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Productivity of Winter Wheat (*T. aestivum*, *T. durum, T. spelta*) Depending on Varietal Characteristics in the Context of Climate Change

Margaryta Korkhova[1], Antonina Panfilova[1], Yevhenii Domaratskiy[1*], Iryna Smirnova[1]

[1] Mykolayiv National Agrarian University George Gongadze St., 9, Mykolayiv, 54020, Ukraine

* Corresponding author's e-mail: jdomar1981@gmail.com

ABSTRACT

This article presents the results of studies of winter wheat species and varieties depending on the meteorological conditions of the research years. The purpose of the research is to determine the density of the productive stem, the mass of 1000 grains, the yield and quality of winter wheat grain, depending on the species and varietal composition. Methods. Experimental studies were conducted during 2015/2016–2020/2021 yrs in the experimental field of Mykolaiv National Agrarian University (Ukraine). Agricultural techniques for growing winter wheat of various species were generally accepted for the southern steppe zone of Ukraine. Its predecessor was sown peas. Results. It was determined that a larger number of productive stems per unit area (467–853 pcs./m^2) formed plants of the studied varieties of soft winter wheat, while the smallest (443–694 pcs./ m^2) were plants of winter durum wheat varieties. The largest mass of grain from one ear (1.06–1.20 g) on average over the years of research was formed by plants of spelt wheat varieties, and the smallest was formed 0.96–1.01 g of soft wheat plants. It was found that a higher yield of soft winter wheat (6.03 t/ha) on average over the years of research was formed in the Vidrada variety, hard wheat (5.58 t/ha) was formed in the Bosphorus variety, spelt was formed 5.36 t/ha in the Europa variety. The highest grain yield (7.13 t/ha) among the species and varieties put for study was provided by the Vidrada variety (*T. aestivum*) in 2016 yr, which was 5.3% more than in the variety Shestopalivka (*T. aestivum*), 5.9% more than the Linkor variety (T. durum), by 7.0% than the Bosphorus variety (*T. durum*), by 12.5% than that of the Europa variety (T. spelta) and 43.5% more than the Zorya Ukrainy variety (*T. spelta*). It was determined that the largest mass fraction of protein in grain was provided by the spelt Zorya Ukrainy wheat variety as 19.2–25.6% depending on the year of research, while the smallest was provided as 11.0–14.2% by the Shestopalivka soft wheat variety. In the conditions of the Southern steppe of Ukraine, to ensure a high grain yield (5.24–6.03 t/ha) with a high protein content (14.1–15.1%), it was recommended to sow the variety of soft winter wheat Vidrada, hard winter wheat as Linkor and spelt as Europe.

Keywords: soft wheat, hard wheat, spelt, varieties, grain yield, mass fraction of protein.

INTRODUCTION

The consequences of global climate change are dangerous weather disasters, sudden weather changes, floods, strong winds, heavy rains and storms, hail, droughts, which lead to significant environmental and economic damage around the world and affect the yield of most crops, especially cereals (Clark et al, 2022). Climate changes are characterized by diversity, different levels of intensity of their manifestations, frequency of climate anomalies, periodicity of extreme weather events in space and time (Pichura et al. 2022). Physical-geographical Steppe zone is characterized by a high level of temperature regime, scarce, unstable and uneven distribution of precipitation that determe risky agricultural conditions and insufficient yields of agricultural crops (Pichura et al. 2021). One of the main indicators of global warming is the average annual air temperature and rising temperatures during the cold season, as well as a decrease in the duration of the winter period by almost a month (McNutt and Ramakrishnan, 2020). The air temperature in January and February increased by an

average of 1.5–2.5 °C. As a result, spring processes begin two to three weeks earlier, and the duration of the active vegetation period of plants becomes longer by seven to ten days, which should be taken into account by farmers (Malyshev, 2020; Beil et al, 2021). To reduce the impact of climate change on wheat production, the world's main crop, FAO proposes a "Save and grow" crop intensification model, which consists of a sustainable increase in yields on existing agricultural land (Graziano da Silva, 2016).

Wheat is one of the main grain crops in the world (Domaratsky et al., 2019; Panfilova et al, 2020). A common species in grain production is *T. aestivum*, which occupies 90% of all acreage occupied under wheat. The last 10% of the area is occupied under *T. durum* and *T. spelta* (Poltoretskyi et al, 2018). Compared to soft wheat, hard wheat and spelt wheat have significant advantages – they are less affected by diseases and pests, have higher resistance to lodging, drought and shedding. Spelt wheat has significantly more moderate requirements compared to soft wheat for providing soil with nitrogen (Sugár et al, 2019).

These two species of wheat (durum and spelt) have been widely used in organic farming in recent years due to their unpretentiousness to growing conditions and high grain quality. However, their productive potential remains not fully revealed, in comparison with the advanced countries of the world (Wang, et. al., 2020).

At this stage of breeding, spelt wheat forms were selected, as well as soft wheat and speltoid samples that combine high levels of productivity with high levels of gluten and protein (Diordiieva et. al., 2018). According to the Food and Agriculture Organization of the United Nations, rising prices for means of production (fertilizers, plant protection products, fuel and lubricants) will lead to increased production costs and restrictions on the use of means of production, reduced yields and gross grain yields, which will provoke an additional risk of deterioration of the global food security situation in the coming years (FAO, 2022). Therefore, it is spelt wheat that can become an alternative to soft wheat in large areas due to its unpretentiousness to growing conditions. An important factor in increasing wheat productivity is the variety (Domaratsky et al., 2020; 2021; 2022; Panfilova and Mohylnytska, 2019). To date, there are a large number of varieties of soft winter wheat and a sufficient number of durum wheat and spelt wheat, but their comparative assessment of the impact on grain yield and quality under various weather conditions has not been sufficiently studied and covered in the literature.

MATERIAL AND METHODS

Field research was conducted during 2016–2021 in the experimental field of the Training Scientific and Practical Center of Mykolaiv National Agrarian University (GPS: 46.930690, 31.657438; Mykolaiv, Ukraine), which was located in the southern Steppe zone of Ukraine (Fig. 1).

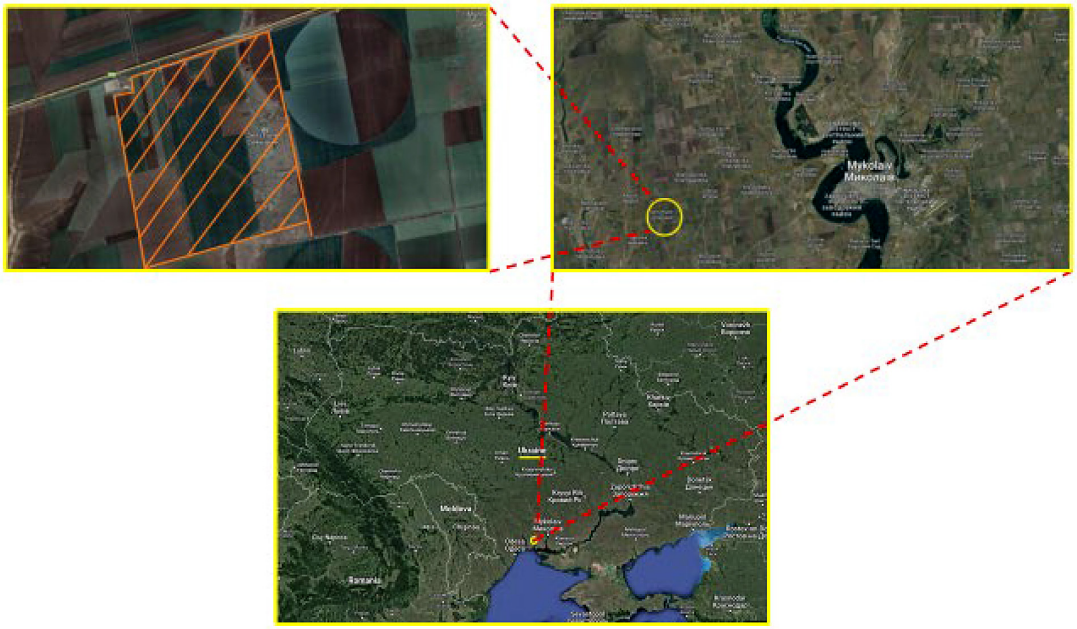

Figure 1. The location of research

The soil of the experimental field was a typical southern chernozem of residual-slightly saline heavy loess on Loess with a humus content (0–30 cm) from 3.1% up to 3.3% and a neutral reaction of the soil solution (pH 6.8–7.2). The arable soil layer contained an average of 15–25 mobile forms of nitrates (by Grandval Lyagu), 41-46 mobile phosphorus (by Machigin) and 389–425 mg/kg of exchange potassium (on a semi-lamp photometer). Agricultural techniques for growing winter wheat of various species were generally accepted for the zone, with the exception of variants that were studied according to the experimental scheme. Its predecessor was sown peas.

Meteorological conditions during the years of research were analyzed using data from the PesslInstruments weather station (iMETOS), equipped with high-precision sensors. Weather conditions in the years of research varied, which made it possible to better study the reaction of the studied factors to the productivity of winter wheat.

The temperature regime was different in 2016/2017, the average annual air temperature was 9.7 °C, which is by 1.7 °C more than the long-term average. The highest monthly average air temperature in September (+21.2 °C) was recorded in 2015/2016, which was by 0.7–3.6 °C more than in other years and by 9.5 °C more than the average for six years (Table 1).

The average monthly air temperature in October (5.7 °C), November (0.7 °C), December (-3.2 °C) and January (-6.6 °C) was the lowest in 2016/2017, which was by 3.7; 3.8; 3.2 and 4.4 °C, respectively, less than the average for 2015/2016–2020/2021. March 2017/2018 was the coldest, the average monthly temperature of which decreased to 1.0 °C, which was by 4.0 °C less than the average for the years of research. The hottest time was May 2017/2018 (19.3 °C), June (23.8 °C) in 2018/2019, and July (26.2 °C) in 2015/2016.

In terms of precipitation, we should note 2018/2019 (574.6 mm) and 2020/2021 (537.2 m), which was by 40.9% and by 31.8%, respectively, more than the average for the years of research (Table 2).

The driest year was 2016–2017, when only 232.6 mm of precipitation fell during the year, which was by 42.9% less than the average for six years. The experiment was laid by splitting the sections. The area of the accounting plot was 25 m^2, the repetition of the experiment was four times.

The field experiment scheme included the following options: factor A. wheat species: *T. aestivum*; *T. spelta*; *T. durum*. Factor B. Varieties: Shestopalivka (st.); Vidrada; Zorya Ukrainy; Europe; Bosphorus; Linkor. All the studied varieties of winter wheat are listed in the State Register of plant varieties suitable for distribution in Ukraine and recommended for growing in the steppe zone. Sowing was carried out in the recommended time frame for this zone as the first decade of October. In a field experiment, the influence of varietal characteristics and weather conditions on the productivity of soft wheat, spelt and hard winter forms was studied. Records and observations, the number of productive stems, the mass of grain from one ear, and grain yield were determined by the method of State Variety testing (Tkachyk et al., 2016). The mass fraction of protein was determined by the method of determining the quality indicators of crop production (Kiyenko, et. al., 2016). Mathematical and statistical processing

Table 1. Average monthly air temperature in research years, 2015/2016–2020/2021

Months	Years						Average
	2015/2016	2016/2017	2017/2018	2018/2019	2019/2020	2020/2021	
September	21.2	17.6	19.2	18.2	17.5	20.5	19.0
October	9.3	5.7	11.2	12.8	11.2	15.2	10.9
November	7.0	0.7	5.3	2.3	7.0	4.8	4.5
December	2.1	-3.2	5.2	-0.4	3.6	1.8	1.5
January	-4.5	-6.6	-0.7	-1.5	0.4	-0.4	-2.2
February	3.4	-0.3	-0.9	1.6	2.7	-0.9	0.9
March	6.0	6.9	1.0	5.8	7.0	3.5	5.0
April	12.5	9.1	14.0	10.3	9.3	8.7	10.7
May	15.9	16.3	19.3	17.6	13.9	15.6	16.4
June	18.0	21.8	22.6	23.8	21.9	20.2	21.4
July	26.2	23.2	25.3	22.9	24.1	24.8	24.4
August	23.8	24.9	22.9	23.3	23.1	23.6	23.6
Average for year	11.7	9.7	12.1	11.4	11.8	11.5	11.4

Table 2. Average monthly precipitation in the research years, 2015/2016–2020/2021

Months	Years						Average
	2015/2016	2016/2017	2017/2018	2018/2019	2019/2020	2020/2021	
September	0.8	15.0	3.7	78.0	2.4	36.6	22.8
October	13.0	13.1	24.0	14.0	39.4	39.6	23.9
November	49.0	18.0	23.0	26.0	7.8	1.6	20.9
December	0.8	19.2	41.0	41.0	30.0	17.2	24.9
January	72.0	15.3	32.0	43.0	24.2	67.0	42.3
February	29.0	13.0	41.0	7.8	110	33.4	39.0
March	23.0	4.3	48.0	5.8	9.8	26.8	19.6
April	52.0	47.0	2.0	46.0	5.0	47.0	33.2
May	85.0	36.0	32.0	55.0	49.2	61.6	53.1
June	35.0	7.8	22.0	178.0	90.2	104.8	73.0
July	0.0	14.0	69.0	26.0	28.4	82.6	36.7
August	0.0	30.0	0.8	54.0	7.0	19.0	18.5
Sum for year	359.6	232.6	338.5	574.6	403.4	537.2	407.7

of research results was performed using variance analysis using the STATISTICA 10.0 program (Ushkarenko et al., 2020).

RESULTS AND DISCUSSION

The density of the productive stem and the weight of grain from the ear are among the most important indicators of the crop structure. According to the requirements of intensive technology, there should be 550–650 spikelets per 1 m^2 (Klipakova et al, 2019). The results shows that a denser productive stem (675–680 pcs./m^2) on average for 2016–2021 was formed in soft wheat varieties (*T. aestivum*), which was 25–121 pcs./m^2 (2.2–18.4%) more than in spelt wheat varieties (*T. spelta*) and for 101–107 pcs./m^2 (14.9–15.9%) than durum wheat (*T. durum*) (Table 3).

It was determined that weather conditions in the years of research influenced the formation of the number of productive stems per unit area. Thus, a larger number of spikelets per 1 m^2 on average for the studied varieties of soft wheat was formed in favorable 2019 (825 pcs./m^2) and 2021 (829 pcs./m^2), while the smallest 497 pcs./m^2 in 2017, in addition, it should be noted that the studied varieties formed the density of productive stem in different ways. So, the Vidrada variety in 2016 and 2017 a more productive stem was formed (705 and 527 pcs./m^2), respectively, which was by 17–60 pcs./m^2 more than that of the Shestopalivka variety, while in 2018, 2019, 2020 and 2021, on the contrary, it was less.

Studying the productive potential of spelt wheat varieties, it was determined that a larger number of productive stems on average over the years of research was formed by the Zorya Ukrainy variety – 665 pcs./m^2, which was 114 pcs./m^2, or 17.1% more than that of the Europa variety. The productive stem of spelt wheat plants was denser in 2017 as 887 pcs./m^2 (Zorya Ukrainy) and 738

Table 3. Number of productive winter wheat stalks, depending on the species and variety, (average for 2016–2021)

Wheat species (Factor A)	Varieties (Factor B)	Years						Average
		2016	2017	2018	2019	2020	2021	
Triticum aestivum	Shestopalivka	692	467	661	836	572	853	680
	Vidrada	705	527	645	813	557	805	675
	Average	**699**	**497**	**653**	**825**	**565**	**829**	**678**
Triticum spelta	Zorya Ukrainy	771	887	641	588	480	625	665
	Europe	625	738	400	510	435	600	551
	Average	**698**	**813**	**521**	**549**	**458**	**613**	**608**
Triticum durum	Bosphorus	605	502	514	675	486	694	579
	Linkor	600	443	549	653	475	690	568
	Average	**603**	**473**	**532**	**664**	**481**	**692**	**574**
LSD_{05} for the Factor A by years		14.1	13.9	13.4	8.4	15.5	12.5	4.4
LSD_{05} for the factor B by years		7.8	9.4	8.9	11.6	16.3	18.1	4.9

pcs./m^2 (Europe), while the least dense (480 and 435 pcs./m^2, respectively) – in 2020.

It was determined that a smaller number of productive stems of winter wheat plants (475–694 pcs./m^2) formed plants of the studied varieties *T. durum* depending on the variety and year of research. Thus, on average for 2016–2021 a larger number of productive stems per unit area was formed by the species *T. aestivum* as 678 pcs./m^2, which was by 70 pcs./m^2 (10.3%) more than the average for Factor B in *T. spelta* and by 104 pcs./m^2 (15.3%) more than *T. durum*.

Based on the results of the variance analysis, a significant influence of the studied factors on the number of productive winter wheat stalks was established. At the same time, the greatest influence on this indicator was had by factor a (wheat species), the share of influence of which on average over the years of research was 61%, and the smallest significant difference (HIP) was 8.4–15.5 pcs./m^2, while Factor B was 22% of HIP 7.8–18.1 pcs./m^2.

The weight of grain from 1 ear, as mentioned above, greatly affects the formation of winter wheat yield and depends on weather conditions and genetic characteristics of the variety (Lozinsky, et. al, 2021). Previous studies have determined that a large mass of grain from 1 ear of spelt wheat on average for three years (2016–2018) was formed in the Europa variety – 1.22 G, which is 16.2% more than in the Zorya Ukrainy variety (Korkhova, et. al., 2019). Three years of research by other scientists (Jablonskytė-Raščė, et. al., 2013) found that the grain weight per ear in spelt wheat was by 11.4% higher than in soft wheat.

As a result of this research, it was found that on average, over six years of research, a large grain mass from 1 ear of winter wheat plants was formed by species *T. spelta* was 1.13 g, whereas *T. aestivum* it was 0.99 g, *T. durum* it was 1.06 g, which was by 12.4 and 6.2% less, respectively (Table 4).

Among the studied soft wheat varieties, the Vidrada variety had a higher grain weight from the ear as 1.01 g, which was by 5.2% more than the Shestopalivka variety. The spelt Europe wheat variety formed a grain mass of 1 vote on average over the years of research of 1.20 g, which was by 13.2% more than the Zorya Ukrainy variety. Among the studied varieties of winter durum wheat, the Bosphorus Variety had a higher grain mass per ear (1.12 g), which was 0.12 g, or by 10.7% more than the Linkor variety.

It was determined that the mass of grain from 1 ear also depended on the weather conditions of the year. Thus, the largest mass of grain from 1 ear was formed in spelt wheat of the Europe variety in 2019 as 1.38 g/ear, in Bosphorus durum wheat in 2017 as 1.35 g/ear, in Vidrada soft wheat in 2017 as 1.19 g/ear

The smallest grain mass per 1 ear (0.81–0.91 g/ear) was formed in plants of all the studied winter wheat species in 2018. Based on the results of the variance analysis, it was determined that on average for 2016–2021, factor A had a greater influence on the formation of grain mass from 1 ear, the share of influence of which was 55%, while Factor B was 2%. The smallest significant difference in Factor A was 0.02–0.05 g/ear, Factor B was 0.02–0.04 g/ear.

The yield potential of winter wheat depends significantly on the species and variety used (Solomon & Daniel, 2021; Ratajczak, et. al., 2020). Previous studies conducted in 2015–2020 determined that among the four durum wheat varieties studied, the lower yield was formed by The

Table 4. Grain weight per 1 ear of winter wheat, depending on the species and variety (average for 2016–2021)

Wheat species (Factor A)	Varieties (Factor B)	Years						Average
		2016	2017	2018	2019	2020	2021	
Triticum aestivum	Shestopalivka	0.99	1.12	0.79	0.90	0.94	1.00	0.96
	Vidrada	1.08	1.19	0.90	0.92	0.91	1.04	1.01
	Average	**1.04**	**1.16**	**0.85**	**0.91**	**0.93**	**1.02**	**0.99**
Triticum spelta	Zorya Ukrainy	1.20	0.95	0.91	1.17	1.03	1.11	1.06
	Europe	1.29	1.11	1.18	1.38	1.21	1.02	1.20
	Average	**1.25**	**1.03**	**1.05**	**1.28**	**1.12**	**1.07**	**1.13**
Triticum durum	Bosphorus	1.17	1.35	0.86	1.21	0.93	1.17	1.12
	Linkor	1.06	1.09	0.81	1.06	0.85	1.11	1.00
	Average	**1.12**	**1.22**	**0.84**	**1.14**	**0.89**	**1.14**	**1.06**
LSD_{05} for the factor A by years		0.02	0.02	0.04	0.05	0.03	0.02	0.01
LSD_{05} for the factor B by years		0.02	0.02	0.02	0.04	0.04	0.04	0.01

Linkor variety as 3.73–6.73 t/ha, and the largest was formed as 4.02–7.69 t/ha by the Linkor variety (Korkhova, M. and Mykolaichuk, V., 2022). Three-year studies (2015–2017) conducted in the Lublin province (Poland) determined that spelt wheat, even when grown using intensive technology, gave a 30–56% lower yield of relatively soft and hard, but was characterized by a higher protein content (Rachon et al., 2020). Studies conducted in the north-eastern part of Poland showed that the highest yield potential among the three winter wheat species studied was *T. aestivum*, which was by 2.14 t/ha higher than the yield of *T. durum* and at 2.55 t/ha as *T. spelta* (Budzyński, et al., 2019).

According to the results, a high yield of winter wheat grain was obtained in soft wheat, which on average for 2016–2021 by varieties was 5.91 t/ha (Shestopalivka) and 6.03 t/ha (Vidrada), which was by 0.33–0.79 t/ha more than in durum wheat varieties and by 0.55–2.39 t/ha than in spelt wheat (Table 5).

It was determined that the yield of winter wheat grain significantly depended on the species, variety and year of research. Thus, the highest grain yield of soft winter wheat (7.13 t/ha) was formed in 2016 by the Vidrada variety, winter durum wheat as 7.11 t/ha in 2019 by the Bosphorus variety and spelt wheat as 6.10 t/ha in 2017 by the Europe variety. This could be explained by different biological characteristics of varieties that had been exposed to different meteorological conditions.

In dry 2020, the grain yield of all the studied varieties of winter wheat was the lowest and amounted to 4.97–5.07 t/ha in soft wheat, such as 3.73–4.15 t/ha in durum wheat and 2.74–4.02 t/ha in spelt wheat.

Based on the results of the variance analysis, it was determined that factor A (wheat species) had a greater influence on the formation of grain yield, the share of influence of which on average for 2016–2021 yrs was 59%, while factor B (varieties) was only 10%. The smallest significant difference in Factor A by year was 0.12–0.26 t/ha, in Factor B it was 0.09–0.27 t/ha.

Research by scientists (Takac et al., 2021; Toth et. al., 2022) it was determined that spelt wheat grain contained a higher amount of protein than soft and hard wheat. Our research also confirmed this. Thus, on average, over the years of research (2016–2021), the mass fraction of protein in winter wheat grain was higher in spelt wheat varieties as 18.2% on average for varieties, which was by 3.9% more than the average for durum wheat varieties and by 4.1% more than in soft wheat varieties (Table 6).

It was determined that among the studied varieties of soft wheat, the Vidrada variety was characterized by a high protein content in the grain (15.0%), which was by 1.9% more than in the Shestopalivka variety. The mass fraction of protein in spelt wheat grain of the Zorya Ukrainy Variety on average for 2016–2021 was 21.3%, which was by 6.2% more than that of the Europa variety. The Linkor winter durum wheat variety was characterized by a higher mass fraction of protein in the grain (14.5%), which was by 0.4% more than the Bosphorus variety.

Studies had shown a significant influence of weather conditions of the year on the formation of the mass fraction of protein in winter wheat grain. Thus, in 2015, soft and hard wheat varieties formed a higher protein content in the grain (14.2–17.2%), while in 2017 (11.0–12.9%) they formed the lowest.

Table 5. The yield of winter wheat grain depending on species and varietal characteristics (average for 2016–2021)

Wheat species (Factor A)	Varieties (Factor B)	Years						Average
		2016	2017	2018	2019	2020	2021	
Triticum aestivum	Shestopalivka	6.75	5.23	5.19	6.68	5.07	6.51	5.91
	Vidrada	7.13	5.89	5.80	6.16	4.97	6.21	6.03
	Average	**6.94**	**5.56**	**5.50**	**6.42**	**5.02**	**6.36**	**5.97**
Triticum spelta	Zorya Ukrainy	4.03	4.21	3.41	3.73	2.74	3.73	3.64
	Europe	6.24	6.10	4.25	5.86	4.02	5.66	5.36
	Average	**5.14**	**5.16**	**3.83**	**4.80**	**3.38**	**4.70**	**4.50**
Triticum durum	Bosphorus	6.63	6.78	3.95	7.11	4.15	4.84	5.58
	Linkor	6.71	4.71	4.41	6.73	3.73	5.12	5.24
	Average	**6.67**	**5.75**	**4.18**	**6.92**	**3.94**	**4.98**	**5.41**
LSD_{05} for the factor A by years		0.12	0.15	0.19	0.17	0.26	0.25	0.04
LSD_{05} for the factor B by years		0.09	0.15	0.14	0.15	0.21	0.27	0.07

Table 6. Mass fraction of protein in winter wheat grain depending on the species and varietal composition (average for 2020–2021)

Wheat species (Factor A)	Varieties (Factor B)	Years						Average
		2016	2017	2018	2019	2020	2021	
Triticum aestivum	Shestopalivka	12.1	11.0	13.3	14.2	13.8	14.0	13.1
	Vidrada	13.6	12.6	14.1	17.2	15.7	16.7	15.0
	Average	**12.9**	**11.8**	**13.7**	**15.7**	**14.8**	**15.4**	**14.1**
Triticum spelta	Zorya Ukrainy	20.8	19.2	25.6	20.2	22.9	19.2	21.3
	Europe	14.9	11.0	16.6	16.4	16.5	15.3	15.1
	Average	**17.9**	**15.1**	**21.1**	**18.3**	**19.7**	**17.3**	**18.2**
Triticum durum	Bosphorus	13.5	12.6	14.3	15.0	14.3	14.8	14.1
	Linkor	13.9	12.9	14.6	15.3	15.0	15.0	14.5
	Average	**13.7**	**12.8**	**14.5**	**15.2**	**14.7**	**14.9**	**14.3**
LSD_{05} for the factor A by years		0.18	0.26	0.47	0.49	0.33	0.20	0.10
LSD_{05} for the factor B by years		0.29	0.20	0.38	0.36	0.31	0.41	0.11

Consequently, the formation of the mass fraction of winter wheat protein was significantly influenced by both the species and varietal composition, which was confirmed by dispersion analysis. The share of influence of factors over the years of research was on average 51% for factor A (wheat species) and it was 6% for Factor B (varieties).

CONCLUSIONS

In the Southern steppe of Ukraine, there are more productive stems per unit area (467–853 pcs./m^2) form varieties of soft winter wheat, and less productive ones (443–694 pcs./m^2) varieties of winter durum wheat. It was determined that a larger grain mass from 1 ear was formed in spelt wheat varieties (0.91–1.38 g/ear), and a smaller one was formed 0.79–1.19 g. A higher grain yield (4.97–7.13 t/ha) was formed by the Vidrada winter wheat variety, and the smallest one was formed 2.74–4.21 t/ha. The largest mass fraction of protein in the grain (19.2–25.6%) was formed by the spelt Zorya Ukrainy wheat variety, and the smallest one was formed 11.0–14.2% by the Shestopalivka soft winter wheat variety. Thus, it was determined that to obtain a winter wheat grain yield of 5.24–6.03 t/ha with a mass fraction of protein of 14.1–15.1%, Vidrada (soft), Europa (spelt) and Linkor (hard) varieties should be sown. In order to obtain high-protein grain at the level of 19.2–25.6%, spelt winter wheat of the Zorya Ukraine variety should be sown.

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