Effect of potassium sources on potato tuber yield and chip quality

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ABSTRACT

Many potato producers for fry industry changed from the use of potassium chloride to potassium sulfate, as there is a concept that the use of this source improves tuber quality. The aim of this work was to evaluate the effect of these two potassium sources on yield, specific gravity and chip color of potato chipping cultivars. The experiment was carried out on a Dystrophic Red Latosol, in Canoinhas, Brazil, in spring season 2016. Treatments consisted of two potato cultivars, BRSIPR Bel and Atlantic, and two sources of potassium, chloride and sulfate, applied in the furrow at the planting time, in rates based on soil analysis. Experimental design was a randomized complete block in a split-plot arrangement with four replications. Main plots were cultivars and subplots potassium sources. 100 days after planting each sub-plot was evaluated for yield, specific gravity and chip color. There was no significant effect of potassium source on yield components, specific gravity and chip color of BRSIPR Bel and Atlantic.

Keywords: Solanum tuberosum, mineral nutrition, fertilizer, BRSIPR Bel, Atlantic.

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Potato crops demand high investment in fertilizers, and depending on price and growing season, it can account for more than 30% of total crop production cost (Agrianual, 2014). Therefore, there is a need to develop fertilizer management strategies for potato, increasing the efficiency of fertilizer use.

Potato crop is highly responsive to fertilization, which can be attributed to high production potential, short cycle and relatively superficial root system (Fernandes & Soratto, 2012). However, due to the high potential of response to fertilization, the use of large amounts of fertilizer per unit area has been verified (Queiroz et al., 2013). Often 3 to 4 t ha⁻¹ of formula 04-14-08 (N-P₂O₅-K₂O) are applied, which is equivalent to 120 to 160 kg ha⁻¹ of N, 420 to 560 kg ha⁻¹ of P₂O₅ and 240 to 320 kg ha⁻¹ of K₂O (Mallmann et al., 2011).

Among the three macronutrients present in traditionally used formulations, potassium is the most absorbed by the crop and essential to obtain high tuber yield (Reis Junior & Monnerat, 2001). This nutrient is required by plants for the translocation of sugars and starch synthesis, thus influencing the quality of tubers, including dry matter, which is an important characteristic for tubers destined to processing industry (Quadros et al., 2009). Potato tubers with high dry matter content produce crisp potato chips, with less fat absorption (Araujo et al., 2016).

The application of potassium at lower rates than the crop requirement, usually reduces tuber yield and specific gravity, which correlates with dry matter content of tubers (Pauletti & Menarim, 2004). Therefore, it is very important to determine the potassium requirement to prevent reduction of dry matter content of potato tubers (Reis Júnior & Fontes, 1996; Reis Júnior & Monnerat, 2001).

In relation to potassium excess in soil and its increased concentration in the plant, there occur a reduction of the osmotic potential and increased water absorption, causing dilution of starch contents and dry matter in the tubers (Stark et al., 2003). The chloride source provides higher potassium uptake in the tuber than the sulfate source, but this effect is dependent on the cultivar.

RESUMO

Efeito de fontes de potássio na produtividade de tubérculos e qualidade de chips de batata

Muitos produtores de batata para indústria de fritas têm trocado o uso do cloreto de potássio por sulfato de potássio pois há o conceito de que a utilização desta fonte melhora a qualidade dos tubérculos. O objetivo do presente trabalho foi avaliar o efeito da aplicação dessas fontes de potássio na produtividade, peso específico e cor de fritura de cultivares de batata destinadas ao processamento na forma de chips. O experimento foi realizado em Latossolo Vermelho Distórico, em Canoinhas-SC, na primavera de 2016. Os tratamentos constaram de duas cultivares de batata, BRSIPR Bel e Atlantic, e duas fontes de potássio, sulfato e cloreto, aplicados no sulco de plantio, em doses baseadas na análise de solo. O delineamento experimental foi em blocos casualizados, em arranjo de parcelas subdivididas com quatro repetições, com as cultivares compondo as parcelas e as fontes de adubo as subparcelas. Aos 100 dias após o plantio, a produção de tubérculos de cada subparcela foi avaliada em relação ao rendimento de tubérculos, ao peso específico e cor de chips. Não houve efeito significativo do sulfato ou cloreto de potássio, nas variáveis componentes da produção, peso específico e cor de chips das cultivares BRSIPR Bel e Atlantic.


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395
Potassium chloride (KCl) is the main potassium source used in fertilization, due to its lower price. However, many producers adopted potassium sulfate (K₂SO₄) as potassium source, since it is believed to improve tuber quality (Reis Junior & Monnerat, 2001; Kumar et al., 2007). Many reports mention that potassium sulfate represent superior results regarding vitamin C, ash, carbohydrates, energy and starch, and worse results in relation to tuber water content compared to potassium chloride; but it depends on cultivar (Beringer et al., 1990; Kumar et al., 2007; Quadros et al., 2009). So, the chloride source would have a deleterious effect on potato crop, especially when applied late, since the assimilation of chlorine ion affects combinations with phosphorus, decreasing the carbohydrate synthesis (Quadros et al., 2009). In addition, it slows translocation of these photoassimilates to tubers in comparison to sulfate source (Kumar et al., 2007). Potassium chloride also raises the salt content that can damage the root system of plants, and consequently their development, besides the possibility of phytotoxicity to chlorine (Grangeiro & Cecílio Filho, 2004).

This study was installed to evaluate the effect of two potassium sources (chloride and sulfate) on tuber yield and chip quality of two potato cultivars.

**MATERIAL AND METHODS**

The experiment was carried out on a Dystrophic Red Latosol (Embrapa, 2006), in Canoinhas (26°10’38”S, 50°23’24”W, 839 m altitude), in spring season 2016. Average rainfall from September to December 2015, was, respectively 60.20, 198.40, 91.60, and 224.40 mm, while historical average, from 1987 to 2005, was 152.20, 188.20, 224.40 mm, while historical average, respectively 60.20, 198.40, 91.60, and 224.40 mm. Average temperature in these months was, 20.90°C, while the historical average temperature in these months was, 124.20, and 141.10 mm. Average from 1987 to 2005, was 152.20, 188.20, 224.40 mm, while historical average, respectively 60.20, 198.40, 91.60, and 224.40 mm. Average rainfall from 1987 to 2005, was 152.20, 188.20, 224.40 mm, while historical average, respectively 60.20, 198.40, 91.60, and 224.40 mm. Average temperature in these months was, 20.90°C, while the historical average temperature in these months was, 124.20, and 141.10 mm.

Soil preparation started one month before planting date, with plowing and flattening. Prior to planting, soil samples were collected from the experimental area, whose analysis revealed the following composition: organic matter = 3.9%, pH (SMP)= 4.6, P= 56 mg dm⁻³, K= 250 mg dm⁻³, Al= 3.0 cmolc dm⁻³, Ca= 2.6 cmolc dm⁻³, Mg= 0.9 cmolc dm⁻³, CTC= 22.6 cmolc dm⁻³, SB= 4.1 cmolc dm⁻³ and V= 18%.

The experimental design was randomized complete block in split-plot arrangement with four replications. Main plots were cultivars and subplots sources of potassium. Plots consisted of two rows each of 25 plants of the same cultivar, spaced 0.75 m between rows and 0.35 m between plants.

Treatments consisted of a factorial combining two potassium sources, potassium chloride (KCl, 60% of K₂O) and potassium sulfate (K₂SO₄, 50% of K₂O), and two potato chipping cultivars recommended: Atlantic, the most used cultivar worldwide for chipping (Webb et al., 1978), and BRSIPR Bel, a cultivar launched by the Brazilian Agricultural Research Corporation (Embrapa) and the Agronomic Institute of Paraná (Iapar) (Pereira et al., 2015).

Potassium sources were applied in the planting furrow at a rate of 140 kg ha⁻¹. In addition, all fertilization of P₂O₅ (100 kg ha⁻¹) as simple superphosphate, and N (140 kg ha⁻¹) as ammonium sulfate were applied based on interpretation of soil analysis and recommendations of Silva & Lopes (2017).

Type II seed tubers that had been cold stored for four months were planted on August 29, 2016. Fifteen days later, earthing up was manually performed. Cultural and phytosanitary treatments followed recommendations for the region (Pereira, 2010).

Plots were harvested 100 days after planting, and tubers were graded as marketable (tuber transversal diameter above 45 mm) and non-marketable (tuber transversal diameter equal to or below 45 mm), counted and weighted. Specific gravity was measured using a Snack Food Association hydrometer (Silva et al., 2014). Chip color was assessed using three medium sized and healthy tuber samples, cut transversely in slices, fried in vegetable oil at an initial temperature of 180°C until bubbling stopped, then scored for color using a 1 to 9 grade scale (1= dark, 9= light), adapted from Silva et al. (2014).

Tuber yield data were transformed to t ha⁻¹, and number of tubers to number ha⁻¹/1000. Data were checked for normal distribution of residues by the Lilliefors test, submitted to analysis of variance, and means compared with the use of the t test, using the program Genes (Cruz, 2013).

**RESULTS AND DISCUSSION**

According to meteorological data, the average temperatures of the growing season were very similar to historical average temperature for the region. Rainfall averages were also normal for the season, and well distributed. Precipitation in the first month was below historical average. But, it is known that until the 30 days after planting, the potato crop does not need large water volumes, as there is enough reserve in the tubers. According to Pereira (1991), during this period, about 1.66 mm daily are necessary, which is less than the close 2 mm daily observed in the period. In November, rainfall was slightly below historical average, but it was well distributed during the month. In the period of tuber bulking and maturation, 2.81 mm daily is necessary (Pereira, 1991), which was less than the 3.05 mm observed in this study. And in December, the amount of rain was above average, but the greater amount occurred later in the month, when the experiment had already been harvested. So, it is confirmed that the meteorological conditions for the period were adequate for good plant development.

The analysis of variance revealed significant differences (p≤0.05) among cultivars for marketable tubers, number of tubers, mass of non-marketable tubers, and specific gravity. There were no differences for other traits, as well as for potassium sources and cultivar x potassium source interaction (Table 1).

‘Atlantic’ was more productive than ‘BRSIPR Bel’, presenting larger tubers, therefore classified in greater proportion as marketable. This cultivar also had higher specific gravity (Table
Effect of potassium sources on potato tuber yield and chip quality

Table 1. Means and p statistic for yield, specific gravity and chip color for two potato cultivars BRSIPR Bel and Atlantic, as function of two potassium fertilizers sources, potassium sulfate (K2SO4) and potassium chloride (KCl), in spring 2016, in Canoinhas. Canoinhas, Embrapa, 2017.

<table>
<thead>
<tr>
<th>Evaluations</th>
<th>NMT1</th>
<th>NNMT (ha⁻¹/1000)</th>
<th>TNT</th>
<th>MMT (t ha⁻¹)</th>
<th>MNMT (t ha⁻¹)</th>
<th>TTM</th>
<th>SG</th>
<th>Cor**</th>
</tr>
</thead>
<tbody>
<tr>
<td>BRSIPR Bel</td>
<td>61.17 a</td>
<td>237.23 a</td>
<td>298.40 a</td>
<td>11.78 b</td>
<td>16.16 a</td>
<td>27.93 a</td>
<td>1.080 b</td>
<td>7.19 a</td>
</tr>
<tr>
<td>Atlantic</td>
<td>89.11 a</td>
<td>107.57 b</td>
<td>196.68 a</td>
<td>18.37 a</td>
<td>8.94 b</td>
<td>27.32 a</td>
<td>1.090 a</td>
<td>6.88 a</td>
</tr>
<tr>
<td>K2SO4</td>
<td>72.62 a</td>
<td>167.35 a</td>
<td>239.96 a</td>
<td>14.95 a</td>
<td>12.22 a</td>
<td>27.17 a</td>
<td>1.084 a</td>
<td>7.25 a</td>
</tr>
<tr>
<td>KCl</td>
<td>77.65 a</td>
<td>177.45 a</td>
<td>255.11 a</td>
<td>15.19 a</td>
<td>12.88 a</td>
<td>28.07 a</td>
<td>1.082 a</td>
<td>7.12 a</td>
</tr>
</tbody>
</table>

1.083, equivalent to 20.85% of dry matter, meets the ideal minimum (20%) for chipping (Araujo et al., 2016).

In the present study potassium rate was based on recommendation of Silva & Lopes (2017), which is lower than that used by some producers in different regions of the country. They apply 3.0 t ha⁻¹ of the formula 04-14-08 (N-P₂O₅-K₂O), which represents 71% of the recommended rate used in the present study. According to Oliveira (2013), the effects of these two sources of potassium on potato quality are more visible in excessive rates.

The potato crop is very responsive to fertilization (Nava et al., 2007). For high yields, nutrient extraction is relatively high and for the production of 1.0 t ha⁻¹ of tubers, approximately 8.0 kg of K₂O, 5.3 kg of N and 1.2 kg of P₂O₅ are extracted (Nava et al., 2007). For cultivar Monalisa, in Pinhão-PR, the maximum net revenue was obtained with the increase of 320 kg of K₂O in the formulation, it would require 7.0 t ha⁻¹ of fertilizer (Mallmann et al., 2011). However, excessive rates should be avoided, as they may reduce economic sustainability, by having a great impact on the production cost (Fernandes & Soratto, 2013), the environmental sustainability (Reis Junior & Monnerat, 2001) and tuber quality (Júnior & Fontes, 1996).

For these experimental conditions, potassium sources, sulfate or chloride, showed no effect on tuber yield components, specific gravity and chip color of cultivars BRSIPR Bel and Atlantic.

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