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Potassium sources and calcium and magnesium doses in carrot crop fertilization

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ABSTRACT

Fertilization has an important influence on carrot productivity and on the quality of the produced root, being responsible for most of the production cost of the crop. In this context, we evaluated the use of potassium (K) sources associated with calcium (Ca) and magnesium (Mg) doses in carrot cultivation. In a randomized block design in a triple factorial scheme (2x2x2), we evaluated two doses and sources of potassium [potassium chloride (KCl), 120 kg ha⁻¹ of K₂O; potassium sulfate (K₂SO₄) 120 kg ha⁻¹ of K₂O + 42,5 kg ha⁻¹ of S]; Two doses of Mg [magnesium sulfate (MgSO₄), zero kg ha⁻¹ of Mg; 25 kg ha⁻¹ of Mg + 34,2 kg ha⁻¹ of S]; two doses of the commercial algae product *Lithothamnium calcareum* as an alternative source of Ca [zero kg ha⁻¹ of seaweed; 200 kg ha⁻¹ of seaweed (24 kg ha⁻¹ of Ca)], all with six replications. Total productivity, 3A, commercial and percentage of discard carrot were evaluated. Regardless of the source of K used, the carrot production was median (above 40 t ha⁻¹), with no application of Ca or Mg. The application of 25 kg ha⁻¹ of Mg and zero Ca altered the Ca:Mg ratio in the soil and provided a significant increase in yield when KCl was used. The association of *L. calcareum* algae with KCl reduces total yield and increases carrot disposal.

Keywords: *Daucus carota*, *Lithothamnium calcareum*, potassium chloride, red algae extract, productivity, carrot quality.

RESUMO

Produção de cenouras submetidas a fontes de potássio e doses de cálcio e magnésio

A adubação tem importante influencia na produtividade da cenoura e na qualidade da raiz produzida, sendo responsável pela maior parte do custo de produção da cultura. Neste contexto, avaliou-se a utilização de fontes de potássio (K), associadas a doses de cálcio (Ca) e magnésio (Mg) no cultivo da cenoura. No delineamento de blocos ao acaso, em esquema fatorial triplo (2x2x2), avaliaram-se duas fontes e doses de potássio [cloreto de potássio (KCl), na dose de 120 kg ha⁻¹ de K₂O; sulfato de potássio (K₂SO₄) na dose de 120 kg ha⁻¹ de K₂O + 42,5 kg ha⁻¹ de S]; duas doses de Mg [sulfato de magnésio (MgSO₄), zero kg ha⁻¹ de Mg; 25 kg ha⁻¹ de Mg + 34,2 kg ha⁻¹ de S]; duas doses do produto à base da alga *Lithothamnium calcareum* como fonte alternativa de Ca [zero kg ha⁻¹ de alga; 200 kg ha⁻¹ de alga (24 kg ha⁻¹ de Ca)], com seis repetições. Foi avaliada a produtividade total, 3A, comercial e percentual de cenoura descarte. Independente da fonte de K utilizada, a produção da cenoura foi mediana (acima de 40 t ha⁻¹), sem aplicação de Ca ou Mg. A associação de alga *L. calcareum* com KCl reduz a produtividade total e aumenta o descarte da cenoura. A utilização da alga *L. calcareum* como fonte de Ca proporcionou aumento da produção quando associado com a aplicação de 25 kg ha⁻¹ de Mg via MgSO₄ e quando a fonte de K foi K₂SO₄.

Palavras-chave: *Daucus carota*, *Lithothamnium calcareum*, cloreto de potássio, extrato de algas vermelhas, produtividade, qualidade da cenoura.

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Carrot (*Daucus carota* subsp. *sativus*) is among the five most cultivated vegetables in Brazil, and the state of Minas Gerais is its largest producer, with 7.1 thousand hectares of planted area, and an average productivity of 39.7 t ha⁻¹, which corresponds to 40% of the national production; about 80% of this is located in the Alto Paranaíba and Triângulo Mineiro regions (Beling, 2017).

The carrot production is sustained by high doses of mineral fertilizers. By assessing the crop's nutrient uptake curve, Cecilio Filho & Peixoto (2013) observed that nitrogen (N), phosphorus (P), potassium (K), magnesium (Mg) and sulfur (S) are the nutrients most accumulated in the roots, whereas calcium (Ca) was more accumulated in the aerial part.

Dezordi *et al.* (2016), assessing the

differences between summer and winter cultivars, observed that there were no differences in the extractions of N, P, Ca, S, boron (B), copper (Cu) and zinc (Zn) in both seasons; however, through the nutrient balance, Mn, Mg, K and Ca were the most limiting nutrients for carrot crops in the Alto Paranaíba region. Gerendás & Führs (2013) highlight that the balance between K, Ca and Mg is reflected in the crops' quality and

productivity.

There is a low demand in carrot crops for K up to 40 days after seeding; afterwards, the demand increases in the plant's aerial part and stabilizes at about 100 days. Meanwhile, in the roots, there is increasing absorption until the end of the cycle (Cecilio Filho & Peixoto, 2013).

Calcium (Ca) is a constituent element of cell walls and second messenger to environmental stimuli, which makes it essential for the stability of biomembranes and cell walls (Taiz *et al.*, 2017). Of the total accumulated Ca during the carrot cycle, only 25% goes to the roots (Cecilio Filho & Peixoto, 2013); it is usually supplied by liming and phosphate fertilization with single and triple superphosphate, both containing Ca in its composition.

Some products based on red algae (*Lithothamnium calcareum*) have been used as an alternative source to the use of limestone as an acid corrector (Melo & Furtini Neto, 2003; Guiry *et al.*, 2014), also used in agriculture, livestock and human food (Aslam *et al.*, 2010). Nabti *et al.* (2017) highlight that algae-based products provide Ca, stimulate seed germination, root development and nutrient absorption.

The Mg in plant cells is part of the chlorophyll ring structure and acts on the activation of enzymes involved in respiration, photosynthesis, as well as DNA and RNA synthesis (Taiz *et al.*, 2017), and it is increasingly absorbed by the end of the crop's cycle. However, it is known that there is an antagonistic reaction in Mg absorption in relation to K (Senbayram *et al.*, 2015). Sulfur (S) is found in certain amino acids (cystine, cysteine and methionine) and is a constituent of several coenzymes and vitamins, such as coenzyme A, S-adenosylmethionine, biotin, vitamin B1 and pantothenic acid, which are essential for metabolism. In addition, it is a constituent of proteins and essential for plant growth and development (Taiz *et al.*, 2017).

Assessing carrot crops' nutritional management is an efficient strategy to improve its productivity and quality for human consumption. Thus, this study's goal was to assess the use of potassium

sources associated with calcium and magnesium doses in carrot crops in the Alto Paranaíba-MG region, Brazil.

MATERIAL AND METHODS

The study was carried out in Guaritas Farm, in the municipality of São Gotardo, state of Minas Gerais, Brazil (19°27'40.0"S, 46°07'53.8"W, 1201 m altitude), from 01/11/2018 to 04/16/2018, in a commercial area with center pivot irrigation.

According to the classification by Beck *et al.* (2018), the region's climate is classified as Cwb, subtropical highland climate, with temperate summers, characterized by a dry season and a well-defined rainy period, which occurs from October to March, with an average temperature of 18°C and 850 mm of average rainfall (Luz *et al.*, 2009).

The region's soil is classified as Dystrophic Red-Yellow Oxisol, with considerably clayey texture (Santos *et al.*, 2018), with the arable layer (0-20 cm) presenting: pH (H₂O)= 6.2; P_{rem} = 12.8 mg dm⁻³; P_{resine} = 35.8 mg dm⁻³; K = 147.2 mg dm⁻³; Ca = 4.2 cmol_c dm⁻³; Mg = 1.4 cmol_c dm⁻³; S = 18.6 mg dm⁻³; H+Al = 3.1 cmol_c dm⁻³; CTC = 9.09 cmol_c dm⁻³; SB = 5.99 cmol_c dm⁻³, organic matter (OM) = 3.1 dag kg⁻¹ and V% = 66. Regarding the micronutrients, B = 0.8 mg dm⁻³; Cu = 2.7 mg dm⁻³; Fe = 32.4 mg dm⁻³; Mn = 9.5 mg dm⁻³ and Zn = 18.6 mg dm⁻³ were found. According to the results of the soil analysis and the classification proposed by Alvarez *et al.* (1999), the P and K contents in the soil are classified as "very good" and those of Ca and Mg as "good".

The study was carried out in a randomized complete block design, with a triple factorial scheme (2x2x2), using the following treatments: Two doses of potassium in the form: 1 - Potassium chloride (KCl), 120 kg ha⁻¹ of K₂O; 2 - Potassium sulfate (K₂SO₄) 120 kg ha⁻¹ of K₂O + 42,5 kg ha⁻¹ of S; Two doses of magnesium using magnesium sulfate (MgSO₄): 1 - zero Mg; 2 - 25 kg ha⁻¹ of Mg + 34,2 kg ha⁻¹ of S; two doses of the commercial algae product *Lithothamnium calcareum* as an alternative source of Calcium (Ca):

1 - Zero seaweed; 2 - 200 kg ha⁻¹ of seaweed (24 kg ha⁻¹ of Ca), all with six replications.

The K₂SO₄ contains 48% K₂O and 17% S, while MgSO₄ contains 9.5% Mg and 13% S in its composition.

Once the base fertilization was completed, we provided 40 kg ha⁻¹ of N and 600 kg ha⁻¹ of P₂O₅, supplied via MAP (10% N and 48% P₂O₅) and triple superphosphate (41% to 46% P and 10% to 12% Ca) in all treatments, as recommended by Raji *et al.* (1997). There was no fertilization with manure or organic compounds in the experimental area.

The *Lithothamnium calcareum* mineral extract contains 12% calcium, 1% magnesium and measurable levels of 77 other minerals (Table 1); it is sold as a dietary supplement under the name Aquamin® (GRAS 000028) and is used in a variety of products for human consumption in Europe, Asia, Australia and North America.

The area was prepared in a conventional manner, with subsoiler, harrowing and rotary hoe, leaving the soil free of clods. The base fertilizer was applied manually (by hauling) at the moment of planting and according to each treatment; then a rotary tiller bed former was used to create the beds; in sequence planting was made with a mechanical seeder. There was no need to correct the soil acidity in the study area.

Planting was done in beds measuring 0.3 m high x 1.80 m wide: four double lines were distributed, with spacing of 0.25 m between them, and of 0.15 m between single lines. The experimental units (beds) were 1.8 m wide x 4.0 m long, and the plot's useful area were the two central double lines, dismissing 1 m of each end of the plot, which were considered borders.

Sowing was carried out mechanically on 11/01/2018, using the Juliana hybrid carrot cultivar from the Seminis company, characterized by being a summer-adapted cultivar. 800.000 seeds/ha were sown; thinning was performed 30 days after sowing to standardize the stand on 700.000 plants/ha.

The remaining crop treatments,

covering fertilization, spraying, thinning and others were conducted according to routine and specific technical guidelines for carrot cultivation.

Irrigation was performed via central pivot, with a blade to replace the calculated evapotranspiration. The reference evapotranspiration (ET_o) was estimated by applying the Penman-Monteith equation, on a daily basis (Allen *et al.*, 2006).

At the end of the cycle, on 04/16/2018, the useful area's whole plants were harvested, and the root was used to determine productive variables: total and commercial productivity, 3A productivity (category chosen due to higher market remuneration), and percentage of disposed carrots. The carrot 3A is characterized by its length varying between 22 and 26 mm.

Roots were used to determine the total yield of each plot (Totprod), weighing all harvested roots. For all productive variables, the roots were weighed with the aid of an electronic scale and the data were converted to t ha⁻¹.

Then, the roots were classified with the support of carrot washers from the region of São Gotardo-MG, Brazil; these professionals are trained to perform carrot classification in the following categories: disposal, 1A, 2A, 3A and G. Once the carrots were classified, each category was weighed. The sum of the weights of categories 1A, 2A, 3A and G were defined as commercial productivity (Comprod). We calculated the percentage of disposed carrots (%Disp) in relation to Totprod to perform a disposal evaluation.

Each category's average price in the region's market was monitored for a two-month period. Drawing from these data, a weight correction was made according to the market price of all categories for the 3A category (Prod3A). This analysis is interesting when working with crops that have a qualitative yield factor, and can be considered economic yield.

The normality of data (Lilliefors) and homogeneity of error variances were assessed by the Cochran & Bartlett test for all data. The results were submitted to a variance analysis with the application of the F test; the mean

values were compared to each other by the Tukey test at 5% probability, with the aid of the R Core Team software.

RESULTS AND DISCUSSION

Through the variance analysis (F test), we observed that there were single and triple interactions between sources of potassium (K), calcium (Ca) and magnesium (Mg). Concerning the analyzed variables, significant interactions occurred only for sources of potassium (K) in the disposal percentage (% Disp); for sources of calcium (Ca) in category 3A (Prod3A) and between sources of K x Mg x Ca in commercial productivity (Comprod).

These interactions evidence the fact that Mg alone does not interfere with carrot production; K and Ca are the elements that most affect it. K is

one of the most required nutrients by plants, and its rates are two to three-fold in comparison to Ca (Taiz *et al.*, 2017). Therefore, K is an essential element for plant growth, yet in the plant system, it is an extremely dynamic ion with high soil mobility. The risk of K leaching is low in soils of medium and clayey texture, but high in sandy soils, influencing the critical levels in soil and plant. Ca, in turn, is an element that acts synergistically in the accumulation of nutrients such as P, K, Mg, S, and sodium (Na), and this evidences the importance for balanced nutrition in carrot crops (Singh *et al.*, 2012).

Some studies demonstrate that K has the function of transporting carbohydrates from the source (leaves) to the sinks, which, in the case of carrots, are the tuberous roots. Thus, the proper supply of K to crops allows the formation of roots of higher commercial

Table 1. Mineral composition of seaweed *Lithothamnium calcareum*. Uberaba, IFTM, 2018.

Element	µg g ⁻¹	Element	µg g ⁻¹	Element	µg g ⁻¹
Aluminum	291	Hafnium	<0.03	Rubidium	1.95
Antimony	6.74	Holmium	<0.05	Ruthenium	0.088
Arsenic	<0.2	Indium	0.052	Samarium	0.529
Barium	64.2	Iodine	32.8	Scandium	0.041
Beryllium	0.306	Iridium	<0.05	Selenium	0.672
Bismuth	0.081	Iron	915	Silicon	504
Boron	39.5	Lanthanum	0.372	Silver	0.250
Bromine	10.1	Lead	0.158	Sodium	4,150
Cadmium	0.070	Lithium	2.77	Strontium	1,810
Calcium	351,500	Lutetium	0.065	Sulfur	5,700
Carbon	122,000	Magnesium	25,800	Tantalum	0.060
Cerium	2.17	Manganese	57.5	Tellurium	0.048
Cesium	0.096	Mercury	0.008	Terbium	0.030
Chloride	910	Molybdenum	0.052	Thallium	0.088
Chromium	0.820	Neodymium	0.034	Thorium	<0.02
Cobalt	0.082	Nickel	1.48	Thulium	0.061
Copper	4.89	Niobium	0.142	Tin	0.197
Dysprosium	0.078	Osmium	<0.05	Titanium	27.8
Erbium	4.27	Palladium	<0.01	Tungsten	0.188
Europium	0.051	Phosphorus	310	Vanadium	37.5
Fluoride	7.28	Platinum	<0.01	Ytterbium	0.096
Gadolinium	0.109	Potassium	5,176	Yttrium	1.22
Gallium	2.48	Praseodymium	0.228	Zinc	15.8
Germanium	0.207	Rhenium	<0.05	Zirconium	0.339
Gold	<0.01	Rhodium	<0.01		

Source: Aslam *et al.* (2010).

quality (Filgueira, 2008). Evaluating the extraction of macronutrients by the carrot as a function of K doses in cover, Corrêa & Cardoso (2017) observed that they follow a decreasing order of extraction by the aerial part, root and total $K > Ca > N > Mg > S > P$; $K > N > Ca > P > S > Mg$ and $K > N > Ca > P > Mg > S$, respectively and that there were no differences between the doses evaluated for Ca, Mg and S.

By analyzing the total carrot yield using the same dose of K (120 kg ha⁻¹), regardless of the source (KCl or K₂SO₄), and without the application of Mg (zero dose), the application of 200 kg ha⁻¹ of calcium, using the commercial algae product *Lithothamnium calcareum* as an alternative source, did not cause any changes in crop yield (Table 2).

However, applying 25 kg ha⁻¹ of Mg using KCl as K source, the yield increases by 31% at zero Ca dose (without algae application), and by 20% when compared to using K₂SO₄ as the K source. Using K₂SO₄ as the K source, adding 200 kg ha⁻¹ of algae-based Ca, the yield increases by 29.4% compared to KCl as a K source. Nonetheless, the yield is statistically equal to the treatment without the use of seaweed, which demonstrates that the potassium source being used is likely to be the one directly influencing the production, which can be justified by the high solubility and absorption of K when using any of the sources (KCl or K₂SO₄) and that the addition of 200 kg ha⁻¹ of Ca via algae, caused better plant development and higher carrot productivity.

In this study, higher carrot yields

have been observed with the application of K in coverage, and the crop has not always responded to the addition of calcium, since this nutrient's main effect on carrot production is indirect, through the soil's Ca/Mg ratio. In general, for most crops to present good yields, the Ca/Mg need should be equivalent to Ca:Mg rate between 3 and 4 in the soil (Raij *et al.*, 1997). In this study, the initial chemical analysis of the soil already had a ratio equal to 3, which must have increased with the application of Ca doses in the treatments, which justifies the results presented for Ca and Mg.

Evaluating cover fertilization with N, K and Ca in commercial carrot production, Luz *et al.* (2009) observed that the combined application of sources increased the productivity of commercial roots, especially roots between 18 and 22 cm (classification 2A), results similar to those found in this study for K (KCl source).

Assessing nutrient accumulation and exportation in "Forto" carrots, Cecilio Filho & Peixoto (2013) observed that N, P, K, Mg and S were preferentially accumulated in the root, while Ca mainly in the leaves; the decreasing order of accumulation was $K > N > Ca > P > S > Mg$, attesting the importance of K and Ca in production due to their higher extractions. Mg is the nutrient least extracted by the plant, and the small amounts in the soil are sufficient to nourish the plant, which may justify the carrot's lack of response to the application of Mg in the present study.

Concerning the amount and percentage of disposed carrots

production, we observed that the use of K₂SO₄ as a K source caused losses of 1.7 t ha⁻¹, which was 24% lower when compared to the use of KCl. There were no statistical differences between Ca and Mg sources (Table 3). These differences may be influenced by the sulfur (S) available in fertilization with K₂SO₄ (42.5 kg ha⁻¹ of S), which provided better conditions for plant development.

Soluble or exchangeable K may occasionally be included among the major constituents of soil salinity when applied as chloride (KCl) or sulfate (K₂SO₄), and less often as nitrate. Nonetheless, excess salts in the soil in any of these forms may hinder plant growth and yield due to the osmotic effects and toxicity of specific ions present in high concentrations in the soil solution. Even though soils of medium and clayey texture are less subject to salinization effects caused by fertilizers when compared to sandy soils, this condition should be evaluated when choosing the type of fertilizer to be used, as well as application amounts and frequency (Taiz *et al.*, 2017).

Regarding the commercial carrot production, we observed that there

Table 2. Commercial production (t ha⁻¹) (Comprod) of carrots grown with potassium (K), magnesium (Mg) and calcium (Ca) doses in São Gotardo. Uberaba, IFTM, 2018.

Source	Comprod			
	Mg1		Mg2	
	Ca1	Ca2	Ca1	Ca2
KCl	30.2aA	29.7aA	36.5aA	25.2bB
K ₂ SO ₄	33.9aA	31.3aA	29.2bA	35.7aA
CV (%)	8.99			

*Means followed by the same lowercase letter in the column and uppercase on the line do not differ from each other by the Tukey test ($p < 0.05$). KCl and K₂SO₄ = potassium chloride and potassium sulfate at 120 kg ha⁻¹ of K₂O; Mg1 and Mg2 = magnesium sulfate (MgSO₄) at zero dose and 25 kg ha⁻¹ of Mg; Ca1 and Ca2 = zero dose and 200 kg ha⁻¹ of seaweed (24 kg ha⁻¹ of Ca), with *Lithothamnium calcareum* algae product, respectively.

Table 3. Disposal of total carrot production not classified for sale, grown with potassium (K), magnesium (Mg) and calcium (Ca) doses in São Gotardo. Uberaba, IFTM, 2018.

Source	Disposal (t ha ⁻¹)		
	K	Mg	Ca
1	9.5a	8.8a	9.6a
2	7.8b	8.5a	7.7a
CV (%)	26.51		
Source	Disposal (%)		
	K	Mg	Ca
1	24.5a	20.8a	23.7a
2	18.5b	22.2a	19.3a
CV (%)	11.39		

*Means followed by the same lowercase letter in the column do not differ from each other by the Tukey test ($p < 0.05$). K: 1 = potassium chloride (KCl) and 2 = potassium sulfate (K₂SO₄) at a dose of 120 kg ha⁻¹ of K₂O; Mg: 1 and 2 = magnesium sulfate (MgSO₄) at zero dose and 25 kg ha⁻¹ of Mg; Ca 1 and 2 = dose zero and 200 kg ha⁻¹ of seaweed (24 kg ha⁻¹ of Ca), with commercial product based on *Lithothamnium calcareum* algae, respectively.

were no differences between the K sources and Ca and Mg doses used, and the values varied between 39.7 and 42.8 t ha⁻¹, depending on the K source used (KCl or K₂SO₄). We also observed that the production of Prod3A carrots is equivalent to practically 9% of total carrot production (Totprod), and the production of this category increased when there was calcium application (Table 4).

These results indicate that the practice of liming for pH correction is sufficient to meet the demands of the crop in Ca and Mg, causing the levels of these nutrients to rise in the soil in sufficient quantities to supply the plant, which can be proven through the previous chemical analysis of the soil, where the levels of Ca and Mg were classified as very good and good, respectively, justifying the lack of effect of the application of Ca and Mg.

Evaluating commercial carrot yield with different potassium doses, Silva *et al.* (2016) conducted data adjustment with quadratic regression, in which the maximum point was 61.5 kg ha⁻¹ of K₂O, while fresh matter production reached a

Table 4. Total carrot production (Totprod, t ha⁻¹) and those classified as 3A (Prod3A) grown with doses of potassium (K), magnesium (Mg) and calcium (Ca) in São Gotardo. Uberaba, IFTM, 2018.

Source	Totprod (t ha ⁻¹)		
	K	Mg	Ca
1	42.1a	41.2a	42.8a
2	40.5a	41.4a	39.7a
CV(%)	6.85		
Prod3A			
KCl	4.2a	4.2a	4.5a
K ₂ SO ₄	4.4a	4.4a	4.1b
CV(%)	25.8		

K: 1 = potassium chloride (KCl) and 2 = potassium sulfate (K₂SO₄) at a dose of 120 kg ha⁻¹ of K₂O; Mg: 1 and 2 = magnesium sulfate (MgSO₄) at zero dose and 25 kg ha⁻¹ of Mg; Ca 1 and 2 = dose zero and 200 kg ha⁻¹ of seaweed (24 kg ha⁻¹ of Ca), with commercial product based on *Lithothamnium calcareum* algae, respectively. *Means followed by the same lowercase letter in the column do not differ from each other by the Tukey test (p<0.05).

maximum of 87.7 kg ha⁻¹ of K₂O, which evidences that K influenced in the root's commercial classification.

According to Luz *et al.* (2009), in an experiment also conducted in the region of São Gotardo-MG, the total number of carrot roots was not significantly affected by topdressing treatments, totaling maximum root yield (27.5 t ha⁻¹); when using the 20-00-20 formulation, the values obtained were lower than those obtained by this study with the application of the 229.1 kg ha⁻¹.

In their study, Zanfirov *et al.* (2012) observed that the maximum yield obtained in carrot cultivation (103.8 t ha⁻¹) occurred using 41.6 kg ha⁻¹ of K₂O and, when compared to the control without potassium application (90.7 t ha⁻¹); there was a 14% increase in the production, values higher than those found in this study.

K is the main nutrient related to the quality of production and/or product, as it takes part in the activation of several enzymes during photoassimilate biosynthesis and carbohydrate transport (Taiz *et al.*, 2017), that's why it is more accumulated in all parts of the plant (Corrêa & Cardoso, 2017). The importance of K in carrot production was evidenced in this study, regardless of the K source used (KCl or K₂SO₄). There was high yield with the 120 kg ha⁻¹ dose when no Mg was applied, or without *Lithothamnium calcareum* application as source of Ca.

The soil Ca:Mg ratio before planting was 3, which is considered ideal in other studies (Filgueira, 2008; Luz *et al.*, 2009); when altered by the application of 25 kg ha⁻¹ of Mg and zero Ca there was a significant increase in production when the K source was KCl. However, applying 200 kg ha⁻¹ of *Lithothamnium calcareum* algae as Ca source, the production dropped substantially, which confirms the need to maintain this relationship.

The combination of *Lithothamnium calcareum* algae with potassium chloride (KCl) in carrots base fertilizer reduced the total yield and increased the disposed carrot classification. The use of *L. calcareum* algae as a Ca source only provided a significant increase in production if applied along with 25 kg

ha⁻¹ of Mg using magnesium sulfate (MgSO₄), when the K source was potassium sulfate (K₂SO₄).

The association of *L. calcareum* algae with KCl reduces total productivity and increases carrot disposal, however, as a Ca source, it only provided a significant increase in production when associated with the application of 25 kg ha⁻¹ of Mg via MgSO₄ and when the source of K was K₂SO₄.

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