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# Physiological quality of wheat seeds produced in different municipalities in the north of the State of Paraná

## *Qualidade fisiológica de sementes de trigo produzidas em diferentes municípios do norte do estado do Paraná*

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**RESUMO**

Dado a importância da triticultura para a agricultura brasileira, o estudo teve como objetivo avaliar a qualidade fisiológica de sementes de trigo produzidas em diferentes municípios do norte do estado do Paraná. O experimento foi conduzido no Laboratório de Sementes da Universidade Estadual de Londrina (UEL). O ensaio consistiu na análise da qualidade fisiológica de sementes de trigo cv. CD 116, produzidas em quatro municípios do estado do Paraná (Rolândia, Cambé, Marilândia do Sul e Ibiporã), na safra 2011, amostradas, ao acaso, em diferentes cooperativas e empresas produtoras de sementes. O experimento foi conduzido em delineamento inteiramente casualizado e a qualidade fisiológica dos lotes de sementes de trigo foi avaliada a partir das variáveis: primeira contagem de germinação e germinação (teste de germinação); viabilidade (teste de tetrazólio); vigor (testes de envelhecimento acelerado e frio); vigor, índice de velocidade de emergência e tempo médio de emergência (teste de emergência de plântulas em areia); comprimento de parte aérea e de plântula, e massa seca de parte aérea e de plântula (teste de comprimento de plântulas). Os dados foram submetidos à análise de variância e as médias comparadas pelo Teste de Tukey ($p < 0,05$). Houve influência do município onde as sementes foram produzidas na qualidade fisiológica de sementes de trigo. No presente experimento, os campos de produção localizados em Rolândia e em Cambé contribuíram para lotes com maior germinação e vigor. Sendo assim, o local de cultivo é um fator que deve ser levado em consideração durante o planejamento da lavoura. O teste de tetrazólio, assim como as variáveis tempo médio de emergência, comprimento de plântula e massa seca de parte aérea, não foram eficientes na separação dos lotes quanto à qualidade fisiológica.

**PALAVRAS-CHAVE:** *Triticum aestivum; local de cultivo; germinação; viabilidade; vigor.*

**ABSTRACT**

Due to the importance of triticulture for Brazilian agriculture, the study aimed to evaluate the physiological quality of wheat seeds produced in different municipalities in the north of the State of Paraná. The experiment was conducted at the Seed Laboratory of the State University of Londrina (UEL). The assay consisted of analyzing the physiological quality of wheat seeds cv. CD 116, produced in four municipalities in the state of Paraná (Rolândia, Cambé, Marilândia do Sul, and Ibiporã), in the 2011 cropping season, sampled at random in different cooperatives and seed-producing companies. The experiment was conducted in a completely randomized design and the physiological quality of the wheat seed batches was evaluated from the variables: first germination count and germination (germination test); viability (tetrazolium test); vigor (accelerated aging and cold tests); vigor, emergence speed index, and mean emergence time (seedling emergence test in the sand); shoot and seedling length, and shoot and seedling dry mass (seedling length test). The data were subjected to variance analysis and the means were compared using the Tukey test ($p < 0.05$). The municipality where the seeds were produced influenced the physiological quality of wheat seeds. In the present experiment, the production fields located in Rolândia and Cambé contributed to batches with greater germination and vigor. Therefore, the production environment is a factor that must be taken into consideration when planning the crop. The tetrazolium test, as well as the variables, mean emergence time, seedling length, and shoot dry mass, were not efficient in separating the batches according to physiological quality.

**KEYWORDS:** *Triticum aestivum; production environment; germination; viability; vigor.*

## INTRODUCTION

Wheat (*Triticum aestivum* L.) is a grass belonging to the Poaceae family and is grown worldwide. Worldwide, it is the second-largest cereal crop, accounting for 30% of world grain production, surpassed only by wheat. Brazil is currently the fourteenth largest wheat producer in the world, with an estimated 10.3 million tons of wheat in the 2023/24 harvest (CONAB 2023).

The country is among the top ten importers of grain, but this position could change in the coming years, given that Brazilian production has grown by 76% over the past five years. The results for 2022 show Brazil's largest wheat harvest in history, reaching 9.5 million tons of grain (EMBRAPA 2022). The largest producing state is Rio Grande do Sul, followed by Paraná, which produced 4,764.2 and 4,270.9 tons, respectively, in the 2023 harvest. This represents a 16.9% reduction for Rio Grande do Sul and a 22.0% increase for Paraná compared to the 2022 harvest (CONAB 2023).

Due to the importance of wheat cultivation for Brazilian agriculture, the use of quality seeds is essential, as they are the agricultural input that carries the desired characteristics for efficient crop management, resulting in higher productivity. Seed vigor is known to be influenced by environmental and nutritional factors. Therefore, the use of seeds with high physiological quality combined with appropriate cultural practices favors obtaining uniform stands (BIGOLIN et al. 2022).

Seed quality is defined as the set of genetic (genetically pure seed without varietal mixture), physical (pure seed free of contaminants and inert material), physiological (seed with high vigor and germination, guaranteeing good performance in the field), and health (pathogen-free seed) attributes (PELISSARI & COIMBRA 2023). According to ZUFFO et al. (2023), it is essential to use seeds with high physiological and sanitary quality in order to ensure maximum seedling vigor. However, all these characteristics culminate in the seed's performance in the field, ensuring a quality stand with high levels of production (PELISSARI & COIMBRA 2023).

Because seed is one of the main agricultural inputs, as it brings characteristics to the field that will determine management, and given the influence of the environment on the physiological component of seeds, farmers and professionals in the field must pay attention to factors capable of influencing seed quality in the production field. Linked to abiotic and biotic stresses, these factors can contribute to poor seed formation, especially during physiological maturation. Therefore, the region where the seeds are produced is a determining factor, as both temperature and humidity during production can affect the physiological quality of the batches (NUNES et al. 2023).

Weather variations are among the main factors influencing agricultural efficiency and can affect crop yields by impacting the quantity and quality of the final product. For this reason, it is important to monitor climatic conditions during all stages of crop development (VARGAS et al. 2023).

NUNES et al. (2023) reported that periods of high temperature associated with a lack of rainfall, known as veranicos, have caused significant damage to the seed sector. The authors found that the maximum and minimum temperatures to which the production field was subjected influenced the percentage of green soybean seeds, as well as the percentage of normal seedlings (accelerated aging), processing yield, and seed vigor and viability (tetrazolium).

According to VARGAS et al. (2023), the wheat crop is highly sensitive to climatic conditions, which can cause problems during its phenological stages, directly impacting the final quality of the produced material. Excessive rainfall during the final stages of wheat development can cause indirect damage, such as the emergence of diseases favored by high rainfall, such as gibberella (*Gibberella zeae* [Schw.] Petch) and blast (*Pyricularia grisea* [Cooke] Sacc.), which develop under conditions of continuous wetness (more than 10 hours), from the beginning of grain development to the end of grain filling, facilitating the spread of these pathogens.

In terms of climate risks for wheat crops in southern Brazil, the main ones are excessive rainfall, frost, and hail, which can affect the quality and final quantity of production. Excessive rainfall can cause a decrease in the number of grains per ear, the thousand-seed weight, and crop yield (VARGAS et al. 2023).

Seed lots that do not meet the minimum germination standards (80% for wheat) are not released for sale as propagating material (MAPA, 2013). It is therefore necessary to assess the physiological quality of seed lots to verify their potential. As the germination test does not provide information on seed vigor and does not detect the intermediate events that can occur during the deterioration process, only the final stages, vigor tests are important tools as adjuncts to the germination test in seed quality research (ARAÚJO et al. 2022).

Seed companies control quality through germination and vigor tests, which are used to assess the physiological quality of seeds (ARAÚJO et al. 2022). However, it is unlikely that a single vigor test can be appropriate, suggesting that the results of several tests should be used together to assess the vigor of seed lots.

Therefore, prior knowledge of the factors capable of influencing the physiological quality of seed lots is crucial for making informed decisions, especially when choosing a production area. For this reason, the aim of the study was to evaluate the physiological quality of wheat seeds produced in different municipalities in northern Paraná state.

## MATERIAL AND METHODS

The experiment was conducted at the Seed Laboratory of the State University of Londrina (UEL). The assay consisted of analyzing the physiological quality of wheat seeds cv. CD 116, produced in four municipalities in the state of Paraná (Rolândia, Cambé, Marilândia do Sul and Ibiporã), in the 2011 crop season, randomly sampled from different cooperatives and seed producing companies. As the aim of the study was to evaluate the influence of the wheat production site on the physiological quality of the seeds, the cultivar and harvest were considered independent factors.

The selection of seed lots considered the hectoliter weight (HW), which was measured upon receipt of the seeds. All the batches used in this study had a hectolitre weight ≥ 78 kg $hL^{-1}$, given that this value refers to the standard hectolitre weight used in marketing (NUNES et al. 2011).

All the seeds used were obtained from production fields located in municipalities in the north of Paraná, with geographical coordinates and altitudes as follows: Rolândia (23º16' S, 51º19' W, 750 m), Cambé (23º16' S, 51º17' W, 670 m), Marilândia do Sul (23º44' S, 51º18' W, 758 m) and Ibiporã (24º19' S, 49º08' W, 497 m). The municipalities served as the treatments in the study. Rainfall data during the wheat harvest, from April to August 2011, were provided by companies in the region, as shown in Table 1.

Table 1. Monthly, total and average rainfall (mm) during wheat production (April-August), 2011 harvest, in municipalities in the north of the state of Paraná.

*Table 1. Monthly, total, and average precipitation (mm) during wheat production (April-August) in the 2011 cropping season for municipalities in northern Paraná State.*

| Precipitation | Rolândia[1] | Cambé[2] | Marilândia do Sul[3] | Ibiporã[4] |
|---|---|---|---|---|
| April | 127.0 | 110.9 | 105.0 | 111.5 |
| May | 10.0 | 4.1 | 18.0 | 4.9 |
| June | 101.0 | 66.4 | 162.0 | 88.6 |
| July | 93.0 | 83.6 | 180.0 | 84.4 |
| August | 72.0 | 46.5 | 92.0 | 45.8 |
| Average | 80.6 | 62.3 | 111.4 | 67.0 |
| Total | 403.0 | 311.5 | 557.0 | 335.2 |

Data provided by: [1] COROL, [2] EMBRAPA, [3] SEMENTES MAUÁ and [4] IAPAR.

The experiment was conducted using a completely randomized design, and the physiological quality of the wheat seed lots was assessed using the following tests:

**Germination test**

Four subsamples of 100 seeds each were used for each treatment. The seeds were placed between two sheets of Germitest paper, moistened with distilled water at a rate of two and a half times the dry mass of the substrate. The experimental units were placed in a germinator at 20°C, and evaluations were conducted after four days (first germination count) and eight days (final germination count) following test setup. The results were expressed as a percentage of normal seedlings (BRASIL, 2009).

**Tetrazolium test**

Two replicates of 50 seeds from each batch were wrapped in three sheets of Germitest paper, moistened with distilled water at a rate of two and a half times their dry mass, and incubated in a germinator at 20 °C for 12 hours. Then, using a scalpel, the researcher sectioned the seeds longitudinally along the embryo and ¾ of the endosperm and placed them in 50 mL plastic cups, where a 0.1% solution of tetrazolium (2,3,5 triphenyl tetrazolium chloride) was added. The experimental units were then placed in an incubator set at 40 °C for 1.5 hours. The seeds were then rinsed under running water and kept submerged until they were individually evaluated. When the tissues were crimson red, they were considered alive and vigorous, classifying them as viable seeds; when they were pale pink or milky white, the tissues were considered deteriorating or dead, respectively, characterizing them as non-viable seeds (BRASIL 2009). The results were expressed as a percentage of viable seeds.

**Accelerated aging test**

Four subsamples of 50 seeds each were used for each treatment. The seeds were distributed in a single layer over a wire mesh fixed inside polystyrene boxes (Gerbox®). 40 mL of distilled water was added to the bottom of each box. They were covered, thus achieving approximately 100% RH inside, and then kept in a germinator at 42 °C for 60 hours (MARCOS FILHO 1999). After the aging period, the seeds were subjected to a germination test, according to the methodology described by BRASIL (2009). The evaluation was carried out four days after the test, and the results were expressed as a percentage of normal seedlings.

**Cold test**

Four subsamples of 50 seeds each were used for each treatment. The seeds were placed between three sheets of Germitest paper, moistened with distilled water at a rate of three times the dry mass of the substrate. The prepared rolls were placed in a germinator at 10 °C, where they were kept inside plastic bags sealed with crepe tape (to reduce evaporation) for seven days (BARROS et al. 1999). After this cooling period, the rolls were transferred to germinators at 20 °C for four days, after which the percentage of normal seedlings was assessed.

**Seedling emergence test in sand**

Four replicates of 50 seeds each were placed in crystal polystyrene boxes (Gerbox®) filled with sand. The substrate was moistened to 70% of its field capacity, and throughout the experiment, water was replenished as needed to maintain constant conditions. The test was evaluated daily for twelve days, until emergence stabilized, to determine the emergence speed index (ESI), calculated according to MAGUIRE (1962), and the average emergence time (EMT, in days), according to LIMA et al. (2006). Seedlings with a coleoptile equal to or greater than 2 cm were considered normal, and the results were expressed as a percentage.

**Seedling length test**

Four subsamples of 20 seeds each were used for each treatment. The seeds were placed between two sheets of Germitest paper, moistened with distilled water at a rate of two and a half times the dry mass of the substrate. The rolls from each repetition were grouped together with rubber bands, placed upright, wrapped in a plastic bag, and put inside a germinator set at a constant temperature of 20 °C. The evaluation was conducted on the eighth day. The length of the aerial part and the total length of normal seedlings were measured using a graduated ruler. The results were expressed in $mm \cdot seedling^{-1}$ (NAKAGAWA 1999). Subsequently, the dry mass of the aerial parts and roots was determined. The aerial parts and roots from each treatment were packed separately in labeled paper bags and placed in a thermoelectric oven with forced air circulation at 80 °C for 24 hours. They were then weighed on a digital balance (AW 320® Shimadzu), and the average seedling dry mass was obtained by summing the mass of each part of the normal seedlings (aerial part + root) and dividing by the number of normal seedlings in each subsample. The results were expressed in $g \cdot seedling^{-1}$ (NAKAGAWA 1999).

The data was submitted to analysis of variance and the means were compared using the Tukey test ($p < 0.05$).

## RESULTS AND DISCUSSION

Table 2 shows the seed performance results from the germination test, including first germination count and total germination, as well as the tetrazolium test. The lots produced in Rolândia, Cambé, and Marilândia do Sul showed the highest germination in the first count, differing statistically from Ibiporã. In the germination test, the quality of the seeds from Rolândia did not differ significantly from Cambé, with both showing higher averages, and Cambé in turn did not differ from Marilândia do Sul. Seeds produced in Ibiporã consistently showed inferior physiological quality, as evidenced by the germination variable.

According to MAPA (2013), the seed lots produced in Marilândia do Sul and Ibiporã, with 71% and 41% germination respectively, cannot be marketed as seed because they did not reach the minimum germination requirement of 80%. BURATTO et al. (2020), when evaluating wheat genetic materials produced in four municipalities in Paraná, also observed the influence of the cultivation location on physiological quality, noting that the material produced in one of the production fields (Irati) showed germination of less than 80%.

Table 2. First germination count (FGC - %), germination (G - %), and tetrazolium (T - %) of wheat seeds produced in different municipalities in northern Paraná state.

*Table 2. First count of germination (FCG - %), germination (G - %), and tetrazolium (T - %) of wheat seeds produced in different municipalities in the north of the State of Paraná.*

| Municipality | PCG | G | T |
|---|---|---|---|
| Rolândia | 55 a | 84 a | 69 a |

| | | | |
|---|---|---|---|
| Cambé | 55 a | 81 ab | 80 a |
| Marilândia do Sul | 58 a | 71 b | 76 a |
| Ibiporã | 32 b | 41 c | 50 a |
| CV (%) | 15.58 | 7.66 | 11.39 |

Averages followed by the same letter in the column do not differ statistically by the Tukey test at 5%.

However, the tetrazolium test did not reveal any differences in seed quality, indicating that it was not effective in distinguishing between the analyzed lots, and is considered subjective due to its reliance on visual assessment. According to SANTOS et al. (2023), the tetrazolium test is an alternative technique for assessing seed quality and viability. In addition, it can be conducted more quickly compared to the germination test, facilitating decision-making in the seed production chain (FRANÇA-NETO & KRZYZANOWSKI 2018). It is therefore necessary to use various vigor tests to characterize seed lots.

When analyzing seed vigor using the cold test, it was observed that the quality of the material from Ibiporã and Marilândia do Sul was again inferior to the others, which is consistent with the results obtained from germination. However, in the accelerated aging test, the batch from Marilândia do Sul showed no statistical difference from Rolândia and Cambé, outperforming the one from Ibiporã (Table 3).

Table 3. Cold test (F - %), accelerated ageing (AE - %), emergence of seedlings in sand (Em - %), emergence speed index (ESI) and mean emergence time (EMT - days) of wheat seeds produced in different municipalities in the north of the state of Paraná.

*Table 3. Cold test (C - %), accelerated aging (AA - %), seedling emergence in sand (Em - %), emergence speed index (ESI), and mean emergence time (EMT - days) of wheat seeds produced in different municipalities in the north of the State of Paraná.*

| Municipality | C | AA | In | ESI | EMT |
|---|---|---|---|---|---|
| Rolândia | 76 a | 54 a | 85 a | 19.85 a | 4.75 a |
| Cambé | 84 a | 52 a | 88 a | 20.74 a | 4.73 a |
| Marilândia do Sul | 54 b | 46 a | 81 a | 18.58 a | 4.61 a |
| Ibiporã | 44 b | 16 b | 44 b | 9.13 b | 5.45 a |
| CV (%) | 9.90 | 27.32 | 7.40 | 11.70 | 8.67 |

Averages followed by the same letter in the column do not differ statistically by the Tukey test at 5%.

These results were confirmed by seedling emergence performance in sand and the emergence speed index (ESI), which correlated with accelerated aging and the first germination count. However, the vigor of the seeds was not reflected in the average emergence time (EMT) variable, with no significant difference between the lots, which took approximately five days to emerge (Table 3).

According to SPONCHIADO et al. (2014), the vigor tests of first germination count, accelerated aging, seedling length, electrical conductivity, and emergence speed index were the most sensitive in separating lots into different vigor classes. This differs from the results obtained in this study, confirming the need to use as many tests as possible to assess the physiological quality of seed lots.

However, according to the seedling length test, despite the lower performance of the seeds produced in Ibiporã in most of the tests analyzed, the length of the aerial part of the seedling did not differ significantly when compared with Rolândia and Cambé, and the latter with Marilândia do Sul. However, in comparison with those from Ibiporã, Marilândia showed lower results. A possible reason for the low vigor of the material produced in Marilândia do Sul is the excess rainfall during the spike stage (Table 1), since excess relative humidity after flowering can be harmful to the crop, as it favors the occurrence of gibberella and brusone (VARGAS et al. 2023).

The same was not observed for the total seedling length and the dry mass of the aerial part, with no statistically significant difference for these variables. In terms of seedling dry mass, Rolândia did not differ from Cambé and Ibiporã, which, in turn, did not differ from Marilândia do Sul (Table 4). BURATTO et al. (2020) found that the location where wheat was grown in the state of Paraná influenced the physiological quality of the seeds, as measured by germination percentage, aerial part length, root length, and dry mass, corroborating the results observed in this study. MARINHO et al. (2021) and SOUZA et al. (2021), when evaluating wheat seeds produced in Londrina and Ponta Grossa, both municipalities in Paraná, also observed that the location of cultivation influences the productive performance of cultivars.

Table 4. Shoot length (CPT - mm.seedling$^{-1}$) and seedling length (CP - mm.seedling$^{-1}$), and shoot dry mass

(MSPA - g.seedling$^{-1}$) and seedling dry mass (MSP - g.seedling$^{-1}$) of wheat seeds produced in different municipalities in the north of the state of Paraná.

*Table 4. Shoot (CPT - mm.plântula$^{-1}$) and seedling length (CP - mm.plântula$^{-1}$), and shoot (MSPA - g.plântula$^{-1}$) and seedling dry mass (MSP - g.plântula$^{-1}$) of wheat seeds produced in different municipalities in the north of the State of Paraná.*

| Municipality | CPA | CP | MSPA | MSP |
|---|---|---|---|---|
| Rolândia | 94 ab | 272 a | 0.0018 a | 0.0031 a |
| Cambé | 89 ab | 255 a | 0.0014 a | 0.0027 ab |
| Marilândia do Sul | 79 b | 251 a | 0.0011 a | 0.0022 b |
| Ibiporã | 106 a | 273 a | 0.0013 a | 0.0027 ab |
| CV (%) | 8.90 | 5.47 | 26.62 | 15.24 |

Averages followed by the same letter in the column do not differ statistically by the Tukey test at 5%.

Since the physiological quality of seeds is associated with various attributes, it is important to test it using multiple methods of analysis, as combining these methods enables more reliable results.

## CONCLUSION

The municipality where the seeds were produced influenced the physiological quality of wheat seeds. In this experiment, the production fields located in Rolândia and Cambé contributed to batches with higher germination and vigor. Therefore, the place of cultivation is a factor that should be considered when planning the crop.

The tetrazolium test, as well as the variables average germination time, seedling length, and shoot dry mass, were not effective in differentiating the lots in terms of physiological quality.

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