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WHEAT CULTIVARS WITH AGROECOLOGICAL MANAGEMENT IN THE WEST OF PARANÁ STATE

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ABSTRACT - The agroecological wheat crop in western Paraná is an excellent option for crop rotation, contributing to the quality of the no-tillage system. In this way, the present study aimed to evaluate the agronomic characteristics, the productivity of six wheat cultivars in the agricultural year 2021 cultivated in the West of Paraná in an agroecological system. The experiment was carried out between June and September 2021. Six genotypes were used: TBIO Audaz, TBIO Toruk, BRS Belajoia, ORS Madrepérola, ORS 1403 and UTF 18. The cycle of these cultivars is early to medium. Crop management was carried out in the agroecological system. For fertilization, 8 t ha^{-1} of chicken litter and the super-lean fertilizer were used. During the maturation period, the production components and grain yield were determined. As a result, it was found that during the crop cycle there was a water deficit which compromised the development of the crop. The highest hectoliter weight was found in the cultivar BRS Belajoia (77.7). In the present work, no cultivar reached the hectoliter weight to be classified as type 1. The highest hectoliter weight was found in the cultivar BRS Belajoia (77.7); however, in the present work, no cultivar reached the hectoliter weight to be classified as type 1.
Keywords: organic wheat, winter cereals, sustainable agriculture.

CULTIVARES DE TRIGO COM MANEJO AGROECOLÓGICO NO OESTE DO PARANÁ

RESUMO - A cultura do trigo agroecológico no Oeste do Paraná é uma excelente opção para rotação de culturas, contribuindo para a qualidade do sistema de plantio direto. Desta forma o presente estudo teve por objetivo avaliar as características agronômicas e a produtividade de seis cultivares de trigo cultivadas em sistema agroecológico no ano agrícola 2021 no Oeste do Paraná. O experimento foi realizado entre os meses de junho a setembro de 2021. Foram utilizados seis genótipos: TBIO Audaz, TBIO Toruk, BRS Belajoia, ORS Madrepérola, ORS 1403 e UTF 18. O ciclo destas cultivares é de precoce a médio. O manejo da cultura foi realizado no sistema agroecológico. No período de maturação determinou-se os componentes de produção e a produtividade de grãos. Como resultado constatou-se que durante o ciclo da cultura houve déficit hídrico o que comprometeu o desenvolvimento da cultura. O maior peso hectolitro foi constatado no cultivar BRS Belajoia (77,7). No presente trabalho nenhum cultivar atingiu o peso do hectolitro para ser classificada como tipo 1. A produtividade média do trigo agroecológico no Oeste do Paraná foi 2125 kg ha^{-1} e não houve diferença significativa entre as cultivares. Durante o ciclo da cultura houve déficit hídrico o que comprometeu o desenvolvimento do trigo agroecológico. A produtividade média do trigo agroecológico no Oeste do Paraná foi 2125 kg ha^{-1} e não houve diferença significativa entre as cultivares. O maior peso hectolitro foi constatado no cultivar BRS Belajoia (77,7); entretanto, no presente trabalho nenhuma cultivar atingiu o peso do hectolitro para ser classificada como tipo 1.
Palavras-chave: trigo orgânico, cerais de inverno, agricultura sustentável.

INTRODUCTION

Wheat is the main winter crop grown in Southern Brazil. However, the state of Paraná, in regions that have favorable climatic conditions for this crop, has been losing ground to corn grown in autumn/winter, called second-crop corn or "safrinha". The "safrinha" corn is grown after soybean cultivation mainly in the states of Goiás, Mato Grosso, Mato Grosso do Sul and Paraná. This cultivation system accounts for 74% of the national corn production and in Paraná it represented 16.4% of the total cultivated area in the country (CONAB, 2022).

Recently, with less crop rotation, there have been significant corn production losses due to the incidence of diseases transmitted by the corn leafhopper (*Dalbulus maidis*), which can cause a loss of 70% of production (COTA et al., 2021). As an alternative to the cultivation of second crop corn, wheat has great potential for expansion, both in traditional producing regions and in the areas of the Central-West region.

Wheat is a relevant product in Brazil's basic food basket. However, the country cannot meet its domestic demand for consumption. In 2021, it produced 6.43 million

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tons, with the southern region accounting for 5.6 million tons; that is, 87.5% of the total production. The expected national consumption of wheat was 11.6 million tons per year. Therefore, we have an annual deficit of 5.17 million tons (CONAB, 2022).

Brazil needs to import wheat to meet domestic demand, and most of its imports come from Argentina. In order to increase the national production of wheat, to ensure profitability to producers, a public policy that favors rural credit, rural insurance and guarantees minimum prices should be implemented (SOUZA; VIEIRA FILHO, 2021).

In addition to the economic and social aspects, wheat cultivation has an impact on soil conservation, and its cultivation gains greater importance in the no-tillage system (NTS). In the NTS, crop rotation should include species that favor straw mulch yield. The production of wheat straw mulch fed to the soil can vary greatly, as it depends on the soil, climatic conditions and the genetic material used.

This variation in dry matter production is shown in a review of some studies. In a study carried out by Santos (2020), the dry matter production obtained was 4519.15 kg ha^{-1}; for Oliveira and Borszowskei (2020) it was 7,142.15 kg ha^{-1} and Wenneck et al. (2021), 6,100 kg ha^{-1}.

The dry mass produced by wheat is persistent in the soil due to its high carbon/nitrogen (C/N) ratio, which allows this biomass to decompose more slowly (PIRES, 2017). This greater persistence of straw on the surface contributes to increasing the content of organic matter in the soil, protects the soil from direct sunlight, reduces thermal amplitude, reducing the germination of weeds and promoting chemical and physical improvements in the soil.

However, the agro-climatic risks for wheat cultivation should be assessed. Due to these risks, Embrapa proposed an agricultural climate risk zoning for this crop. This zoning consists of a risk management instrument in agriculture (Decree No. 9,841/2019). It aims to inform about the climatic conditions of each region of Brazil, in order to help in decision-making about the best time to plant crops, according to the different types of soil and cycles of cultivars. The referred zoning aims to minimize climate risks in wheat production (FEDERAL, 2021).

The agricultural climate zoning quantifies the risks that may cause losses in wheat production during its development. It classifies the sowing period into three risk levels: 20%, 30% and 40% according to the cultivar maturity groups (I, II and III). These groups were defined according to the duration of the crop development cycle (sowing to physiological maturity). These characteristics are usually determined by the photoperiod, together with the type of soil (Type 1, 2 and 3) and published in ordinances (FEDERAL, 2021).

Worldwide there is a search for a pesticide-free agriculture or with less toxic pesticides. Thus, several types of sustainable agriculture have been proposed. In Brazil there are signs of a change in eating habits among Brazilians towards a greater consumption of products grown in a sustainable way (BORGUININI et al., 2015). The use of organic flour has been gaining ground, whether in special bakeries or in school meals in municipalities that prioritize the purchase of organic products.

Thus, wheat should be included in crop rotation in the no-tillage system to maintain soil quality. This is particularly important in the organic no-till system, which requires a lot of straw mulch and crop rotation. Therefore, it is very important to look for wheat cultivars that adapt well to the soil and climate conditions of the region, as this will result in good yield and ensure profitability to producers.

The present study aimed to evaluate the agronomic characteristics and yield of six wheat cultivars grown in an agroecological system in 2021 crop year, in Western Paraná.

MATERIAL AND METHODS

Description of the area and weather conditions during cultivation

The area is located in the municipality of Entre Rios do Oeste – Paraná (PR)**,** in Centro Vocacional Tecnológico de Agroecologia, Mandioca e Agricultura Sustentável do Oeste do Paraná (CVT), at an altitude of 521m and geographical coordinates 24°40’54” S and 54°17’3” O. The soil is classified as a typical Eutroferric Red Latosol according to the Brazilian Soil Classification System (SANTOS et al., 2015). According to the Köppen climate classification, it is a mesothermal, humid subtropical climate (*Cfa*), with hot summers, average temperature above 22°C and precipitation trends, occasional frosts in winter and temperature below 18°C (Figure 1).

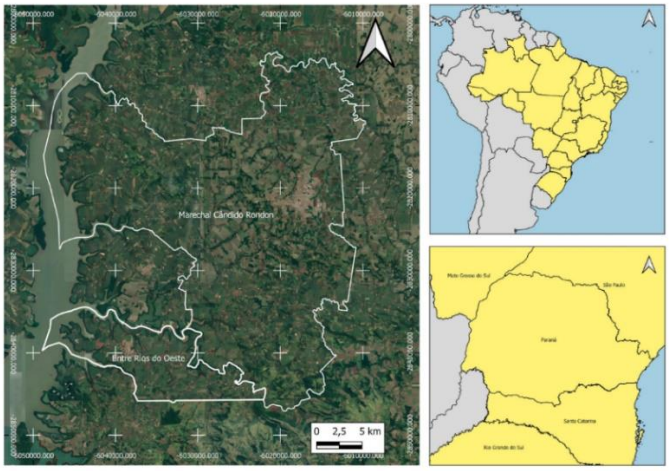

FIGURE 1 - Location of the experimental area in the municipality of Entre Rios, Paraná. Source: CARVALHO, A.O. (2022).

Meteorological data were collected, showing the average precipitation between the months of June and September 2021 and the minimum and maximum temperatures during the experimental period, for the development of the crop. The average annual precipitation is 1,600 to 1,800 mm (CAVIGLIONE et al., 2000) (Figure 2).

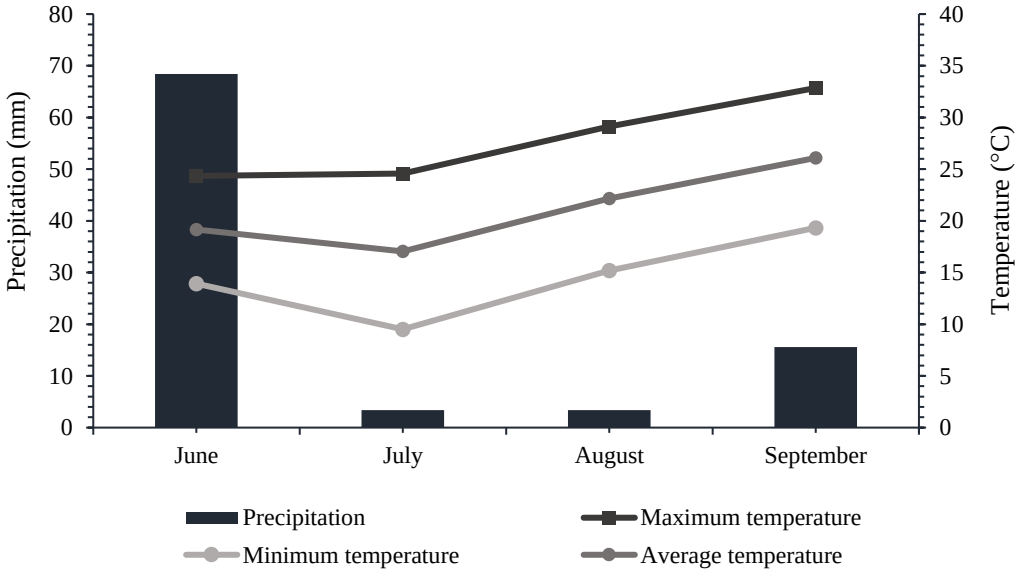

FIGURE 2 - Precipitation, maximum, average and minimum temperature in degrees Celsius during the conduction of the experiment in Entre Rios do Oeste, PR. Marechal Cândido Rondon Automatic Station.

The experimental design was completely randomized with five replications. Six wheat cultivars were evaluated. The cultivars were: TBIO Audaz, TBIO Toruk, BRS Belajoia, ORS Madrepérola, ORS 1403 and UTF 18, with a cycle ranging from early to medium, adapted to cultivation in Paraná and described in Table 1. To determine the amount of seeds to be sown (kg ha^{-1}), the weight of one thousand seeds, percentage of germination and number of desired plants per square meter were considered (Table 2).

TABLE 1 - Description, characteristics and technical-agronomic information on the six wheat cultivars used in the experiment.

Cultivars	Regions of adaptation	Industrial Class	Cycle	Agronomic characteristics
TBIO Audaz	Can be cultivated in the states of RS, PR, SC, MS and in the Cerrado	(Improver)	Early	Plant height: medium – low (0.90-0.80 m), excellent health, with an excellent level of resistance to leaf spot, bacteriosis and wheat mosaic

Continuation of Table 1 - Description, characteristics and …

TBIO Toruk	Can be cultivated in the states of RS, PR, SC MS and in the Cerrado	(Bread and Improver)		Plant height: medium – low (0.90-0.80 m), good resistance to lodging, good tolerance to pre-harvest germination
BRS Belajoia	Can be cultivated in the states of RS, PR, SC (Cold regions)	Bread	Early/medium	Plant height: low (0.75 m), earing at 80 days, maturation at 128 days, powdery mildew resistant; moderately resistant to wheat mosaic, yellow spot, brown spot, leaf *Giberella* and septoria; moderately susceptible to scab
ORS Madrepérola	Can be cultivated in the states of RS, PR, SC MS and in the Cerrado	(Wheat bread /bleacher)	Medium Early	Plant height: average (0.86 m), frost behavior in the vegetative phase: S/I, lodging behavior: MR, threshing behavior: MR and *Giberella* behavior: MR
ORS 1403	Can be cultivated in the states of RS, PR, SC, SP, MS and in the Cerrado	Bread	Medium	Plant height: medium (0.87 m), high yield potential, high industrial quality, average maturity of 132 days, resistant to powdery mildew, resistant to leaf spots (yellow, brown, glume and speckled), rust and *Giberella*
UTF 25	Can be cultivated in PR and SC	(Wheat bread /bleacher)	Early	Plant height: tall (0.95 m), aluminum resistant, moderately resistant to yellow spot, powdery mildew and leaf rust

Source: Seidel, E.P. et al. (2022).

TABLE 2 - Weight of thousand seeds (WTS), seed germination percentage, desired number of plants per square meter and the amount of seeds to be sown and weight in kilograms per hectare of seeds used.

Wheat cultivar	WTS (g)	Germination (%)	Plants per m^2	Quantity (Kg ha^{-1})
Tbio Audaz	33,50	80	350	137,94
ORS 1403	31,00	95	350	127,65
BRS Belajoia	32,90	96	350	135,47
UTF 18	33,40	95	350	137,53
ORS Madrepérola	36,50	99	350	150,29
Toruk Gebana	37,32	95	350	153,67

The area has been cultivated in the agroecological and no-tillage systems, and periodically every 2 years chemical analyzes are carried out. The results of the last chemical analysis were in 2020. The results were: OM: 26.26 g dm^{-3}; pH $CaCl_2$: 5.40; P: 97.29 mg dm^{-3}; K, Ca, Mg: 0.79; 6.09 cmolc dm^{-3} and 2.27, respectively. Base saturation: 74%. Mn, Cu and Zn: 87.12; 10.46 and 4.80 mg dm^{-3}, respectively. The following extraction methods were use: Mehlich for evaluation of the availability of P, K, Mn, Cu and Zn; KCl extraction for Ca, Mg and Al, and the Sodium Dichromate method for determining the organic matter (OM).

On May 19, 2021, 8 tons of poultry litter were distributed per hectare. Wheat was sown on June 5, 2021 in the no-tillage system, with the use of a hydraulic seeder with 17 rows. There was a 17 cm spacing between rows and the seeder was set to sow 350 viable seeds per square meter, with seeds buried at approximately 3 cm depth. At 30 days, a Supermagro biofertilizer produced in the experimental farm was applied at a dose of 3%. Three spontaneous manual collections of plants were carried out on July 30, 2021, August, 3rd, 2021 and August 18, 2021. The most common were ruby (*Leonurus sibiricus*) and turnip (*Raphanus sativus*). Phytosanitary management was standardized for all cultivars.

The evaluations of the agronomic characteristics were carried out before the harvest and after, of productivity of the cultivated areas. The harvest was carried out on 09/28/2021, when the plants were at the stage of physiological maturation of the grains, identified using grain analysis methodology in the field, squeezing the grain with the fingernail, until it is completely hardened. The harvest of wheat cultivars that have an early and early/medium cycle were harvested on the same day. For the analyses, 15 plants were collected at random, with 5 replications.

The plants were pulled out, placed in raffia bags and taken to the Vocational Center Laboratory (CVT) for evaluations, such as plant height, ear length, stem diameter, peduncle diameter, number of spikelets ear^{-1}, number of grains per ear, number of spikelets m^{-2} and productivity (kg ha^{-1}) and hectoliter weight. The height of the plants was determined by the average distance between the ground level and the upper end of the highest ear, the length of the ear was determined by the distance between the base and the upper end of the ear, the diameter of the stalk and the peduncle was determined with a digital caliper, measuring

the average stem and for productivity an area of 90 m² (15 m length x 6 m width) was harvested. After harvesting, the grains were weighed on a digital scale, with a precision of 300 g, and taken to an air circulation oven at 65ºC. With the data, the productivity in kg ha^{-1} was estimated, correcting the water content to 13%. Hectoliter weights were obtained according to the methodology described in the Seed Analysis Rules (BRASIL, 2009), in triplicate and the results were expressed in kg hl^{-1}.

The data were tabulated and submitted to normality test and then analysis of variance was performed using the F test. Subsequently, the data were submitted to Tukey test at 5% error rate, with the aid of SISVAR software (FERREIRA, 2014).

RESULTS AND DISCUSSIONS

Figure 2 shows the meteorological data recorded in the Centro Vocacional Tecnológico (CVT) in Entre Rios do Oeste, from June to September 2021, the period in which the experiment was conducted. The total rainfall during the crop cycle was 90.80 mm; however, precipitation was concentrated in the month of June, reaching 68.40 mm. The low rainfall in the months of July and August reduced the production of tillers by plants and did not favor the development of the culture. As it originates from semi-arid regions, wheat is more efficient in the use of water compared to other crops. However, photosynthesis, formation and remobilization of metabolites and establishment of the number of viable grains per ear are affected during the occurrence of water deficit.

Analysis of these meteorological data is very important, since, in addition to precipitation, temperature and photoperiod will also interfere with crop development (RIBEIRO et al., 2009). The average temperature in the present study was 16ºC. This temperature favored the development of the culture. According to Fontaneli et al., (2012) the optimal temperature for wheat development should be around 20ºC and between 15 and 20ºC during tillering. According to Wardlaw (1994), at average temperatures above 16ºC there is a decrease in yield at a rate of 3 to 4% for each degree increase. High temperature reduces root development, the number of productive tillers, and can compromise the differentiation of spikelets and flowers (RODRIGUES et al., 2011; PIMENTEL et al., 2015; FIOREZE et al., 2019). It also impacts the deposition of starch and proteins in wheat, shortening the crop cycle (ZHENG et al., 2016) and reducing yield (RIBEIRO et al., 2012).

Table 3 presents the phytotechnical results for the wheat cultivars developed in an agroecological system, with statistical difference for the number of spikes m^{-2}, plant height, stem diameter, peduncle diameter and mass per hectoliter, with no statistical difference for number of spikelets ear^{-1}, number of grains ear^{-1} and length of ear. The number of spikes m^{-2} was in the range of 221.8 to 289.1, with higher values observed in the cultivars TBIO Toruk, BRS Belajoia, TBIO Audaz and ORS 1403, related to yield and number of plants and tillers. The cultivars ORS Madrepérola and UTF 18 had a lower number of ears, probably compromised by the water deficit, during the tillering phase.

TABLE 3 - Mean result (± Standard Error) of number of ears/m2, plant height, number of spikelets per ear and number of grains per ear, ear length, stem and peduncle diameter, hectoliter weight of wheat varieties grown in agroecological system at the CVT in Entre Rios do Oeste.

Cultivar	Number of ears m^{-2}	Plant height (cm)	Number of spikelets per ear	Number of grains per ear
TBIO Toruk	289.1 ± 11.7 a*	49.4 ± 1.2 d	19.1 ± 1.3^{ns}	37.2 ± 1.9^{ns}
BRS Belajoia	278.2 ± 10.3 a	48.1 ± 0.2 d	23.6 ± 1.9	42.5 ± 3.9
ORS Madrepérola	244.1 ± 23.5 b	52.8 ± 2.3 c	16.8 ± 2.3	30.8 ± 3.8
TBIO Audaz	275.2 ± 12.1 a	57.8 ± 0.5 b	22.9 ± 0.7	41.9 ± 1.0
ORS 1403	283.8 ± 10.3 a	63.6 ± 1.5 a	27.2 ± 2.9	48.9 ± 4.8
UTF 18	221.8 ± 11.4 b	57.5 ± 2.0 b	21.2 ± 2.8	40.7 ± 5.3
CV(%)	11.28	5.57	21.10	20.34
	Ear length (cm)	Stem diameter (mm)	Peduncle diameter (mm)	Hectoliter weight
TBIO Toruk	8.34 ± 0.87^{ns}	2.79 ± 0.07 b	1.63 ± 0.03 a	75.9 ± 0.31 b
BRS Belajoia	8.61 ± 0.19	3.06 ± 0.08 a	1.66 ± 0.03 a	77.7 ± 0.17 a
ORS Madrepérola	8.16 ± 0.45	2.53 ± 0.07 c	1.52 ± 0.05 b	74.1 ± 0.33 c
TBIO Audaz	8.25 ± 0.09	2.89 ± 0.01 b	1.54 ± 0.02 b	75.5 ± 0.23 b
ORS 1403	8.02 ± 0.22	2.76 ± 0.08 b	1.54 ± 0.03 b	76.3 ± 0.31 b
UTF 18	8.87 ± 0.34	2.80 ± 0.06 b	1.67 ± 0.04 a	73.9 ± 0.29 c
CV(%)	11.80	5.38	4.96	0.81

*Means followed by the same letters in the column do not differ from each other by the Scott-Knott test (p>0.05).

For plant height, the highest value was verified for the cultivar ORS 1403 and the average of the cultivars was 54.86 cm, below that described in Table 1. The water deficit observed during crop development (Table 2) contributed to this reduction. at plant height. Plant lodging did not occur, which is not relevant for the evaluated cultivars. One of the reasons that may have contributed was the low rainfall that

occurred during the period from June to September 2021, when the height of the plants is being defined.

One of the parameters used to indicate seed quality is the mass per hectoliter (PH). This index is given in kilograms of wheat grain in 100 L of volume. This assessment follows criteria determined by Normative Instruction No. 7 of August 15, 2001, of the Ministry of Agriculture, Livestock and Supply (BRASIL, 2001). According to this standard, wheat grain is classified into two groups I and II, with group II divided into three types, being type 1 (with a minimum of 78 kg hl^{-1}), type 2 (with a minimum of 75 kg hl^{-1}) and type 3 (with a minimum of 70 kg hl^{-1}).

Table 3 shows the hectoliter weight (PH) of the six wheat cultivars, with the highest value for the BRS Belajoia cultivar and the lowest value for the UTF 18 and ORS 1403 cultivars, respectively. There were statistical differences in PH (weight per hectoliter) between cultivars. However, in the present work, no cultivar reached the hectoliter weight to be classified in group 2 as type 1 (minimum of 78 kg hl^{-1}), indicated for milling, with better product quality and flour yield. The cultivars TBIO Toruk, BRS Belajoia, TBIO Audaz and ORS 1403 were classified in group 2 (75 kg hl^{-1}); while ORS Mother of Pearl, UTF 18 were classified as type 3 (BRASIL, 2001).

Figure 3 shows the yield of cultivars harvested 123 days after sowing, with an average of 2125 kg ha^{-1}. The productivity obtained was below the national average, according to data from Conab (2021). Productivity ranged from 1875 kg ha^{-1} to 2338 kg ha^{-1}. Productivity lower than the national average was mainly due to water deficit during the crop cycle (Figure 2). Thus, the evaluated cultivars did not have the maximum genetic expression of their productive potential. There was no statistical difference for productivity between wheat cultivars cultivated in an agroecological system evaluated.

The difficulty of finding works with wheat cultivated in agroecology, the comparison of productivity was in relation to the conventional system, that is, with the use of soluble chemical fertilizers. In the study carried out by Fioreze et al. (2020), in the southern region, on the Santa Catarina plateau, the agronomic performance of off-season wheat cultivars was evaluated, with the application of soluble fertilizers. Among the evaluated cultivars was the cultivar TBIO Audaz, which had an average productivity of 4178 kg ha^{-1}. Silva et al. (2019) evaluating the productivity of wheat with organic and chemical fertilization, grown in a conventional system, in the municipality of Corbélia (PR), near Entre Rios do Oeste and with similar climatic conditions, found an average productivity of 4677.94 kg ha^{-1}. These yields were observed in climatic conditions suitable for the development of the crop and considered very good.

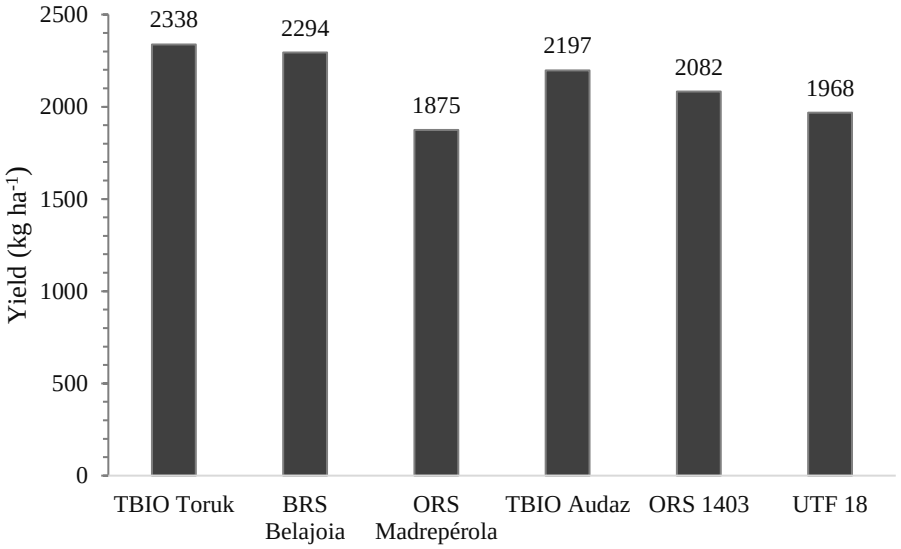

FIGURE 3 - Yield of wheat cultivars in Western Paraná in 2021 grown in an agroecological system.

As there was a water deficit during wheat cultivation in 2021, further studies are needed to evaluate the most productive cultivars in agroecological systems. It is also suggested to evaluate alternative sources of fertilization and to experiment with networks.

CONCLUSIONS

During the crop cycle there was a water deficit which compromised the development of agroecological wheat. The average productivity of agroecological wheat in Western Paraná was 2125 kg ha^{-1} and there was no significant difference between cultivars.

The highest hectoliter weight was found in the cultivar BRS Belajoia (77.7); however, in the present work, no cultivar reached the hectoliter weight to be classified as type 1.

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REFERENCES

BORGUINI, R.G.; TORRES, E.A.F.S. Alimentos orgânicos: qualidade nutritiva e segurança do alimento. **Segurança Alimentar e Nutricional**, v.13, n.2, p.64-75, 2015.

BRASIL. Ministério da Agricultura, Pecuária e Abastecimento. **Regras para Análise de Sementes.** Ministério da Agricultura, Pecuária e Abastecimento. Secretaria de Defesa Agropecuária. Brasília, DF: Mapa/ACS, 2009. 395p.

BRASIL. MINISTÉRIO DA AGRICULTURA, PECUÁRIA E ABASTECIMENTO. **Instrução Normativa SARC nº 7, de 15 de agosto de 2001.** Aprova o regulamento técnico de identidade e qualidade do trigo. Diário Oficial da República Federativa do Brasil, Brasília, 21 de agosto de 2001.

CAVIGLIONE, J.H.; KIIHL, L.R.B.; CARAMORI, P.H.; OLIVEIRA, D. **Cartas climáticas do Estado do Paraná.** Londrina: Instituto Agronômico do Paraná, v.1, 2000.

CONAB. COMPANHIA NACIONAL DE ABASTECIMENTO. **Séries históricas das safras.** 2020. Available at: <https://www.conab.gov.br/info-agro/safras/serie-historica-das-safras. Acessed in: 10 May. 2022.

CONAB. COMPANHIA NACIONAL DE ABASTECIMENTO. **Acompanhamento da safra brasileira.** 2021. Available at: <https://www.conab.gov.br/info-agro/safras/graos>. Acessed in: 4 Apr. 2022.

COTA, L.V.; OLIVEIRA, I.R.; SILVA, D.D.; MENDES, S.M.; COSTA, R.V.; SOUZA, I.R.P.; SILVA, A.F. **Manejo da cigarrinha e enfezamentos na cultura no milho.** Sete Lagoas, Embrapa Milho e Sorgo, 2021. Available at: <https://www.embrapa.br/en/busca-de-publicacoes/-/publicacao/1130346/manejo-da-cigarrinha-e-enfezamentos-na-cultura-do-milho#:~:text=Resumo%3A%20Com%20o%20lan%C3%A7amento%20da,produtor%20rural%2C%20levando%20conhecimento%20t%C3%A9cnico>. Acessed in: 12 mai. 2022.

FEDERAL. Governo Federal. **Zoneamento Agrícola.** 2017. Available at: <https://www.gov.br/agricultura/ptbr/assuntos/riscos-seguro/programa-nacional-de-zoneamento-agricola-de-risco-climatico/zoneamento-agricola>. Acessed in: 12 May. 2022.

FERREIRA, D.F. Sisvar: a guide for its bootstrap procedures in multiple comparisons. **Ciência e Agrotecnologia**, v.38, n.2, p.109-112, 2014.

FIOREZE, S.L.; VACARI, J.; TUREK, T.L.; MICHELON, L.H.; DRUN, R.P. Componentes produtivos do trigo em função da temperatura no período de diferenciação de espiguetas. **Revista de Ciências Agroveterinárias**, v.18, n.1, p.24-32, 2019.

FIOREZE, S.L.; OLIVEIRA, J.C.; MAZZUCO, V.; WUADEN, A.F.; DRUN, R.P. Desempenho agronômico de cultivares de trigo para safrinha no Planalto de Santa Catarina, Brasil. **Revista de Ciências Agroveterinárias**, v.19, n.2, p.188-196, 2020.

FONTANELI, R.S.; SANTOS, H.P. **Forrageiras para integração lavoura-pecuária-floresta na região sul-brasileira**. Embrapa Trigo - Livro científico (ALICE), 2012.

OLIVEIRA, D.L.; BORSZOWSKEI, P.R. Taxa de decomposição da palhada de trigo e liberação de NPK em sistema de plantio direto no município de Ponta Grossa-PR. **Revista TechnoEng**, v.1, [s.n.], [s.p.], 2020.

PIMENTEL, A.J.B.; ROCHA, J.R.A.S.C.; SOUZA, M.A.; RIBEIRO, G.; SILVA, C.R.; OLIVEIRA, I.C.M. Characterization of heat tolerance in wheat cultivars and effects on production components. **Revista Ceres**, v.62, n.2, p.191-198, 2015.

PIRES. J.F. **A importância do trigo para a sustentabilidade da agricultura brasileira.** Embrapa Trigo, 2016. Available at: <https://www.embrapa.br/busca-de-noticias/-/noticia/23416523/artigo---a-importancia-dotrigo-para-a-sustentabilidade-da-agricultura-brasileira>. Acessed in: 14 May. 2022.

RIBEIRO, G.; PIMENTEL, A.J.B.; SOUZA, M.A.; ROCHA, J.R.A.S.C.; FONSECA, W.B. Estresse por altas temperaturas em trigo: impacto no desenvolvimento e mecanismos de tolerância. **Revista Brasileira de Agrociência**, v.18, n.2-4, p.133-142, 2012.

RIBEIRO, T.L.P.; CUNHA, G. R.; PIRES, J.L.F.; PASINATO, A. Respostas fenológicas de cultivares brasileiras de trigo à vernalização e ao fotoperíodo. **Pesquisa Agropecuária Brasileira**, v.44, n.11, p.1383-1390, 2009.

RODRIGUES, O.; TEIXEIRA, M.C.C.; COSTENARO, E.R.; SANA, D. **Ecofisiologia:** bases para elevado rendimento de grãos. In: PIRES, J.L.F.; VARGAS, L.; Cunha, G.R. (Eds.). Trigo no Brasil: bases para produção competitiva e sustentável. Passo Fundo: Embrapa Trigo, 2011. p.115-134.

SANTOS, D.L.D. **Distribuição da palhada de trigo e seu efeito sobre a microvariabilidade** da cultura da soja. 2020. 73 p. Dissertação (Mestrado em Agricultura de Precisão) - Universidade Federal de Santa Maria, Santa Maria, 2020.

SANTOS, H.G.; JACOMINE, P.; ANJOS, L.; OLIVEIRA, V.; LUMBRERAS, J.; COELHO, M.; OLIVEIRA, J. **Sistema Brasileiro de Classificação de Solos.** Brasília, DF: Embrapa, 2018.

SANTOS, D.D.; GUIMARÃES, V.F.; KLEIN, J.; FIOREZE, S.L.; MACEDO JÚNIOR, E.K. Cultivares de trigo submetidas a déficit hídrico no início do florescimento, em casa de vegetação. **Revista Brasileira de Engenharia Agrícola e Ambiental**, v.16, n.1, p.836-842, 2012.

SILVA, R.G.; BORSOI, A.; LIMA, P.R.; SOUZA PINTO, J.; DANIEL, C.; LAVRATTI, M.B. Adubação orgânica e química na cultura do trigo. **Revista Cultivando o Saber**, v.12, n.3, p.54-61, 2019.

SOUZA, R.; FILHO, J. Produção de trigo no Brasil: análise de políticas econômicas e seus impactos. **Revista de Política Agrícola**, v.30, n.2, p.45, 2021.

WARDLAW, I.F.; WRIGLEY, C.W. Heat tolerance in temperate cereals: an overview. **Functional Plant Biology**, v.21, n.6, p.695-703, 1994.

WENNECK, G.S.; SAATH, R.; ARAUJO, L.L.; PEREIRA, G.L.; REZENDE, R.; WENNECK, G.S. Decomposition of the remaining straw during soybean growing in the midwestern Paraná, Brazil. **Revista de Agricultura Neotropical**, v.8, n.4, e6534, 2021.

ZHENG, B.; CHENU, K.; CHAPMAN, S.C. Velocity of temperature and flowering time in wheat - assisting breeders to keep pace with climate change. **Global Change Biology**, v.22, n.2, p.921-933, 2016.