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Bean seed performance under different temperatures

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INFO

Keyworks
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ABSTRACT

The study evaluated the germination performance of bean seeds (BRS Expedito) from different regions of southern Brazil submitted to different germination temperatures (20, 25 and 30º C). Were evaluated to germination (GER), first germination count (PCG), germination speed index (IVG), shoot dry mass (MSPA) and root dry mass (MSR). The seeds from São Mateus (PR) presented the highest average values for the variables GER, PCG and IVG in the three temperatures tested. The temperature increase (20 to 30 ºC) significantly influenced the dry biomass accumulation in the shoots and seedlings roots. The results indicate the existence of a phenotypic plasticity acquired by the cultivar due to local adaptation of the ecotypes.

RESUMO

Palavras-chave
ecótipo
Phaseolus vulgaris
plasticidade fenotípica
temperatura de germinação

Desempenho de sementes de feijão sob diferentes temperaturas

O estudo avaliou o desempenho germinativo de sementes de feijão (BRS Expedito) de diferentes regiões do sul do Brasil submetidas a diferentes temperaturas de germinação (20, 25 e 30º C). Foram avaliados: germinação (GER), primeira contagem de germinação (PCG), índice de velocidade de germinação (IVG), massa seca da parte aérea (MSPA) e massa seca da raiz (MSR). As sementes de São Mateus (PR) apresentaram os maiores valores médios para as variáveis GER, PCG e IVG nas três temperaturas testadas. O aumento da temperatura (20 a 30 ºC) influenciou significativamente o acúmulo de biomassa seca nas raízes e da parte area das platulas de feijão. Os resultados indicam a existência de uma plasticidade fenotípica adquirida pela cultivar devido à adaptação local dos ecótipos.

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INTRODUCTION

Beans (*Phaseolus vulgaris* L.) are one of the main agricultural crops produced in Brazil. The importance of this culture goes beyond the economic aspect, as it represents a factor of food and nutritional security, besides presenting cultural importance in the cuisine of several countries (Barbosa & Conzaga, 2012). For Brazilian agriculture, bean crop occupies a prominent place, being that Brazil is the third largest bean producer and consumer in the world, behind Myanmar and India, which rank first and second, respectively (Wylot et al., 2019). Brazilian production in the 2017/2018 harvest was approximately 3.39 million tons (Coelho, 2018).

In Brazil, about 30% of bean production is obtained in the Southern Region, between the states of Rio Grande do Sul, Santa Catarina and Paraná. In this region, low atmospheric and soil temperatures (below 12 °C) at the beginning or after the first days of bean crop sowing can cause failure in seedling emergence and, consequently, an uneven stand establishment (Vieira et al., 2006). In contrast, high atmospheric and soil temperatures (above 30 °C) also negatively affect germination, seedling emergence, stand establishment and early development. Both situations are undesirable as crop yield may be negatively affected.

Climate variables (especially atmospheric temperature) for southern Brazil are not homogeneous across the three states, with significant regional differences (Wrege et al., 2012). This climatic heterogeneity results in different agroclimatic zones, which in turn can lead to different responses of agricultural crops. Knowledge about germination characteristics of the same bean cultivar with seed lots from different agroclimatic zones is unknown. Considering that seeds of the same bean cultivar have an identical genetic load, it is expected that the germination behavior of different seed lots of the same cultivar will be similar.

The response of expected seed germination variables of different lots of the same cultivar may vary when subjected to the same abiotic conditions. This may be the result of phenotypic plasticity acquired by the cultivar due to consecutive cultivation of the species in environments that may result in slight differences in selection pressure. In this context, the hypothesis of this work is that the germination performance of the same bean cultivar, with seed lots from different agroclimatic zones, will be different when subjected to the same temperature conditions. Therefore, the objective of this study wasto evaluate the germination performance of bean seeds cultivar (BRS Expedito) lots from three different productive regions of southern Brazil when subjected to different temperatures during germination.

MATERIAL AND METHODS

The work was developed at the Department of Fitotecnia of the Federal University of Pelotas (UFPel), Pelotas, Rio Grande do Sul, Brazil. Common bean seeds cv, BRS Expedito, coming from three municipalities that cover different agroclimatic regions in Southern Brazil: Santa Maria and Pelotas in Rio Grande do Sul State; and São Mateus do Sul in Paraná, from the 2017/2018 harvest. Santa Maria is classified as Agroclimatic Zone II (agroecological region 1C) and Pelotas, as Zone V (agroecological region 12A), according to Maluf et al. (2000). São Mateus do Sul does not compose an Agroclimatic Zone according to the proposed classification for the State of Rio Grande do Sul (Maluf et al. 2000), but according to the Climate Risk for the State of Paraná, the climate risk for bean cultivation in this municipality fluctuate between 25 to 36% (Vieira & Trazilbo, 2006).

All evaluations were performed in B.O.D Incubator (LUCA-161/03, Brazil), with temperatures adjusted to 20, 25 and 30 °C and photoperiod that 24-hour of light. The experimental design was completely randomized, with the treatments distributed in a 3 x 3 factorial scheme (seed lots x temperature). Each treatment consisted of eight repetitions of 100 seeds. The following parameters were evaluated: germination (GER), first germination count (PCG), germination speed index (IVG), shoot dry mass (MSPA) and root dry mass (MSR).

Germination was evaluated according to the recommendations for the germination test described in the Rules for Seed Analysis - RAS (Brasil, 2009). Results were expressed as a percentage, being the PCG was performed in conjunction with the GER test. It was counting the number of normal seedlings on the fifth day after sowing (Brasil 2009). Subsequently, the results were converted and expressed as a percentage. The IVG was calculated by the formula [$IVG = \sum (ni/ti)$], where ni = number of seeds that germinated in time ‘‘i’; ti = time after test installation; $i = 1 \rightarrow 9$ days. Results were expressed in dimensionless unit (Maguire, 1962).

For the MSPA and MSR evaluations, eight paper rolls with 25 seeds each were prepared. These were maintained under the same conditions as described

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for the germination test. After a period of five days of germination, 10 seedlings were randomly collected. Firstly, the seedlings were separated in root and shoots, placed in Kraft paper packages and placed in oven drying at 65 ± 2.0 °C for 48 hours. After this period, the mass was measured on an analytical balance accurate to 0.0001 g. Results were expressed in grams (Nakagawa, 1999).

The data obtained were analyzed for normality (Shapiro Wilk) and homoscedasticity (Hartley) using the R Studio Software (R Core Team, 2015). Subsequently, the data were submitted to analysis of variance (ANOVA) and the averages compared by the Tukey test with 95% confidence level, with the aid of the Sisvar version 5.6 statistical program (Ferreira, 2014).

RESULTS AND DISCUSSION

Bean seeds from São Mateus (PR) presented the highest average values for the variables GER and IVG at the three temperatures tested (Table 1). These results may indicate a phenotypic plasticity of the cultivar. This plasticity occurs due to small differences in selection pressure caused by cultivar cultivation in environments with different agroclimatic characteristics, which may result in ecotypes with local adaptation. However, these results may also indicate differences in the physiological quality of different seed lots. In general, faster germination and seedling uniformity are the result of higher seed physiological quality (Minuzzi et al., 2010). The physiological quality of seeds is one of the characteristics that directly influence bean seed germination (Zucareli et al., 2015).

Table 01- Germination mean and standard error (GER), First Germination Count (PCG) and Germination Speed Index (IVG) of three bean seed lots with different provenances under different temperatures.

	Origin	Temperature °C		
		20	**25**	**30**
GER (%)	São Mateus	93.5 ± 1.08 Aa	93.7 ± 1.84 Aa	95.5 ± 1.18 Aa
	Santa Maria	83.2 ± 1.30 Bb	89.0 ± 1.96 Aa	79.5 ± 3.28 Bb
	Pelotas	74.0 ± 3.38 Cb	79.0 ± 2.96 Ba	77.2 ± 10.64 Ba
PCG (%)	São Mateus	51.5 ± 2.62 Ab	92.5 ± 1.66 Aa	94.5 ± 1.66 Aa
	Santa Maria	48.0 ± 4.00 Ab	80.2 ± 2.28 Ba	75.0 ± 3.20 Ba
	Pelotas	34.0 ± 2.58 Bb	71.7 ± 2.96 Ca	78.0 ± 4.02 Ba
IVG	São Mateus	27.2 ± 0.44 Ab	45.0 ± 0.62 Aa	49.8 ± 0.47 Aa
	Santa Maria	22.9 ± 0.15 Bc	38.4 ± 1.09 Bb	44.0 ± 1.35 Ba
	Pelotas	20.4 ± 0.30 Bc	33.8 ± 1.23 Cb	38.8 ± 1.05 Ca

* Means followed by the same uppercase letter in the columns and lowercase letters in the rows do not differ statistically from each other by the Tukey test at 5% probability.

The temperatures of 25 and 30 ºC resulted in the highest average values for GER and PCG, while the temperature of 30 ºC resulted in the highest average values of IVG for the three seed lots (Table 1). Seeds from São Mateus (PR) presented higher germination (95.5) at 30ºC, while seeds from Santa Maria (RS) and Pelotas (RS) presented higher germination at 25ºC, with 89.0 and 79.0 of germinated seeds (%), respectively. The seeds of the lots of São Mateus (PR) and Pelotas (RS) presented higher average values for PCG at 30ºC, with 94.5 and 78.0% of germination seeds, respectively. However, seeds from São Mateus (PR) presented higher PCG at 25ºC.

The results of seed physiological quality evaluation for different bean cultivars that observed germination varying from 83.0% to 99.0% for 'cafezinho' and 'carioca (L2)' cultivars at 25ºC (Neto et al., 2014). While evaluating the effect of temperature on during germination in several bean cultivars, subjected to variations of 8°C to 45°C, it was observed that temperatures above 40°C make germination unfeasible (Machado-Neto et al., 2006). While temperature responses may be influenced by seed lot provenance, suggesting that germination response estimates should be derived for locally adapted ecotypes rather than extended to all members of a species (Machado-Neto et al., 2006).

The results obtained to IVG for the three seed lots were significantly lower at 20ºC (Table 1). Delay in germination occurs mainly at the shorter

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or longer length of Phase II (increase in water absorption rate, which will culminate in the emission of the primary root by the seed) during the seed soaking process, influenced by temperatures, whereas low temperatures reduce, while high temperatures increase germination speed (Nascimento, 2000). Low temperatures may decrease the seed's ability to absorb water, limiting the activity of various metabolic pathways, and reduce the speed of the germination process, explaining the decrease in germination of the three genotypes at a temperature of 20°C at first germination count and at IVG (Bewley & Black, 1994; Sbrussi & Zucareli, 2014).

The temperature increases from 20 to 30 ºC, influenced significantly the dry biomass accumulation in the shoots and seedlings roots (Table 2). The temperature of 30ºC resulted in the highest mean values for MSPA and MSR. For MSPA, the seed lots from Pelotas (RS) and São Mateus (PR) showed better performances at 30°C when compared to Santa Maria (RS), while for MSR no differences were observed between seed lots in biomass accumulation for this temperature. At 25°C, the seeds from Pelotas (RS) resulted in the highest accumulation of MSPA, while for MSR the seed lots from Pelotas (RS) and São Mateus (PR) presented the best performance in the accumulation of MSPA. biomass in the roots. However, at 20°C, there was no difference in MSPA and MSR accumulation for seed lots from different regions.

Table 02 - Mean and standard error of shoot dry mass (MSPA) and root dry mass (MSR) of three bean seed lots under different temperatures.

Origin		Temperature (°C)		
		20	**25**	**30**
MSPA (g)	São Mateus	0.12 ± 0.02 Ac	0.40 ± 0.01 Bb	0.54 ± 0.01 Aa
	Santa Maria	0.13 ± 0.02 Ac	0.42 ± 0.02 Bb	0.48 ± 0.00 Ba
	Pelotas	0.11 ± 0.01 Ac	0.47 ± 0.01 Ab	0.55 ± 0.02 Aa
MSR (g)	São Mateus	0.13 ± 0.01 Bb	0.15 ± 0.01 ABb	0.57 ± 0.01 Aa
	Santa Maria	0.12 ± 0.01 Bb	0.14 ± 0.06 Bb	0.55 ± 0.02 Aa
	Pelotas	0.15 ± 0.02 Ab	0.17 ± 0.04 Ab	0.59 ± 0.01 Aa

* Means followed by the same uppercase letter in the columns and lowercase letters in the rows do not differ statistically from each other by the Tukey´s test at 5% probability.

The lower accumulation of shoot biomass and root biomass at 20ºC, as well as lower values for GER, PCG and IVG, may be a result of thermal stress caused by the low temperature during the germination process. Seeds subjected to heat stress generally have a reduction in water absorption capacity, slowing down cell growth speed, and consequently reducing carbon assimilation capacity and accumulation of photoassimilates in developing plant tissues (Bewley & Black, 1994).

From the obtained results, it is confirmed the hypothesis that the germinative performance of the cultivar, with seed lots from different agroclimatic zones, is different when subjected to the same temperature conditions. These results may indicate a phenotypic plasticity due to small differences in population selection pressure caused by cultivar cultivation in environments with different agroclimatic characteristics. However, we indicate as the next steps to carry out a more careful evaluation to determine if this phenomenon is a result of local adaptation of ecotypes (populations) or a consequence of the difference in physiological and health quality of seeds for the different lots.

CONCLUSIONS

The germinative performance of the same bean cultivar, with seed lots from different agroclimatic zones, is not the same when submitted to the same temperature conditions, indicating a phenotypic plasticity acquired by the cultivar due to local adaptation of the ecotypes.

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