Australian Journal of Basic and Applied Sciences

2021 February; 15(2): pages 13-18
https://doi.org/10.22587/ajbas.2021.15.2.2

ORIGINAL PAPER AENSI PUBLICATIONS

# Quality of Barley Produced in a Low Altitude Location in Subtropical Climate Conditions

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**Received date: 12 December 2020, Accepted date: 20 February 2021**

**Cite as:** C. Mateus Freiberg., D. N. Follmann., R. M. Rossato., L. E. Lemainski., B. R. C. Pinto., M. V.R. Schlickmann., R. L. Backes., F. T. Bolzan., 2021. Quality of Barley Produced in a Low Altitude Location in Subtropical Climate Conditions. Australian Journal of Basic and Applied Sciences, 15(2): 13-18. DOI: 10.22587/ajbas.2021.15.2.2.

**ABSTRACT**

**Barley (*Hordeum vulgare* L.) is one of the main winter cereals, intended primarily for brewing. The physiological characteristics of barley seeds are fundamental for the production of quality malt. To meet the requirements of Brazilian legislation for malt manufacturing, the minimum germination power required of seeds is 95%, thus, the objective of this study was to evaluate the seed quality of barley cultivars and whether they meet the minimum quality requirements for malt production when produced in a low altitude site in a subtropical environment. The experiment field was conducted in 2019 at the Federal University of Santa Maria (UFSM), located in the municipality of Santa Maria-RS. Four barley cultivars (BRS Quaranta; BRS Korbel; BRS Cauê, and BRS Brau) were analyzed. After the harvest, the seeds were taken to the Seed Analysis Laboratory (LAS-UFSM), where the physiological quality tests of the seeds were performed. The design used was completely randomized, with four repetitions. The evaluations performed to analyze the physiological quality of the seeds were radicle length (RL), shoot length (SL), germination test (GT), first germination count (FGC), vigor from shoots (VFS), and weight of one thousand seeds (WTS). The data obtained in the experiment were submitted to variance analysis and the means were compared by the Scott-Knott test at 5% significance, with the aid of the SISVAR software. The cultivars BRS Cauê and BRS Korbel showed values of radicle length and shoot superior to the other. The cultivar BRS Korbel obtained a higher seed weight. Therefore, the cultivar BRS Brau showed higher germination and vigor, obtaining a value higher than the minimum germination power required for malt manufacturing, indicating that with the proper management and positioning of cultivars it is possible to produce barley grains that meet the requirements for malt production in a low-lying site in southern.**

**Keywords: *Hordeum vulgare* L.; Germination power; Malt production; Vigor.**

## INTRODUCTION

Barley is one of the leading winter cereals and the fifth most produced grain in the world (Penckowski and Borsato, 2016). The production of national barley in 2020 was 364.8 thousand tons and is concentrated in the southern region due to climatic


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conditions (Conab, 2020). Barley is grown on a commercial scale exclusively for the manufacture of malt, the main raw material of the brewing industry (Ferreira, 2015).

In the processing of barley for malt manufacturing, the minimum germination power required of seeds is 95%, as established by ordinance 691/1996 (Brasil, 1996). For seed germination to occur, it is subjected to favorable conditions of the controlled temperature, humidity, and aeration (Venturini Filho, 2018). According to Carvalho and Nakagawa (2000), germination is the phenomenon by which, under appropriate conditions, the embryonic axis continues its development, which had been interrupted at physiological maturity. Thus, germination power is characterized as the most important aspect to be observed in beer barley, because grains without germination power cannot be used in malt production (Silva, 2007).

Another factor that affects plant establishment is vigor, defined as the sum of attributes that gives the seed the potential to germinate, emerge, and quickly result in normal seedlings (Krzyzanowski and França-Neto, 2001). Seeds with low vigor suffer reduced viability when they are subjected to conditions of high temperature and humidity (Bressan, 2018). Therefore, vigor is directly associated with the physiological quality of seeds, becoming a relevant characteristic to be observed in beer barley.

The physiological potential of seeds is based on genotype, with cultivars producing better quality seeds within the same species (Bazzo et al., 2018), a fact that conditions the development of research for the evaluation and regional recommendation of barley cultivars. In addition to genetic differences between cultivars, the cultivation environment also promotes a difference in the physiological quality of barley seeds (Jaques, 2018). Climate, genetics and management are determining factors for the production of barley with a quality standard for malting, particularly in relation to the germination power, size, protein content and grain health (Minella, 2019). The choice of more competitive cultivar in the region of intention to cultivate is a decisive factor for the success of the enterprise (Souza, 2019).

The physiological characteristics of barley seeds are fundamental for malt production and quality seed production. In this sense, the objective of this article was to evaluate the physiological quality of the seeds of barley cultivars produced in a low-altitude site in a subtropical environment.

## MATERIALS AND METHODS

To determine the physiological quality of the seeds, seeds from the field experiment were used, conducted in 2019 at the Federal University of Santa Maria (UFSM), located in the municipality of Santa Maria- RS (latitude 29º71'S, longitude 53º70'W and 90 m altitude). The predominant climate in the region is of the humid subtropical Cfa type, according to the Köppen classification (Alvares et al., 2013).

The soil is classified as Arênico Dystrophic Red Argisol (Santos et al., 2018). The chemical and physical analysis of the soil presented the following contents: clay = 18%, organic matter = 1.9%, pH = 4.8, P (Melich) = 22.6 mg $dm^{-3}$, K = 0.184 cmol $cdm^{-3}$, H+Al = 4.4 cmol $cdm^{-3}$, $Ca^{+2}$ = 2.1 cmol $cdm^{-3}$ and $Mg^{+2}$ = 0.7 cmol $cdm^{-3}$. Four barley cultivars BRS Quaranta, BRS Korbel, BRS Cauê and T4 - BRS Brau were analyzed, representing an important portion of the barley cultivars available in the Brazilian market.

The experiment was sown in the field on June 5, 2019, with a density of 300 plants/ $m^2$. The basic NPK fertilization was 300 kg $ha^{-1}$ of the commercial formula 5-20-20. The nitrogen fertilization in coverage was divided into two applications with equal amounts, in the tapering and stretching stages, totaling 81 kg of N $ha^{-1}$.

The applications of herbicides, insecticides, and fungicides were carried out based on the level of incidence and doses according to the recommendation of the products applied. Among the diseases, the incidence of powdery mildew (*Blumeria graminis* f. Sp. Hordei) stands out, in which a greater number of fungicide applications was required for control. The rainfall and temperature data were obtained by the National Institute of Meteorology (INMET), registered at the location of the automatic surface weather station in Santa Maria-RS.

The harvest was carried out on October 23, 2019, 4 $m^2$ of useful area of each experimental unit was evaluated, which were subjected to screening, cleaning (removal of impurities), and drying of the samples, which later remained stored with the moisture of 13%. The repetitions of the experimental units in the field for each cultivar were mixed and homogenized to constitute four samples (one from each cultivar) to be subjected to seed quality analysis.

In the analysis of seed quality, the experimental design used was completely randomized (DIC). The Germination Test (GT) was set up on December 16, 2019. To overcome dormancy in barley seeds, the papers (substrate) were moistened using a 0.5% solution of Gibberellic Acid ($GA_3$) (500mg $GA_3$ / liter), in the amount of 2.5 times the weight of the paper. Four replications of 100 seeds of each cultivar (working sample) were performed. Then the samples remained in a germination chamber type B.O.D at a controlled temperature of 15 ° C.

Seed quality assessments were performed at the Seed Analysis Laboratory (LAS-UFSM), which are: radicle length (RL), shoot length (SL), germination test (GT), first germination count (FGC), the vigor of the aerial part (VAP) and the weight of a

thousand seeds (WTS). TG, FGC, and WTS were conducted according to the Rules for Seed Analysis-RAS (Brasil, 2009). GT was performed on the seventh day, is considered normal and abnormal plants. The FGC was performed on the fourth day of GT, considering the seedlings that have already started germination and emitted essential (normal) structures. For the SVG, the number of seedlings with shoots greater than 2 centimeters in length was counted. For RL and SL, with the aid of a millimeter ruler, 10 normal seedlings were measured by repetition on the fourth day of the test, from its insertion in the pericarp to its apex. The WTS was obtained by weighing eight repetitions of 100 seeds on a precision scale, expressed in grams.

The data obtained in the experiment were subjected to analysis of variance and the means compared by the Scott-Knott test at 5% significance, with the aid of the SISVAR Version 5.7 software (Ferreira, 2019).

## RESULTS

The results obtained from the analysis of variance demonstrated significant differences for the thermal time and calendar days in all development stages at 5% error probability (Table 1). The experimental precision represented by the coefficient of variation, indicated high reliability and precision of the observed data. In the analysis of variance of the characters presented, the radicle length (RC) did not show a significant effect at 5% probability by the Scott-Knott test. For the other characters, there was an effect of cultivars (Table 1).

**Table 1.** Analysis of variance and significance of the mean square of the sources of variation of five characters in seeds of four barley cultivars.

| Variation source | RL | SL | GT | FGC | SVG | WTS |
|---|---|---|---|---|---|---|
| Cultivate (GL= 3) | $0.38^{ns}$ | 0.58* | 30.75* | 69.50* | 545.22* | 14.34* |
| Error (GL = 9) | 0.16 | 0.05 | 3.45 | 6.62 | 52.97 | 1.32 |
| Average | 3.70 | 3.53 | 92.37 | 89.00 | 56.68 | 37.74 |
| CV (%) | 10.96 | 6.41 | 2.01 | 2.89 | 12.84 | 3.05 |

RL: radicle length, SL: shoot length, GT: germination test, FGC: first germination count, SVG: shoot vigor greater than 2 centimeters, WTS: weight of a thousand seeds. *: Significant effect by the F test at a 5% level of significance. ns: Not significant.

The average radicle length (RL) of the cultivars analyzed was 3.7 cm (Table 2). Analyzing this same character, Bazzo (2018) found higher values for the cultivars BRS Brau and BRS Cauê, with measurements taken on the fifth day in a germinator. For Tavares et al. (2015) the radicle length reached 5.2 cm for the cultivar BRS Cauê, higher than that found by Bressan (2018), of 4.38 cm for this same cultivar, analyzed with the harvest carried out at 107 days after sowing.

**Table 2.** Test of averages of physiological quality characters among barley cultivars in 2019.

| Grow crops | RL (cm) | SL (cm) | GT (%) | FGC (%) | SVG (%) | WTS (g) |
|---|---|---|---|---|---|---|
| BRS Quaranta | 3.94 a | 3.71 a | 92.50 b | 89.00 b | 71.25 a | 37.26 b |
| BRS Korbel | 3.30 a | 3.34 b | 90.25 b | 85.00 b | 47.50 b | 40.54 a |
| BRS Cauê | 3.96 a | 3.96 a | 90.50 b | 87.25 b | 61.00 a | 36.45 b |
| BRS Brau | 3.62 a | 3.10 b | 96.25 a | 94.75 a | 47.00 b | 36.71 b |

RL: radicle length, SL: shoot length, GT: germination test, FGC: first germination count, SVG: shoot vigor greater than 2 centimeters, WTS: the weight of a thousand seeds. Means not followed by the same letter in the column differ by the Scott-Knott test, at 5% significance.

The cultivars BRS Cauê and BRS Quaranta presented higher SL values concerning the cultivars BRS Korbel and BRS Brau, indicating a difference in vigor of the aerial part between the cultivars tested. Authors such as Tavares et al. (2015), found a length of 3.3 cm using the BRS Cauê cultivar. Bressan (2018) obtained 4.05 cm in length to cultivate BRS Cauê. The SVG maintained a similar response to the SL, with emphasis on the cultivars BRS Quaranta (71.25%) and BRS Cauê (61.00%).

The germination of all cultivars, in general, was greater than the minimum requirement of 85% set for commercialization of seeds (Brasil, 2013), ranging from 96.25% for the cultivar BRS Brau to 90.25% for cultivar BRS Korbel. The cultivar BRS Brau showed germination power significantly higher than the others, reaching the minimum requirement of 95% for the malting process. For this same cultivar, Tavares (2015) and Souza et al. (2019) found very similar values, 96.6 and 95%, respectively. For Borowski (2012), the BRS Cauê cultivar obtained 88% germination, a value close to this study (90.50%). For Ferreira (2015) the minimum values of germinative power were greater than 95% for this cultivar. The results found in the study are consistent with those by other authors and highlight the physiological potential of the seeds of the tested cultivars. However, the difference between the

cultivar BRS Brau and the others may be related to the greater resistance to losses caused by climatic factors. There is high rainfall at the end of the cycle, starting on October 2, 2019 (Figure 1).

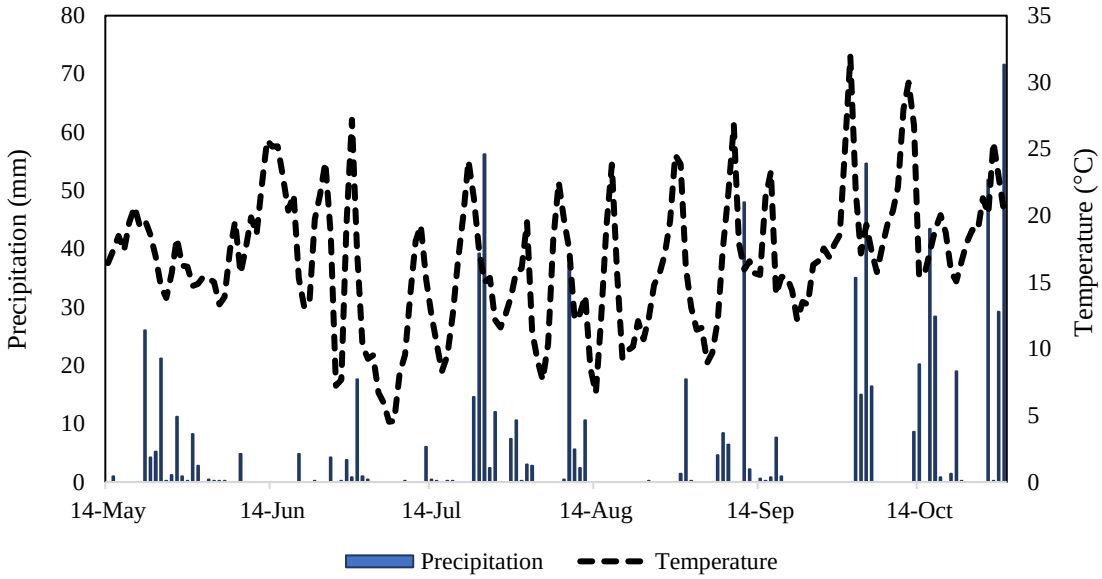


**Figure 1.** Temperature and rainfall during the growing period of barley cultivars in the municipality of Santa Maria-RS (INMET, 2020).

The FGC obtained a similar response to germination, where the cultivar BRS Brau showed a value significantly higher than the other cultivars, with germination power of 94.75%, 9.75% higher than cultivar BRS Korbel, which also presented the lowest value for germination. Jaques (2018), testing different doses of nitrogen for crop, in the municipalities of Alegrete and Pelotas-RS, found values of 95 and 91% for the cultivar BRS Cauê, 89 and 88% for cultivar BRS Brau, respectively. Tunes et al. (2008), with the harvest at 140 days after sowing, found values of 87 and 92% for cultivars MN 721 and Scarlett, in that order. Tavares (2015) and Bressan (2018) using the BRS Cauê cultivar obtained 80% and 87% germination, respectively.

For the weight of a thousand seeds, the cultivar BRS Korbel was superior to the others, obtaining 40.54 g. The cultivars BRS Quaranta, BRS Cauê, and BRS Brau did not differ among themselves, presenting values between 36.45 to 37.26 g. Results consistent with those of Sanches et al. (2015), comparing cultivars on different irrigation depths, which ranged from 37.9 to 44.0 g. For Borowski (2012), the values varied between 42.1 and 45.9 g, including the cultivar BRS Cauê, which presented 44.2 g. For Souza et al. (2019), the values were higher than 50 g, in which the cultivar BRS Brau obtained 55.6 g in the municipality of Domingos Martins-ES.

## DISCUSSION

The assessment of physiological quality is a fundamental factor in the production of seeds, as well as in making decisions as to their purpose (Jacques, 2018). The length analysis is essential to interpret the vigor between seedlings, as these differences are most often quite visible, but there is a need for numerical values to separate the more vigorous ones (Oliveira et al., 2009). On the other hand, cultivars with higher VPA values present a higher germination speed, reaching a size larger than the others, and may be directly related to more vigorous seeds.

The germination percentages are influenced by climatic conditions, frequent rains combined with high temperatures result in rapid losses of viability, and vigor of the seeds in the crops (Delouche, 1980). For Silva (2007), the physiological quality of seeds of barley cultivars tends to decrease when subjected to high temperature and humidity stress. According to Borowiski (2012), due to low dormancy, lower values of germination can be found due to the occurrence of precipitation during the physiological maturation period, which can generate pre-germinated grains, which have already started the germination process and cannot be most used for malt production.

Combined with these losses, the delay in harvesting due to high grain moisture, carried out 140 days after sowing, potentiated the loss of quality, reducing the viability of the seeds due to the consumption of nutritional reserves in the pre-harvest phase (Tunes et al., 2010), also decreasing the seed vigor (Silva, 2007), in the winter period at the beginning of the crop development, during the vegetative stages, there were many days with high cloudiness, decreasing the present solar radiation, characteristic typical winter for this low altitude region in the central region of the state of Rio Grande do Sul.

In this sense, Tunes et al., (2008) and Bressan (2018) analyzing different harvest times concluded that the delay in harvesting contributed to the depreciation of the grain, in addition to increasing the deterioration of barley in the field. For the present study, it is highlighted that the cultivation cycle was very close for the 4 cultivars and the most likely factor that contributed

to greater or lesser twinning was the genetics of the cultivars, that is, the cultivar BRS Brau had a positive interaction with the cultivation environment in a low altitude location in a subtropical climate.

Cultivars with higher FGC values showed accelerated seedling development and, consequently, were considered more vigorous. In the same way as in GT, in FGC, according to Oliveira et al. (2009), seed lots that have a higher percentage of strong normal seedlings will be considered more vigorous and, consequently, better physiological quality and characteristics of industrial interest.

In the analysis of the WTS, lower values than those found by the other authors may be related to the influence of climatic factors during the development of the culture, as Costa et al. (2013) concluded that the mass of a thousand grains is a measure that has strong genetic control, but is also affected by the conditions of temperature and humidity during the maturation phase in the field. The WTS is a physical parameter that allows a subjective assessment of the quality of the grain, thus, it is expected that cultivars with high WTS and good classification have a higher yield and contain high levels of starch (Lizarazo, 2003). For Kobata (2019), the character weight of a thousand grains had a positive relationship with grain yield in a greater number of locations and years, demonstrating to be a character of greater stability.

## CONCLUSION

The cultivars BRS Cauê and BRS Korbel showed higher seedling growth in the radicle and shoots, in addition to the cultivar BRS Korbel obtaining higher seed weight. The cultivar BRS Brau showed higher germination in the germination pattern and the first germination count, obtaining germination power higher than the minimum required by Brazilian legislation for malt manufacturing. Therefore, it is concluded that with the management and proper positioning of cultivars it is possible to produce barley grains that meet the requirements for malt production in a low-lying site in southern Brazil in a subtropical environment.

## ACKNOWLEDGEMENTS

To the Federal University of Santa Maria-UFSM and the Research Group on Ecophysiology and Management of Annual Crops-GEMCA for the support of materials, structure, and area to experiment. To the National Council for Scientific and Technological Development-CNPq, to the Institutional Scientific Initiation Scholarship Program (PIBIC), Institutional Program for Scientific Initiation Scholarships - FAPERGS (PROBIC), the Junior Research Fund Incentive (FIPE Jr) for the scholarships awarded, and to scholarship students and volunteers for their assistance in data collection.

## REFERENCES

Alvares, CA., JL. Stape, PC. Sentelhas, MJL. Gonçalves e G. Sparovek, 2013. Köppen's climate classification map for Brazil. Meteorologische Zeitschrift, v.22, p.711-728.

Bazzo, JHB., T. Barbizan, CP. Cardoso e C. Zucareli, 2018. Qualidade fisiológica de sementes de cultivares de cevada produzidas no norte do Paraná. Journal of Agronomic Sciences, v.7, n.2, p. 21-30.

Borowski, DZ., 2012. Efeito do genótipo, ambiente e suas interações em características agronômicas e de qualidade em cevada cervejeira no sul do Brasil. Dissertação (Mestrado em Agronomia) - Universidade de Passo Fundo, Passo Fundo.

Brasil, 1996. Ministério da Agricultura, Pecuária e Abastecimento. Secretaria Nacional de Defesa Agropecuária. Portaria nº 691, de 22 de novembro de 1996. Aprova a Norma de Identidade e Qualidade da Cevada, para comercialização interna. Brasília: MAPA. Obtido de http://www.codapar.pr.gov.br/arquivos/File/pdf/cevadaindus691_96.pdf em 20 de maio de 2020.

Brasil, 2009. Ministério da Agricultura, Pecuária e Abastecimento. Secretaria Nacional de Defesa Agropecuária. Regras para Análise de Sementes. Brasília: Mapa/ACS.

Brasil, 2013. Ministério da Agricultura, Pecuária e Abastecimento. Secretaria Nacional de Defesa Agropecuária. Instrução Normativa nº 45, de 17 de Setembro de 2013. Brasília: MAPA. Obtido de https://www.gov.br/agricultura/pt-br/assuntos/insumos-agropecuarios/insumos-agricolas/sementes-e-mudas/publicacoes-sementes-e-mudas/copy_of_INN45de17desetembrode2013.pdf em 20 de maio de 2020.

Bressan, PT., 2018. Qualidade das sementes de cevada em função da maturidade fisiológica: parâmetro fisiológico e expressão gênica diferencial de enzimas associadas à germinação. Dissertação (Mestrado em Agronomia) – Universidade Estadual de Ponta Grossa, Ponta Grossa

Carvalho, NM. e J. Nakagawa, 2000. Sementes: ciência e tecnologia da produção. Jaboticabal: FUNEP.

Companhia Nacional de Abastecimento – Conab, 2020. Acompanhamento da safra brasileira: grãos. Terceiro levantamento, dezembro 2020, v. 8, n. 3.

Costa, L., C. Zucareli e CR. Riede, 2013. Parcelamento da adubação nitrogenada no desempenho produtivo de genótipos de trigo. Revista Ciência Agronômica, v. 44, n. 2, p. 215-224.

Delouche, JC, 1980. Environmental effects on seed development and seed quality. Hortsc Science. v.15, p. 175-780. Obtido de: https://ir.library.msstate.edu/bitstream/handle/11668/13411/C-7.pdf?sequence=1&isAllowed=y em: 15 maio de 2020.

Ferreira, C., 2015. Cultivares de cevada semeadas em espaçamentos simples e pareado combinados com doses de adubo e densidades de semeadura. Tese (Doutorado em Agronomia), Universidade Estadual de Ponta Grossa, Ponta Grossa.

Ferreira, DF., 2019. Sisvar: a computer analysis system to fixed effects split plot type designs. Revista brasileira de biometria, v. 37, n. 4, p. 529-535, dec.

INMET - Instituto Nacional de Meteorologia. Estação Meteorológica de Observação de Superfície Automática, Brasília, DF, Brasil. Obtido de http://www.inmet.gov.br/portal/index.php?r=estacoes/mapaEstacoes em 29 julho de 2020.

Jaques, LBA., 2018. Produtividade e qualidade fisiológica de sementes de cevada em função da adubação nitrogenada. Dissertação (Mestrado em Ciências) – Universidade Federal de Pelotas, Pelotas.

Kobata, S., G. Kazue, 2019. Adaptabilidade e estabilidade de genótipos de cevada e relações de causa e efeito com o rendimento de grãos. Dissertação (Mestrado em Desenvolvimento Regional) - Universidade Tecnológica Federal do Paraná, Pato Branco.

Krzyzanowski, FC. e JB. França-Neto, 2001. Vigor de sementes. Informativo ABRATES, Londrina, v. 11, n. 3, p. 81-84, dez.

Lizarazo, DXC., 2003. Parâmetros físico-químicos, germinativos e microestruturais de qualidade em cultivares brasileiros de cevada cervejeira. Dissertação (Mestrado em Ciências) – Universidade Federal de Santa Catarina, Florianópolis.

Oliveira, ACS., GN. Martins, RF. Silva e HD. Vieira, 2009. Testes de vigor em sementes baseados no desempenho de plântulas. Revista Cientifica Internacional. Science- Inter Place. v.1, n.4, p. 1- 21.

Penckowski, LH. e EF. Borsato, 2016. Utilizando regulador de crescimento em cereais de inverno. Castro: Fundação ABC.

Minella, E. 2019. Reunião Nacional de Pesquisa de Cevada.. Indicações técnicas para a produção de cevada cervejeira nas safras 2019 e 2020 / XXXII Reunião Nacional de Pesquisa de Cevada, Passo Fundo, RS, 16 a 17 de abril de 2019; Passo Fundo: Embrapa Trigo.

Sanches, FM., FF. da Cunha, OF. dos Santos, EJ. de Souza, AJF. Leal e GF. Theodor, 2015. Desempênho agronômico de cultivares de cevada cervejeira sob diferentes lâminas de irrigação. Semina: Ciências Agrarias, v. 36, n. 1, p. 89-102.

Santos, HG., PKT. Jacomine, LHC. dos Anjos, VA. de Oliveira, JF. Lumbreras, MR. Coelho, JA. De Almeida, JC. de Araujo Filho, JB. de Oliveira e TJF. Cunha, 2018. Sistema brasileiro de classificação de solos. Brasília: Embrapa Solos.

Silva, AF., 2007. Qualidade fisiológica de sementes de cevada influenciadas pela época de colheita. Dissertação (Mestrado) – Programa de Pós-Graduação em Ciência e Tecnologia de Sementes. Universidade Federal de Pelotas, Pelotas, RS.

Souza, JL., E. Minella, RC. Guarçoni, LF. Favarato e CS. Teixeira, 2019. Desempenho agronômico e qualitativo de cultivares de cevada cervejeira no estado do Espírito Santo. Revista Brasileira de Agropecuária Sustentável, v.9, n.2, p.44-51.

Tavares, LC., AP. Brunes, CA. Rufino, DÂR. Fonseca, GI. Gadotti e FA. Villela, 2015. Tratamento de sementes de cevada com zinco: potencial fisiológico e produtividade de sementes. Semina: Ciências Agrárias, v. 36, n. 2, p. 585-593.

Tunes, LM., ACSA. Barros, PG. Badinelli e DC. Garcia, 2010. Diferentes épocas de colheita e qualidade fisiológica de sementes de cevada. Revista brasileira de sementes. v.32, n.2, p.042-048.

Tunes, LM., ACSA. Barros, PG. Badinelli e F. Olivo, 2008. Testes de vigor em função de diferentes épocas de colheita de sementes de cevada (*Hordeum vulgare* L.). Revista Brasileira de Ciências Agrárias, v.3, n.4, p.321-326.

Venturini Filho, WG., 2018. Bebidas alcoólicas: ciência e tecnologia. São Paulo: Blucher.