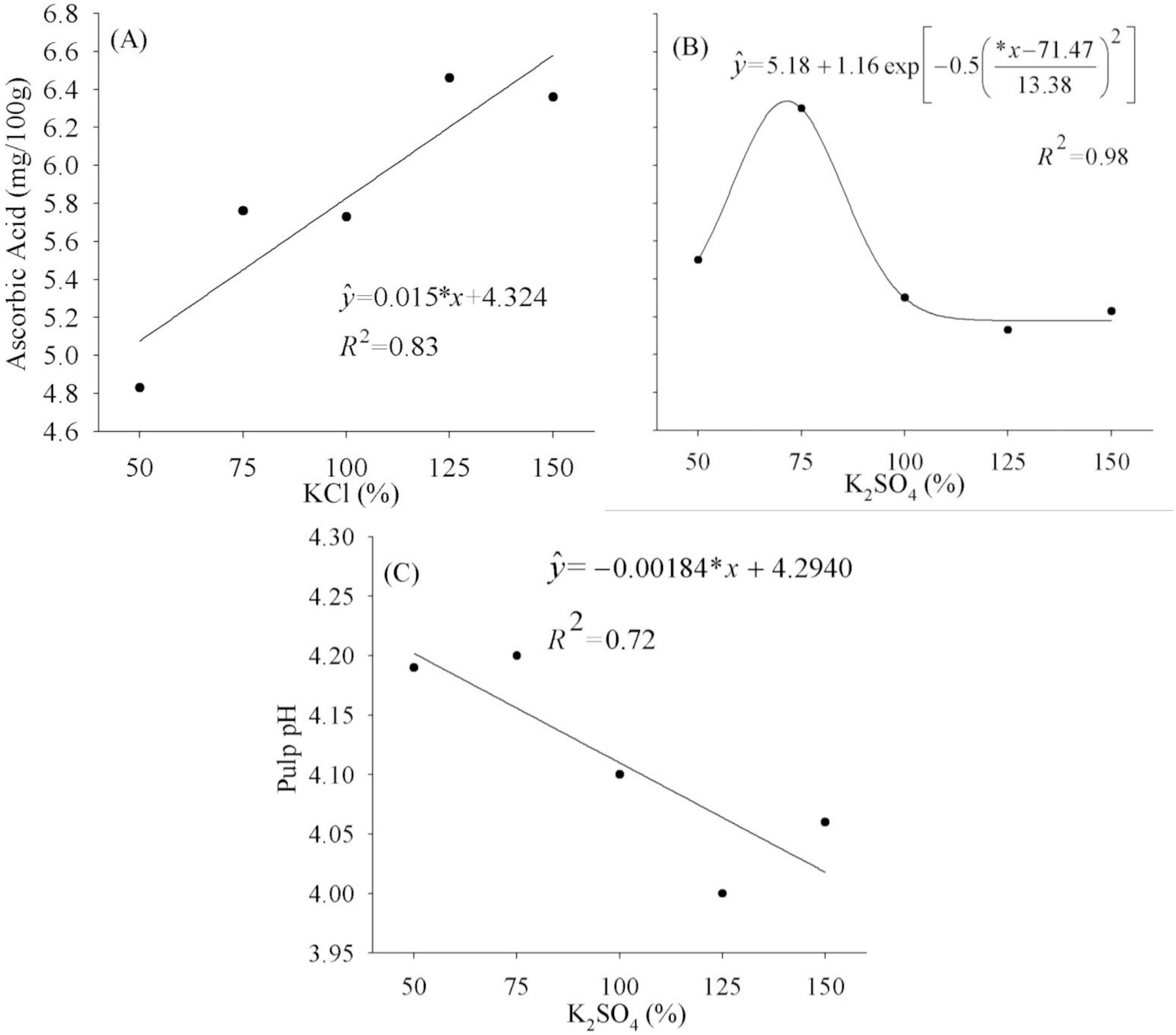

Figure 2. Contents of ascorbic acid (A and B) and pulp pH (C) in Tommy Atkins mango fruits under fertigation with different sources and doses of potassium.

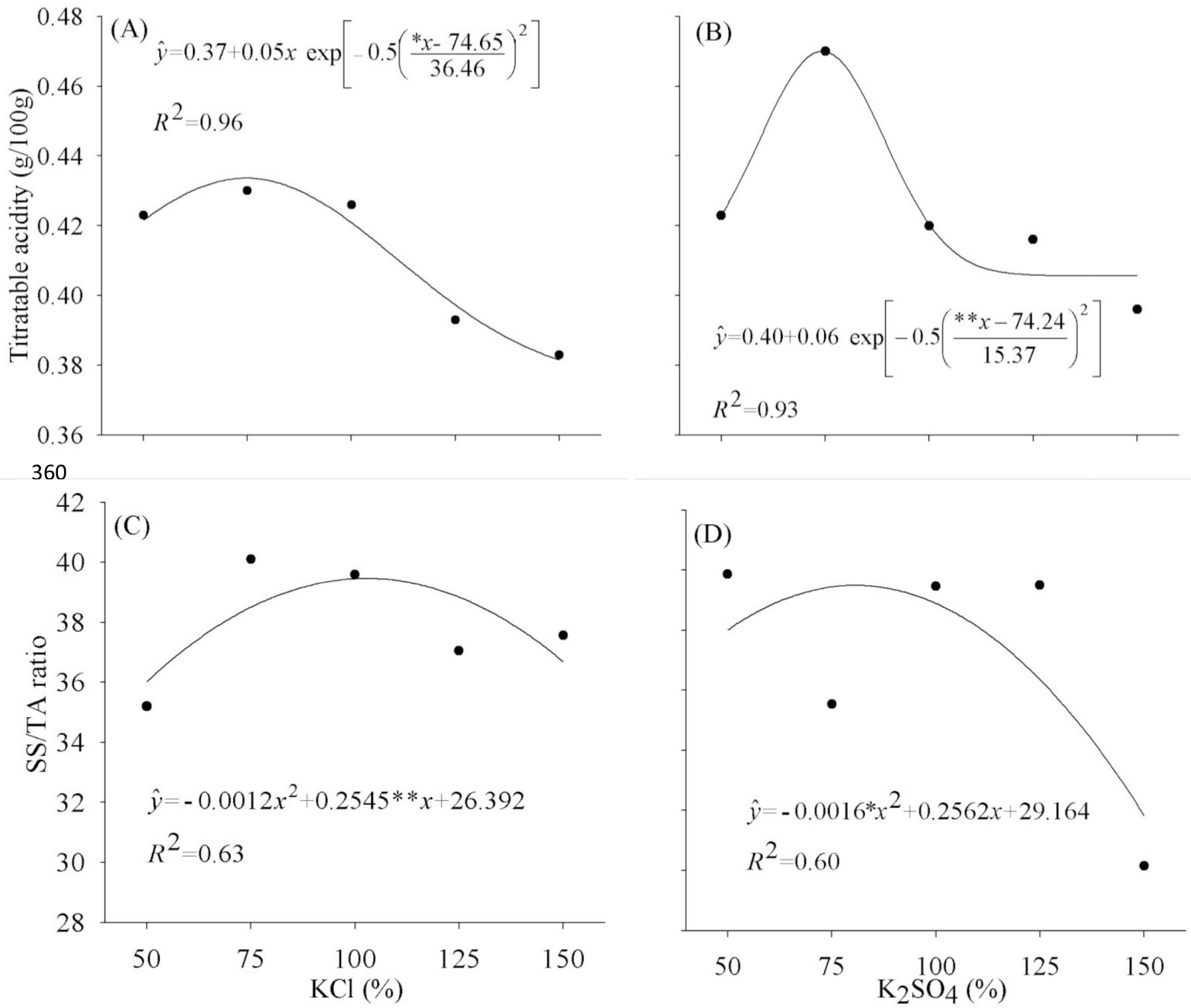

Figure 3. Titratable acidity (A and B) and SS/TA ratio (C and D) in Tommy Atkins mango fruits under fertigation with different sources and doses of potassium.

Conclusions

Potassium sources and doses have effect on fruit weight, production per plant, vitamin C, pH, titratable acidity, soluble solids and soluble solids/titratable acidity ratio in Tommy Atkins mango.

Fertilization with potassium chloride leads to higher weight of mango fruits, whereas fertilization with potassium sulfate causes higher production of mango fruits per plant. Doses lower than the recommendation of potassium sulfate result in higher contents of ascorbic acid in mango fruits.

The dose of 97.7% of the recommendation (349 g plant-1) of potassium sulfate, for the conditions under which the experiment was conducted, led to the minimum quality required in Tommy Atkins mango fruits with respect to the physical-chemical characteristics evaluated.

References

ALMEIDA, E.V.D.; FERNANDES, F.M.; CAIONE, G.; PRADO, R. de M.; BOLIANI, A.C.; CORRÊA, L.D.S. Liming. In: Growing mango cultivar Keitt in production. **Communications in Soil Science and Plant Analysis**, Londres, v.46, n.4, p.430-438, 2015.

AMORIM, D.A.; ROZANE, D.E.; SOUZA, H.A.; MODESTO, V.C.; NATALE, W. Adubação nitrogenada e potássica em goiabeiras 'Paluma': I. Efeito na produtividade e na qualidade dos frutos para industrialização. **Revista Brasileira de Fruticultura**, Jaboticabal, v.37, n.1, p.201-209, 2015.

AULAR, J.; NATALE, W. Nutrição mineral e qualidade do fruto de algumas frutíferas tropicais: goiabeira, mangueira, bananeira e mamoeiro. **Revista Brasileira de Fruticultura**, Jaboticabal, v.35, n.4, p.1214-1231, 2013.

BENASSI, M.T.; ANTUNES, A.J. A comparison of meta-phosphoric and oxalic acids as extractant solutions for the determination of vitamin C in selected vegetables. **Arquivos de Biologia e Tecnologia**, Curitiba, v.31, n.4, p.507-513, 1988.

BRASIL. Instrução normativa nº 1, de 7 de janeiro de 2000/MAPA. Regulamento técnico geral para fixação dos padrões de identidade e qualidade para polpa de frutas. **Diário Oficial da União**, Poder Executivo, Brasília, DF, 10 jan. 2000.

CAETANO, L.C.S.; VENTURA, J.A.; COSTA, A.F.S.; GUARÇONI, R.C. Efeito da adubação com nitrogênio, fósforo e potássio no desenvolvimento, na produção e na qualidade de frutos do abacaxi 'Vitória'. **Revista Brasileira de Fruticultura**, Jaboticabal, v.35, n.3, p.883-890, 2013.

CARNEIRO, M.A.; LIMA, A.M.N.; CAVALCANTE, Í.H.L.; CUNHA, J.C.; RODRIGUES, M.S.; LESSA, T.B.S. Soil salinity and yield of mango fertigated with potassium sources. **Revista Brasileira de Engenharia Agrícola e Ambiental**, Campina Grande, v.21, n.5, p.310-316, 2017.

CAVALCANTE, I.H.L.; LIMA, A.M.N.; CARNEIRO, M.A.; RODRIGUES, M.S.; SILVA, R.L. Potassium doses on fruit production and nutrition of mango (*Mangifera indica* L.) cv. Palmer. **Revista de la Facultad de Agronomia de la Universidad del Zulia**, Maracaibo, v.34, n.4, p.385-399, 2016.

CECÍLIO FILHO, A.B.; GRANGEIRO, L.C. Produtividade da cultura da melancia em função de fontes e doses de potássio. **Revista Ciência e Agrotecnologia**, Lavras, v.28, n.3, p.561-569, 2004.

COSTA, M.E.; CALDAS, A.V.C.; SOUZA, W.C.M.; GURGEL, M.T.; SILVA, R.M. Caracterização nutricional da mangueira 'Tommy Atkins' sob adubação potássica. **Revista Verde de Agroecologia e Desenvolvimento Sustentável**, Pombal, v.6, n.2, p.125-130, 2011.

DUTTA, P.; AHMED, B.; KUNDU, S. Effect of different sources of potassium on yield, quality, and leaf mineral content of mango. **Journal Better Crops With Plant Food**, Norcross, v.5, n.1, p.16-18, 2011.

GANESHAMURTHY, A.N.; SATISHA, G.C.; PRAKASH, P. Potassium nutrition on yield and quality of fruit crops with special emphasis on banana and grapes. **Journal of Agricultural Sciences**, Toronto, v.24, n.1, p.29-38, 2011.

GENÚ, P.J.C.; PINTO, A.C.A. **A Cultura da mangueira**. Brasília, DF: Embrapa Informação Tecnológica, 2002. p.452.

HUNSCHE, M.; BRACKMANN, A.; EMANI, P.R. Efeito da adubação potássica na qualidade pós-colheita de maçãs Fuji. **Pesquisa Agropecuária Brasileira**, Brasília, DF, v.38, n.4, p.489-496, 2003.

LESTER, G. E.; JIFON, J. L.; ROGERS, G. Supplemental foliar potassium applications during muskmelon fruit development can improve fruit quality, ascorbic acid, and beta-carotene contents. **Journal of the American Society for Horticultural Science**, Alexandria, v.130, n.4, p.649-653, 2005.

MOTTA, J.D.; QUEIROZ, A.J.M.; FIGUEIRÊDO, R.M.F.; SOUSA, K.S.M. Índice de cor e sua correlação com parâmetros físico-químicos de goiaba, manga e mamão. **Comunicata Scientiae**, Bom Jesus, v.6, n.1, p.74-82, 2015.

OLIVEIRA, H.T.B.; PEREIRA, E.C.; MENDONÇA, V.; SILVA, R.M.; LEITE, G.A.; DANTAS, L.L.G.R. Produção e qualidade de frutos de mangueira "Tommy Aktins" sob doses de Paclobutrazol. **Agropecuária Científica no Semiárido**, Campina Grande, v.10, n.3, p.89-92, 2014.

PBMH - Programa Brasileiro para a Modernização da Horticultura. **Normas de Classificação de Manga**. São Paulo: Centro de Qualidade em Horticultura (CEAGESP), 2004. 6p. 2004. (Documento, 28).

PINTO, P.A.C.; DIAS, L.E.; ALVAREZ, V.H.V.; CHOUDHURY, M.M.; VIEIRA, G. Avaliação do estado nutricional da mangueira 'Tommy Atkins' no submédio do vale do rio São Francisco: cálculo dos índices DRIS. **Recursos Rurais**, Lugo, v.5, n.6, p.5-13, 2010.

RÖMHELD, V.; KIRBY, E.A. Research on potassium in agriculture: needs and prospects. **Plant and Soil**, Dordrecht, v.335, n.1-2, p.155-180, 2010.

SANTOS, H.G.; JACOMINE, P.K.T.; ANJOS, L.H.C.;

OLIVEIRA, V.A.; LUMBRERAS, J.F.; COELHO, M.R.; ALMEIDA, J.A.; CUNHA, T.J.F.; OLIVEIRA, J.B. **Sistema brasileiro de classificação de solos**. 3.ed. Rio de Janeiro: Embrapa Solos, 2013. p.353.

SILVA, A.C.; SOUZA, A.P.; LEONEL, S. Growth and flowering of five mango cultivar under subtropics conditions of Brazil. **American Journal of Plant Sciences**, Irvine, v.5, n.3, p.393- 402, 2014.

SILVA, F. C. **Manual de análises químicas de solos, plantas e fertilizantes**. 2.ed. Brasília: Embrapa Comunicação para Transferência de Tecnologia, 2009. p.627.

ZENEBON, O.; PASCUET, N.S.; TIGLEA, P. **Métodos físico-químicos para análise de alimentos**. 4.ed. São Paulo: Instituto Adolfo Lutz, 2008. p.1002.