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ORIGINAL ARTICLE

Physiological quality of parsley seeds in relation to doses of nitrogen and potassium

Qualidade fisiológica de sementes de salsa em função de doses de nitrogênio e potássio

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ABSTRACT: Parsley seeds [*Petroselinum crispum* (Mill.) Nyman ex AW Hill] must have germinations higher than 70%. But seed companies have found difficulties to get the minimum standards of germination established for this species, because of the slow and irregular germination after harvesting. The aim of this study was to evaluate the effect of nitrogen and potassium fertilization on the physiological quality of parsley seeds. The experiment was conducted in Bozano – RS. Factorial arrangement was 3x3 (3 doses of N and 3 doses of K_2O). Increasing doses of potassium (0, 50 and 100 kg ha^{-1} of K_2O) and nitrogen (0, 100 and 200 kg ha^{-1} of N) were applied. For the evaluation of the physiological quality of the lots in laboratory, a completely randomized design experiment was performed with the following tests: 1,000-seed weight, standard germination test, first-count germination, germination speed index, and electrical conductivity. Nitrogen and potassium coverage interfere with the physiological quality of parsley seeds. The best lots were obtained using the dose of 100 kg ha^{-1} nitrogen and 50 kg ha^{-1} potassium. Dosage of 200 kg ha^{-1} N will increase vigor and seed weight.

KEYWORDS
Petroselinum crispum,
Apiaceae
Germination
Seed production

RESUMO: *As sementes de salsa [*Petroselinum crispum *(Mill.) Nyman ex AW Hill] devem apresentar germinações superiores a 70% para comercialização. Entretanto, empresas de sementes têm encontrado dificuldades para obterem os padrões mínimos de germinação estabelecidos pela legislação para a espécie, em virtude de sua germinação ser lenta e irregular. Objetivou-se com este estudo avaliar o efeito da adubação nitrogenada e potássica sobre a qualidade fisiológica de sementes de salsa. O experimento foi conduzido em Bozano – RS. O delineamento experimental foi um arranjo fatorial em blocos casualizados em esquema 3x3 (3 doses de N x 3 doses de K_2O). Aplicou-se doses crescentes de potássio (0, 50 e 100 kg ha^{-1} de K_2O) e nitrogênio (0, 100 e 200 kg ha^{-1} de N) em cobertura. Para a avaliação da qualidade fisiológica dos lotes em laboratório, um experimento inteiramente casualizado foi realizado com os seguintes testes: peso de 1.000 sementes, germinação, primeira contagem da germinação, índice de velocidade de germinação e condutividade elétrica. A cobertura com nitrogênio e potássio interferiu na qualidade fisiológica das sementes de salsa. Os melhores lotes foram obtidos para a dose de 100 kg ha^{-1} de N e 50 kg ha^{-1} de K_2O. A dose de 200 kg ha^{-1} de N garantiu aumento no vigor e peso da semente.*

PALAVRAS-CHAVE
Petroselinum crispum
Apiaceae
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Produção de sementes

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1 Introduction

The parsley [*Petroselinum crispum* (Mill.) Nyman ex AW Hill] belongs to Apiaceae family. It has a great importance and commercial value in world gastronomy due to its use as a condiment and medicinal purposes (Pedroso et al., 2010). Parsley planting in Brazil occupied an area of 6540 ha and seed marketing reached R$ 2,098,195.00 in 2011 (Associação Brasileira do Comércio de Sementes e Mudas, 2012).

It is necessary germination higher than 70% for the marketing of parsley seeds lots, according to Ministério da Agricultura, Pecuária e Abastecimento (MAPA). Farmers prioritize parsley seed lots with great germination percentage, higher than established by MAPA, to get an appropriate crop stand. However, seed companies have difficulties to get the minimum germination percentage for sale, because germination is slow and irregular after harvesting (Rodrigues et al., 2011).

Several studies have shown positive influence of mineral nutrition plant in seed production at cultivated species (Kano et al., 2006; Oliveira et al., 2006; Zucareli et al., 2012). Nutrients promote good embryo, endosperm and seeds chemical composition formation, influencing metabolism and vigor (Evangelista et al., 2010; Carvalho et al., 2014). Nitrogen and potassium are one of the most extracted elements by plants and they affect directly in seed quality (Kano et al., 2006).

Nitrogen is absorbed in large amounts by most crop species but can limit the growth and development of plants in higher doses (Meneghin et al., 2008). Nitrogen affects seed quality, influencing the synthesis of amino acids, proteins and other important compounds in metabolism that are fundamental for the embryo development. There are reports of beneficial effects of nitrogen fertilization on seed quality in several vegetables such as onion, bean pod, coriander and sweet corn (Oliveira et al., 2006; Ali et al., 2007; Zucareli et al., 2012).

Potassium performs functions related to osmotic control and activation of enzymes in plants (Wang & Wu, 2013; Anschütz et al., 2014). The content of this nutrient in seeds is essential to supply seedlings in an early stage of development, because roots system cannot provide the demand of potassium at this stage (Grzebisz et al., 2013). Studies demonstrated beneficial effect of potassium fertilizer on physiological quality of soybean seeds (Veiga et al., 2010; Toledo et al., 2011; Batistella Filho et al., 2013). However, the use of increasing potassium doses influenced the number and the seed weight in lettuce (Kano et al., 2006), without affecting physiological quality. Information related to the effects of nitrogen and potassium fertilization in parsley seeds quality is scarce. In this context, the aim of this study was to evaluate the effect of increasing doses of nitrogen and potassium in the physiological quality of parsley seeds.

2 Material and Methods

The experiment was conducted at field from the period of May to November of 2013 in Bozano – RS, located at 28º23’16” S and 53º54’53” W, with altitude of 328 m. Climate is classified as Cfa (humid subtropical, without typical drought) according to Köppen system. The average temperature (°C), precipitation (mm) and relative humidity (%) during execution of the experiment were: May = 16.2; 137.6; 92, June = 15.9; 102.8, 90, July = 18.2; 86.2; 87, August = 25.4; 74.4; 86, September = 24.5; 58.7; 82, October = 23.5; 34.3; 80 and November = 26.5; 37.4; 88, respectively.

The soil of experimental area was previously corrected according to its chemical analysis results and had the following characteristics: pH (H_2O) = 6.0; Available P (mg dm^{-3}) = 5.0; K (mg dm^{-3}) = 352.0; Ca^{2+} ($cmol_c$ dm^{-3}) = 14.7; Mg^{2+} ($cmol_c$ dm^{-3}) = 6.6; H + Al ($cmol_c$ dm^{-3}) = 7.7; Organic matter (dag kg^{-1}) = 3.7; clay (g kg^{-1}) = 300; SMP index = 5.5; Al^{3+} ($cmol_c$ dm^{-3}) = 0.1; CTC_{pH7}($cmol_c$ dm^{-3}) = 29.9; Base saturation (%) = 74.1 and Aluminum saturation (%) = 0.4.

Factorial arrangement was 3 x 3 (3 doses of N and 3 doses of K_2O). It was applied, at coverage, increasing doses of potassium (0, 50 and 100 kg ha^{-1} of K_2O) in the form of potassium chloride, and nitrogen (0, 100 and 200 kg ha^{-1} of N) in the form of calcium nitrate.

Seeds were sown directly in the soil on May 3rd, with 15 seeds per meter spaced 0.5 m between lines. It was used parsley seeds from cultivar “Nativa”. Each plot was represented by four lines with 30 plants per row, totaling 120 plants (4 m^2). Seed harvest was performed only in the useful area that consisted of the 40 plants located at the two central lines from the plot. Cover fertilization treatments were divided into three equal amounts and applied in the plots manually. The first cover fertilization was performed at 30 days after sowing, the second at 60 days, and the third at 90 days after sowing. Irrigation was executed with drip tapes with emitters at every 0.5 m, with a flow rate of 4.0 L h^{-1}, without any nutrient solution. Other crop treatments were performed as recommended for the species.

The harvest of flower stalks occurred 185 days after sowing. The stalks were sent to the Seed Laboratory (LAGEN) from Federal University of Uberlândia, Monte Carmelo Campus for the evaluation of physiological quality in laboratory. The inflorescences were placed on plastic canvas at ambient conditions for two weeks to dry. Then, they were benefited manually and placed in an oven at 38 °C for 24 hours to reach a moisture content around 6%. The following tests were performed:

1000-seed weight (SW): was performed following the method described by Rules for Seed Analysis – RAS (Brasil, 2009) and expressed in grams.

Standard germination test (SGT): conducted with four repetitions of 100 seeds obtained from the samples of each treatment seed lot, distributed equally over two blotters paper, moistened with the amount of distilled water equivalent to 2.5 times the weight of the substrate in transparent plastic boxes (gerboxs) and kept in a B.O.D. incubator (Bio-Oxygen Demand) at 25 °C with a photoperiod of eight hours. The percentage of normal seedlings was computed 28 days after sowing.

First-count germination (FCG): the percentage of normal seedlings on the tenth day after sowing performed together with the germination test.

Germination speed index (GSI): GSI was calculated as $(G_1/N_1) + (G_2/N_2) + ... + (Gn/Nn)$; being G_1, G_2, ..., Gn: the number of germinated seeds in first, second, …, to the last count; and N_1, N_2, ..., Nn: the number of days from sowing to the first, second and last count (Maguire, 1962). The test was performed with the germination test counting the number of germinated seeds every day.

Electrical conductivity (EC): made with four subsamples of 25 seeds preweighed in a precision balance (0.0001 g). The seeds were placed in disposable plastic cups (180 ml) with 50 ml of distilled water (electrical conductivity between 1 and 3 μS cm^{-1}), and remained in a B.O.D. incubator with constant temperature of 25 ºC for 24 hours. The electrical conductivity was read after 24 hours with a conductivimeter. The results were expressed by μS cm^{-1} g^{-1} of seed.

Results were submitted to Analysis of Variance (F-test, $p < 0.01$) after the assumptions of normality of residuals and homogeneity of variances were met with the tests of Shapiro-Wilk and Levene, respectively, both at 1% of significance. Means were compared with Tukey's test at 5% probability. Standard germination test and first-count germination were plotted in graphics for better visualization of results. Orthogonal contrast of the control (no coverage fertilization) *vs* the other treatments was performed applying Scheffé's orthogonal contrast ($p < 0.01$). Data were analyzed using the statistical program SISVAR (Ferreira, 2011).

3 Results and Discussion

There was significant effect (F, $\alpha = 0.01$) in the interaction of nitrogen and potassium fertilization on physiological quality of parsley seeds for all evaluated characteristics, ratifying the influence of nitrogen and potassium in the seed vigor, as verified by other authors (Favarato et al., 2012; Tavares et al., 2013). It was observed an improvement on 1,000-seed weight in the higher dose of nitrogen (200 kg ha^{-1}), regardless of the dose of potassium (Table 1). For this species, nitrogen was essential for the growth of the parsley seeds and probably to increase the seed's reserve. With the highest dose of nitrogen, the increase in weight was observed with no application of K_2O.

It was found that germination speed index (GSI) was influenced by the levels of N and K_2O (Table 1). Without any application of potassium, the GSI was higher in the dose of 200 kg ha^{-1} of nitrogen (9.83 seeds day^{-1}). The same trend was observed at 1,000-seed weight, showing that seeds fertilized with nitrogen have more reserve and consequently germination than when not fertilized with this nutrient. With 100 kg ha^{-1} of K_2O, the dose of 0 and 100 kg ha^{-1} of N also provided higher GSI (8.98 and 9.07 seeds day^{-1}, respectively).

The application of 200 kg ha^{-1} of nitrogen with 50 or 100 kg ha^{-1} of K_2O performed the worst GSI results. When the doses of K_2O increased in the soil, probably the highest dose of N became toxic to seed development, showing that higher doses of both nutrients could affect the development of the plant seeds. It should be avoided doses of 200 kg ha^{-1} of N when potassium is also applied.

Significant effects of N and K_2O could be observed in electrical conductivity (EC) (Table 1). With the doses of 0 and 200 kg ha^{-1} of N, the EC increased with the potassium levels. Higher values in EC indicate potential damage for the seeds and could reflect negatively in the seeds vigor. EC was reduced when the dose of 100 kg ha^{-1} of nitrogen was used with the doses of 50 and 100 kg ha^{-1} of K_2O. The higher dose of nitrogen with 0 or 50 kg ha^{-1} of K_2O and the higher dose of potassium with 0 or 100 kg ha^{-1} of N also promoted EC reduction.

Table 1. Average weight of 1,000 seeds, Germination speed index (GSI) and Electrical conductivity (EC), Standard germination (SGT) and First-count germination (FCG) for different doses of nitrogen and potassium in parsley seeds. Monte Carmelo, 2014.

Tabela 1. Peso médio de 1.000 sementes, índice de velocidade de germinação (GSI) e condutividade elétrica (EC), germinação (SGT) e primeira contagem da germinação (FCG) para diferentes doses de nitrogênio e potássio em sementes de salsa. Monte Carmelo, 2014.

N doses	1,000-seed weight (g)		
	K_2O doses		
	0	50	100
0	1.69Ab	1.30Cc	1.52Bc
100	0.57Cc	1.37Bb	1.63Ab
200	2.14Aa	1.62Ca	1.68Ba
CV (%)		1.37	
N doses	GSI (seeds day^{-1})		
	K_2O doses		
	0	50	100
0	8.21Aab	5.31Bb	8.98Aa
100	6.41Bb	7.59ABa	9.07Aa
200	9.83Aa	6.99Bab	7.54ABb
CV (%)		16.00	
N doses	EC (μS cm^{-1} g^{-1})		
	K_2O doses		
	0	50	100
0	364.47Aa	468.28Bab	449.37ABa
100	748.53Bb	527.92Ab	520.63Aa
200	309.42Aa	380.49Aa	673.56Bb
CV (%)		11.77	
N doses	SGT (%)		
	K_2O doses		
	0	50	100
0	74.25Aa	39.50Bb	75.50Aab
100	59.50Bb	69.00Aa	77.00Aa
200	67.50Aab	62.50Aa	68.25Ab
CV (%)		7.05	
N doses	FCG (%)		
	K_2O doses		
	0	50	100
0	58.75Aab	32.75Bb	58.75Ab
100	53.75Bb	58.25ABa	67.75Aa
200	66.25Aa	50.00Ba	57.50Bb
CV (%)		11.37	

Means followed by the same small letters in a column and capital letters on the lines do not differ significantly by Tukey's test (p-value ≤ 0.05).

According to Kranner et al. (2010) and Menezes et al. (2014), cell membrane degradation is the first event of deterioration process. On this regard, the EC test is often used, which seeds are evaluated indirectly, measuring quantitatively the leachate on solution of embedded seeds. Lower values indicate lower release of exudates, assuming physiological high potential (seeds with increased vigor), or even less intensity disruption of the cell membrane systems.

The germination (SGT) and first-count germination (FCG) increased in the dose of 100 kg ha^{-1} of N with the highest dose of potassium (100 kg ha^{-1}), and percentage of SGT was 77% and 68%, respectively (Table 1). The dose of 100 kg ha^{-1} of N also caused better increments with 50 kg ha^{-1} of K_2O. When there was no fertilization with K_2O, the doses of 200 and 0 kg ha^{-1} of N had the best SGT, but 200 kg ha^{-1} of N ensure higher FCG (Table 1).

When the fertilizers were applied individually, it was found that SGT was greater without the application of fertilizers (74%), but similar results can be obtained with the application of higher doses (66% with 200 kg ha^{-1} of N, 76% with 100 kg ha^{-1} of K_2O), but it also should be considered that higher germinations were detected on the tenth day with these doses (Table 1). Despite the reduction of SW with application of potassium, germination potential was always higher in the higher dose applied (100 kg ha^{-1} of K_2O) for all different levels of nitrogen applied (Table 1).

Alves et al. (2005) found no influence of mineral fertilization (K_2O) on SGT and vigor of coriander seeds (*Coriandrum sativum*), also an Apiaceae. In contrast, Oliveira et al. (2006) found that the use of different doses of N promoted positive effects on physiological quality of coriander seeds. In studies performed by Ali et al. (2007) with onion seeds, germination was positively affected by the increasing doses of N.

The same results were found by Kano et al. (2006) on the physiological quality of lettuce seeds. It would be more appropriate to compare our results with researches from the same species; however, there are not articles with parsley referring to the effects provided by mineral fertilizing on physiological quality of seeds.

In the absence of nitrogen fertilization and application of potassium, there was a decrease on the 1,000-seed weight and increase on EC, whereas, in the absence of potassium fertilization and application of nitrogen, the inverse occurred. For germination, medium doses of both nutrients were more effective in enhancing germination. At the dose of 100 kg ha^{-1} of nitrogen, there was an increase on 1,000-seed weight, SGT, FCG and the GSI and decrease of EC, with application of increasing doses of potassium. Also in the dose of 50 kg ha^{-1} of potassium there was increase of SGT, FCG and GSI and decrease in EC, indicating that doses of 100 kg ha^{-1} of nitrogen and 50 kg ha^{-1} of potassium were more benefic to the quality of parsley seeds.

When the absence of fertilization was compared with fertilizers coverage with Scheffé's orthogonal contrast, differences appeared only in SGT and EC at 0.01 significance. With no coverage, germination decreased by 9.56% and the conductivity increased by 145.30 $\mu S\ cm^{-1}\ g^{-1}$, which reflects in deteriorated seeds. It demonstrates that the presence of mineral nutrients (N and K_2O) potentiated physiological seed quality on the range proposed in this study.

According to Zheng & Wang (2015), when applied in the correct doses, nutrients promote good embryo formation and preservation of endosperm, as well as the chemical composition of the seeds, influencing metabolism and vigor of them. On the positive influence of N and K_2O proven by the results obtained in this study, it is suggested further studies to be carried out with other doses of N and K_2O. It is noteworthy that the time of application of fertilizers coverage, in function of the growth stage of plant, can also be focus of future research.

4 Conclusions

Nitrogen and potassium coverage affects the physiological quality of parsley seeds.

The dose of 100 kg ha^{-1} of nitrogen and 50 kg ha^{-1} of potassium promotes the best results to the physiological quality of parsley seeds.

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