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RESEARCH ARTICLE

Agrobiological characteristics of spelt wheat and intermediate wheatgrass in the conditions of the right-bank forest-steppe of Ukraine

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Estimation of spelt wheat and the species of intermediate wheatgrass by the main agrobiological indicators (calendar dates of the beginning of the main phases of plant development, plant height dynamics, dry mass accumulation, grain yield and protein content) compared to soft wheat was done. The index of stability of grain yield formation was determined. It was found that the main phases of development in spelt wheat occurred on average 10–15 days later than in soft wheat. Plants of intermediate wheatgrass in the first year of cultivation had slower growth. The main phases of development in plants of intermediate wheatgrass of the second and third year of growth occurred almost in the same time with soft wheat. It was established that spelt wheat and intermediate wheatgrass were significantly superior to soft wheat in plant height. In the earing phase, the height of these plants was on average more than 100 cm, which had to be taken into account when growing these crops. It varied from 25 to 42 cm in spelt wheat and from 29 cm to 57 cm in intermediate wheatgrass during the stem elongation phase depending on the weather conditions of the research year. This indicator ranged from 107 cm to 113 cm and from 96 cm to 117 cm, respectively, in the earing phase, and from 137 to 168 cm and from 107 cm to 196 cm in the phase of milk ripeness of grain. Plants of spelt wheat and intermediate wheatgrass had a high stability index of the formation of dry matter and grain yield. It should be noted that intermediate wheatgrass formed a significant vegetative mass even in the earing phase. The vegetative mass in spelt wheat was formed during the earing period – full ripeness of grain. These crops (spelt wheat – 22.1 $\pm$ 0.4, intermediate wheatgrass – 22.4–24.6 $\pm$ 0.2–0.5) were significantly superior to soft wheat (12.1 $\pm$ 0.5) by the content of protein in grain, so it was recommended to involve them in the selection programs to create species with high productivity. However, spelt wheat (5.58 $\pm$ 0.13) was less and intermediate wheatgrass (0.98–1.22 $\pm$ 0.14–0.18) was the most inferior to soft wheat (8.03 $\pm$ 0.27) in terms of grain yield.

Keywords: Spelt wheat; Intermediate wheat-grass; Plant height; Plant development phases; Dry mass; Yield; Protein

Introduction

The main areas of agriculture are the production of high quality products, and the restoration of soil fertility with the use of prairie restoration with perennial cereal crops is a priority task in the United Nations strategy (Agriculture, Forestry and Fishery Statistics, 2016). Currently, spelt wheat is used in organic farming (Poltoretskyi et al., 2018). Intermediate wheatgrass is a promising crop for prairie restoration (Crews et al., 2018).

Western European agriculture is characterized by a high level of productivity of grain crops production. Such productivity is largely the result of specialization and intensification of farms. However, this type of management has led to environmental problems and greater dependence on adverse environmental factors (Duchene et al., 2019).

Spelt wheat is now a world-famous crop used for the production of high quality products. It is able to form the yield in the conditions where soft wheat does not produce it. It is characterized by complex resistance to adverse environmental factors (Hospodarenko et al., 2018), so it attracts the attention of researchers as a crop capable of providing high quality grain.

Interest in the transition to a perennial type of cereal crops cultivation is due to moisture deficit and high temperatures during the vegetation period (Rezzouk et al., 2020). Extreme heat can cause changes in agricultural production and increase the risk of food security (Parker et al., 2020). The study of agronomic and physiological characteristics connected with the formation of the yield amount is an important component in the selection programs for the creation of high-yielding species of grain crops (Chairi et al., 2020). Perennial crops significantly predominate over annuals, as they have a longer vegetation period, permanent soil cover, reduce leaching of nutrients into deeper soil layers, emit more carbon into the soil, increase the resistance of the topsoil to erosion. Intermediate wheatgrass is one of the promising perennial crops (Oliveira et al., 2019).

Intermediate wheatgrass is an ecologically stable perennial crop. A population of intermediate wheatgrass (Kernza species) has now created in the United States by hybridizing of seven parent components of this crop, including soft wheat. It is known that this species forms a large root system that is able to absorb nutrients from hard-to-reach forms. Grain of intermediate wheatgrass is suitable for processing. It has proven to have reduced shedding, high threshing and high resistance to lodging under test conditions in the United States. The grain yield of this species was 696 kg/ha. The plants formed the highest productivity during the first two years of growing. The grain yield of the third growing year was lower (Bajgain et al., 2020). In other researches, intermediate wheatgrass had great advantages while growing as a perennial crop for four years with grazing of farm animals. In addition, this crop is a good precursor for soybean and corn (Hendrickson, 2014). Other scientists also studied intermediate wheatgrass as a fodder crop. In researches, the yield of the vegetative mass of plants varied from 7790 to 9200 kg/ha (Jungers et al., 2018). Observations by other scientists suggested that the species of intermediate wheatgrass – Kernza can be used as a fodder and food crop. In spring and autumn, the vegetative mass is used for fattening farm animals, and crops are used to obtain grain after regrowth in summer (Favre et al., 2019). Intermediate wheatgrass is a promising crop for use in food technology. It was found that the grain of this crop could be used for the production of products with a low glycemic index in the result of the study of the kinetics of starch hydrolysis (Zhong et al., 2019). However, these studies did not indicate how the elements of agrobiological indicators of plants were formed. In addition, the tests were conducted in the United States, which weather conditions were significantly different from the Forest-Steppe of Ukraine. It was not specified what protein content in the grain could be formed by plants of intermediate wheatgrass. Only detailed research on the impact of perennial crops on soil fertility would allow assessing the prospects of new species of perennial cereal crops to keep food security and a number of ecosystem services, especially in the context of climate change (Oliveira et al., 2019).

Materials and Methods

The study was conducted during 2017–2019 in the conditions of the Right-Bank Forest-Steppe of Ukraine at Uman National University of Horticulture. Kalancha (Ukraine) – a cultivar of soft winter wheat (*Triticum aestivum* L.), Zoria Ukrainy (Ukraine) – spelt wheat (*Triticum spelta* L.), Khors (Ukraine) and Kernza (USA) – intermediate wheatgrass (*Elytrigia intermedia* (Host) Nevski) were used in the experiment. Kernza cultivar was obtained by hybridization of *Triticum aestivum* L. / *Elytrigia intermedia* (Host) Nevski.
The experimental plot was located in Mankivka natural-and-agricultural district of the Middle-Dnieper-Buh district of the Forest-Steppe Right-Bank province of the Forest-Steppe zone with geographical coordinates of 48° 46'56,47" of north latitude and 30°14'48,51" of east longitude by Greenwich. Height above sea level was 245 m.
The climate of the region is temperate continental, with an average annual air temperature of 7.4°C. Periods with an average daily air temperature of more than 5°C last 205–215 days, more than 10°C – 161–170, and with a temperature above 15°C – 106–110 days. The sums of active temperatures are 2580–2900°C and hydrothermal index is 1.0–1.2. The relative humidity is 64–88%, according to the Uman weather station. In spring-summer period it decreases to 60–70%, and in autumn-winter period it increases to 80–85%. Average rainfall is 633 mm during the year and from 334 to 412 mm during the period with temperatures above 10°C.
Soil – chernozen podzolized heavy-loamed with high natural fertility, favourable for the growth and development of plants by neutral reaction of soil solution, good physical properties and nutritional regime. Humus content is 3.2–3.4%.
Weather conditions in the research years differed (Table 1). They were more favourable in 2018 for all cereal crops, as there were 35.8 mm of precipitation during the period of active stem growth. In addition, there were 65.6 mm of precipitation in March. The air temperature was also in the optimal range (9+16°C) (Table 2).

Table 1. The amount of precipitation during the vegetation period of cereal crops, mm.

Month	Year of research								
	2017			2018			2019		
	Decade								
	I	II	III	I	II	III	I	II	III
March	1.7	17.0	7.1	20.9	36.9	7.8	4.9	7.1	4.3
April	42.5	10.4	0.4	0.0	0.1	17.4	0.1	12.9	9.4
May	2.9	20.4	23.1	0.8	17.5	0.0	5.4	7.2	23.0
June	1.4	30.4	9.2	9.8	32.1	40.5	53.1	0.4	16.3
July	11.4	27.7	20.1	7.7	34.2	51.0	1.7	27.1	5.0

In 2017, there were 23.7 mm of precipitation during the period of active stem growth, and there were 78.7 mm of precipitation during the phase of spring tillering. However, the air temperature at the beginning of this phase of the development was unfavourable. In 2019, there were only 14.8 mm of precipitation during the period of stem elongation – the beginning of earing phase of soft wheat. Spelt wheat plants were in more favourable conditions than soft wheat because they had a longer stem growth period. There were 67.9 mm of precipitation during this vegetation period of spelt wheat. Conditions of moistening in the period of earing phase – phase of milk ripeness of grain were better in 2018–2019, and worse in 2017 – 64.1 mm of precipitation. The air temperature during this period was optimal for all cereal crops (18–22°C for the earing phase and 22–25°C for the phase of milk ripeness of the grain) during the years of research.

Table 2. Average air temperature during the vegetation period of cereal crops, °C.

Month	Year of research								
	2017			2018			2019		
	Decade								
	I	II	III	I	II	III	I	II	III
March	5.7	4.2	7.7	-4.3	-0.8	0.4	4.6	4.7	4.3
April	11.1	7.6	10.6	10.3	14.8	15.3	9.2	7.3	12.4
May	14.2	12.7	17.3	19.8	15.6	18.4	12.8	18.7	19.2
June	19.2	18.8	22.0	19.3	22.1	19.2	20.7	24.3	22.3
July	19.2	20.0	22.4	19.1	20.6	22.3	20.3	17.3	22.1

Phenological observations were carried out in accordance with the Methodology of state species testing of agricultural crops (2000). The height was determined by measuring the stem length of cereal crops, the value of vegetative mass – by choosing the plants from two running meters with the following weighing, moisture of vegetative mass – by thermogravimetric method, grain yield – by sections by sheaf threshing, protein content – by the method of infrared spectroscopy using Infratek 1241. The stability index was determined by the formula:

$$SE = \frac{HE}{LE},$$

where HE – The greatest manifestation of the feature;
LE – The smallest manifestation of the feature.

The plants height and the dynamics of dry weight growth were determined at the beginning of the stem elongation phase of cereal plants, thenearing phase and the phase of milk ripeness of grain. The experiment was repeated three times. Grouping of the variation coefficient was done according to the following gradations: 0–10% – insignificant, 10–20 – small, 20–40 – medium, 40–60 – large, ≥ 60% – very large. Statistical data processing was performed using Microsoft Excel 2010 and STATISTICA 8. Interpretation of the influence level by partial coefficient (thumb rule – Cohen): 0.02–0.13 – weak, 0.13–0.26 – medium, ≥0.26 – high. The "null hypothesis" was confirmed or refuted during the performing of variance analysis. The value of the coefficient "p" was determined for this purpose, which showed the probability of the corresponding hypothesis. In cases where $p<0.05$ "the null hypothesis" was refuted and the influence of the factor was significant (Tsarenko et al., 2000).

Results and Discussion

The calendar dates of the coming-in of the plant development phases varied significantly depending on the crop and the research year. Plant development phases in spelt wheat came much later than in soft wheat. In 2017, the stem elongation phase of spelt wheat came 4–5 days earlier compared to 2018 and 2019 due to more favourable weather conditions (Table 3). The earing phase and phase of milk ripeness of grain came almost at the same time over the years of research. The calendar dates in the studied species of intermediate wheatgrass differed significantly from soft wheat and spelt wheat, because the crop was grown as a perennial one. In the first year of growth, the plants of intermediate wheatgrass developed more slowly compared to other studied wheat species. Therefore, in 2017, the phase of stem elongation in intermediate wheatgrass plants came 30 days later compared to soft wheat. However, the phases of earing and milk ripeness of grain of intermediate wheatgrass came almost at the same time compared to spelt wheat. In 2018, the phase of stem elongation in intermediate wheatgrass came 8–10 days, and in 2019 – 21–23 days earlier compared to soft wheat. The phases of earing and milk ripening of grain in these years of research came almost at the same dates as soft wheat. It should be noted that the dates of occurring of the development phases while growing intermediate wheatgrass at the second and third years were almost the same. In addition, there was no large difference in the occurring of the development stages between the species of intermediate wheatgrass.

Table 3. Calendar dates of occurring of the main phases of plants development of cereal crops.

Species	Year of research								
	2017			2018			2019		
	1	2	3	1	2	3	1	2	3
Kalancha	10.04	17.05	05.06	15.04	20.05	18.06	25.04	22.05	03.06
Zoria Ukrainy	26.04	06.06	20.06	01.05	04.06	22.06	05.05	08.06	23.06
Kernza	10.05	03.06	15.06	05.04	24.05	03.06	02.04	22.05	01.06
Khors	10.05	04.06	17.06	07.04	26.05	05.06	04.04	25.05	03.06

Note 1 – The beginning of the stem elongation phase, 2 – Earing phase, 3 – Phase of milk ripeness of grain.

On average, for three years of research, the plant height of spelt wheat and intermediate wheatgrass plants of the Khors species in the stem elongation phase was at the level of soft wheat (Table 4). However, in Kernza species of intermediate wheatgrass it was 53% higher than soft wheat. The height of spelt wheat plants in the earing phase was 3.4 times higher than in the stem elongation phase. Plants of intermediate wheatgrass of Khors species – in 3.6, Kernza species – in 2.4 times higher. Plants of spelt wheat were 1.6 times, intermediate wheatgrass were 1.5–1.6 times higher than soft wheat plants. The increase in plant height of all cereal crops in the phase of milk ripeness of grain was smaller compared to the earing phase. Thus, the plants of spelt wheat were 1.4 times, intermediate wheatgrass – 1.5 times higher compared to the earing phase. Plants of spelt wheat were 1.6 times larger than soft wheat and 1.6–1.8 times higher than intermediate wheatgrass.

Table 4. Dynamics of plant height of different cereal crops, cm.

Species (factor A)	Year of research (factor B)			Average over three years
	2017	2018	2019	
Stem elongation (factor C)				
Kalancha	27 ± 2^{1}	39 ± 3^{1}	23 ± 2^{1}	30 ± 8^{3}
Zoria Ukrainy	28 ± 2^{1}	42 ± 2^{1}	25 ± 2^{1}	32 ± 9^{3}
Kernza	23 ± 2^{1}	57 ± 5^{1}	57 ± 5^{1}	46 ± 20^{3}
Khors	21 ± 2^{1}	33 ± 2^{1}	29 ± 1^{1}	28 ± 6^{3}
Earing				
Kalancha	58 ± 2^{1}	88 ± 3^{1}	54 ± 2^{1}	67 ± 19^{2}
Zoria Ukrainy	110 ± 2^{1}	113 ± 2^{1}	107 ± 2^{1}	110 ± 3^{2}
Kernza	98 ± 4^{1}	113 ± 3^{1}	117 ± 2^{1}	109 ± 10^{2}
Khors	96 ± 3^{1}	105 ± 2^{1}	105 ± 2^{1}	102 ± 5^{2}
Milk ripeness of grain				
Kalancha	89 ± 3^{1}	109 ± 2^{1}	77 ± 2^{1}	92 ± 16^{3}
Zoria Ukrainy	144 ± 3^{1}	168 ± 2^{1}	137 ± 2^{1}	150 ± 9^{3}
Kernza	113 ± 2^{1}	183 ± 26^{2}	196 ± 21^{2}	164 ± 45^{3}
Khors	107 ± 3^{1}	162 ± 20^{2}	181 ± 19^{2}	150 ± 39^{3}

p=0,003
Note. 1 – Insignificant, 2 – Small, 3 – Average variation.

Better humidification conditions and higher air temperature in 2018 contributed to the formation of the tallest plants of spelt wheat in the phase of stem elongation. This tendency was also observed in the phases of earing and milk ripeness of grain. Plants of intermediate wheatgrass of both varieties were the smallest in 2017. However, in 2018–2019, this indicator changed less from weather conditions. Thus, the difference in height of soft wheat plants in the phase of milk ripeness was 32 cm, and only 13–19 cm in intermediate wheatgrass depending on the year of research.
The results of statistical processing confirmed the significantly strong influence of "species of cereal crop", "year of research" and "plant development phase" factors on the formation of plant height of cereal crops (Figure 1). It should be noted that the partial coefficient between the studied factors and plant height was the highest – and it was from 0.98 to 0.99. The partial coefficient between the interaction of factors and plant height was less, but their influence was strong. It was obvious that the connection between "species of cereal crop", "year of research" and "plant development phase" factors was weaker or absent, so the influence of AB, AC, BC and ABC was lower compared to A, B, C.

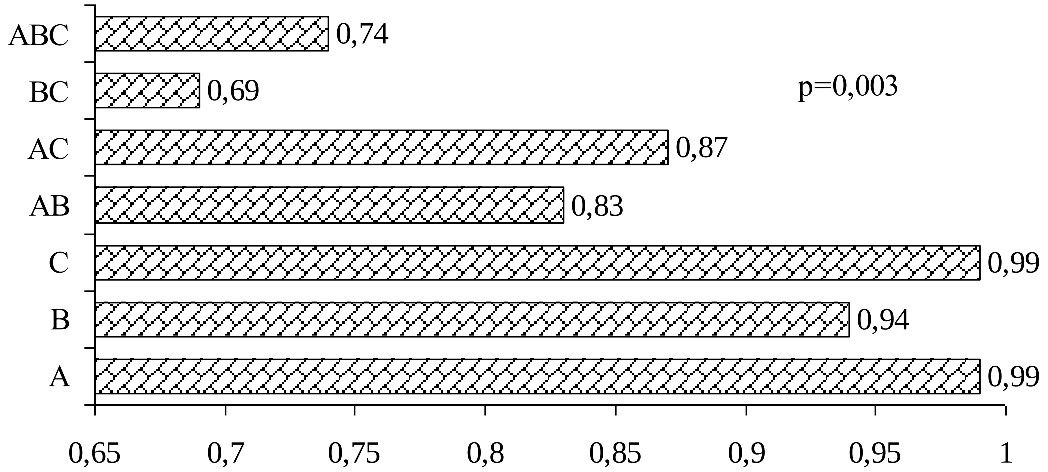

Figure 1. The level of factors influence on the plant height of cereal crops: A – "species of cereal crop" factor, B – "year of research" factor, C – "development phase" factor.

It was found that spelt wheat and intermediate wheatgrass were significantly inferior to soft wheat in the result of studying the dynamics of dry mass formation by plants of the studied cereal crops (Table 5). On average, over three years of research, this indicator in spelt wheat was 1.4 times and in intermediate wheatgrass was 1.2 times less compared to soft wheat in the phase of stem elongation. Plants of spelt wheat accumulated dry weight 1.4 times less than soft wheat in the phases of earing and milk ripeness of grain. Plants of intermediate wheatgrass accumulated dry weight 8–10% less in the earing phase and 1.3 times in the phase of milk ripeness of grain.

Table 5. Dynamics of dry mass formation by plants of different cereal crops, 10^3 kg/ha.

Species	Year of research[1]			Average over three years
	2017	2018	2019	
Stem elongation				
Kalancha	3,71 ± 0,04[1]	3,83 ± 0,05[1]	2,51 ± 0,05[1]	3,35 ± 0,16[1]
Zoria Ukrainy	2,36 ± 0,05[1]	2,43 ± 0,04[1]	2,24 ± 0,04[1]	2,34 ± 0,10[1]
Kernza	2,13 ± 0,04[1]	3,17 ± 0,05[1]	3,10 ± 0,04[1]	2,80 ± 0,58[2]
Khors	2,06 ± 0,05[1]	3,10 ± 0,03[1]	3,03 ± 0,02[1]	2,73 ± 0,58[2]
Earing				
Kalancha	5,22 ± 0,051	5,34 ± 0,03[1]	4,08 ± 0,08[1]	4,88 ± 0,13[1]
Zoria Ukrainy	3,45 ± 0,07[1]	3,57 ± 0,04[1]	3,33 ± 0,05[1]	3,45 ± 0,12[1]
Kernza	3,17 ± 0,06[1]	5,23 ± 0,05[1]	5,11 ± 0,03[1]	4,50 ± 1,16[2]
Khors	3,06 ± 0,04[1]	5,13 ± 0,04[1]	5,08 ± 0,04[1]	4,42 ± 1,18[2]
Milk ripeness of grain				
Kalancha	6,41 ± 0,06[1]	6,56 ± 0,08[1]	5,24 ± 0,04[1]	6,07 ± 0,16[1]
Zoria Ukrainy	4,36 ± 0,06[1]	4,51 ± 0,05[1]	4,27 ± 0,04[1]	4,38 ± 0,12[1]
Kernza	3,50 ± 0,05[1]	5,60 ± 0,08[1]	5,33 ± 0,03[1]	4,81 ± 1,14[2]
Khors	3,33 ± 0,05[1]	5,51 ± 0,07[1]	5,24 ± 0,03[1]	4,69 ± 1,19[2]

p=0,004
Note. 1 – insignificant, 2 – average variation.

More favourable weather conditions in 2018 contributed to the accumulation of more dry weight of all cereal crops. It should be noted that plants of intermediate wheatgrass accumulated the least dry matter compared to wheat in the first year of growth. In 2018–2019, the difference in the accumulation of dry matter by intermediate wheatgrass was insignificant. Thus, the difference between a favourable and a less favourable year of research in the phase of milk ripeness in spelt wheat was 0.24 × 10^3 kg/ha, and 0.27 × 10^3 kg/ha in intermediate wheatgrass. This indicator was 1.32 × 10^3 kg/ha in soft wheat.

The results of statistical calculations confirmed significantly (p≥0.05) the strong influence of the studied factors on the dry mass formation by plants of cereal crops, as the partial coefficient varied from 0.87 to 0.99 (Figure 2).

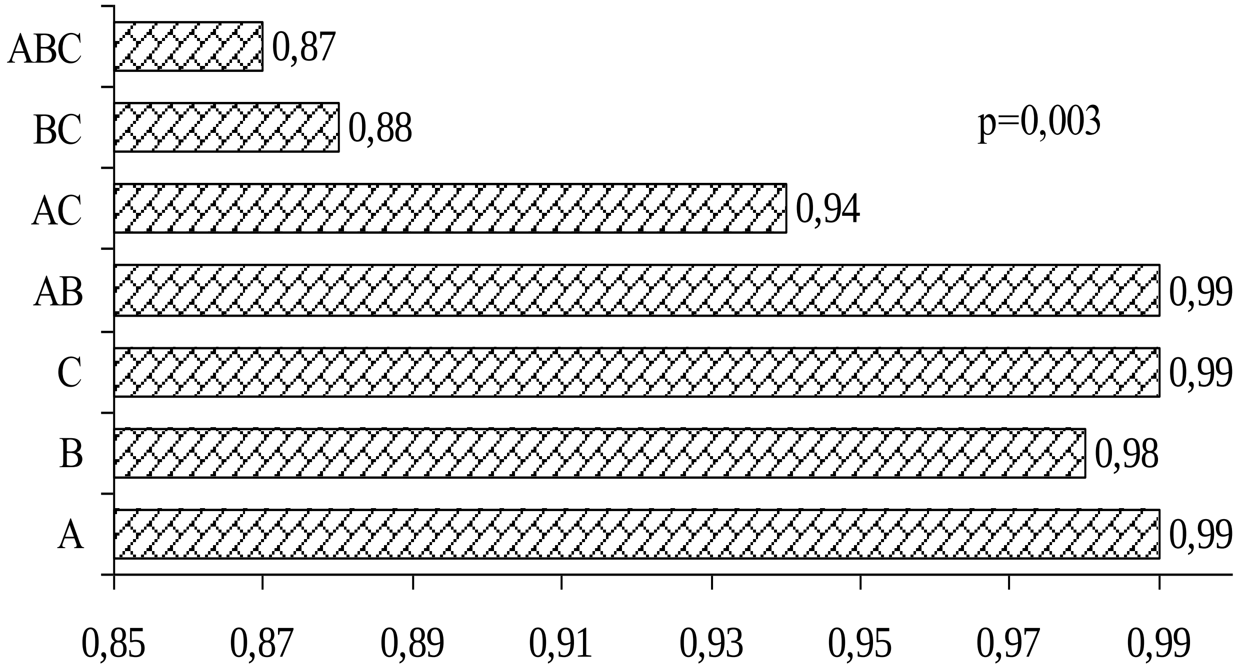

Figure 2. The level of factors influence on the dry mass formation by plants of cereal crops: A – "species of cereal crop" factor, B – "year of research" factor, C – "development phase" factor

Spelt wheat and intermediate wheatgrass by grain yield were significantly inferior to soft wheat (Table 6). On average, over three years of research, this indicator in spelt wheat was 1.4 times and in intermediate wheatgrass it was 6.6–8.0 times lower than in soft wheat. Better moisture supply of plants contributed to the formation of higher grain yield of spelt wheat and intermediate wheatgrass. The yield of grain in intermediate wheatgrass was the lowest in 2017.

Table 6. Yield of grain in different cereal crops, 10^3 kg/ha.

Species	**Year of research**[1]			**Average over three years**	**Stability index**
	2017	**2018**	**2019**		
Kalancha	8,34 ± 0,10[1]	8,73 ± 0,11[1]	7,02 ± 0,06[1]	8,03 ± 0,27[1]	1,2
Zoria Ukrainy	5,54 ± 0,06[1]	5,72 ± 0,06[1]	5,47 ± 0,06[1]	5,58 ± 0,13[1]	1,0
Kernza	1,06 ± 0,04[1]	1,32 ± 0,04[1]	1,28 ± 0,04[1]	1,22 ± 0,14[2]	1,0[3]
Khors	0,78 ± 0,04[1]	1,12 ± 0,03[1]	1,05 ± 0,04[1]	0,98 ± 0,18[2]	1,1[3]

p=0,002
Note: 1 – Insignificant, 2 – Small variation. 3 – Stability index was calculated for 2018–2019.

It should be noted that spelt wheat and intermediate wheatgrass were characterized by the formation of a stable grain yield, as the stability index was 1.1–1.0. Despite the high grain yield in soft wheat, the stability of its formation was lower. On average, over three years of research, the protein content of grain in spelt wheat was 1.8 times higher than in soft wheat (Table 7). This indicator in the grain of intermediate wheatgrass was 1.9–2.0 times higher. It should be noted that the protein content in the grain of spelt wheat and intermediate wheatgrass changed little depending on the weather conditions of the year of research. Spelt wheat and intermediate wheatgrass were significantly inferior to soft wheat in terms of dry mass and grain yield in the conditions of the Right-Bank Forest-Steppe of Ukraine. However, they were significantly dominated by the protein content in the grain. It should be noted that spelt wheat and intermediate wheatgrass had the highest stability in formation of dry mass and grain yield. However, these indicators in intermediate wheatgrass in the first year of growth were lower compared to the plants of the second and third year. This might be caused by the peculiarities of the development of intermediate wheatgrass. It was known that the root system was intensively formed in the first year of growth. The vegetative mass of sowing in the first year was less compared to the second and third year of growing of intermediate wheatgrass (Duchene, 2020). Therefore, the plants of intermediate wheatgrass were less responsive to adverse environmental factors than soft wheat in the second and third years of growth. Despite the fact that the species of intermediate wheatgrass – Kernza was created by the hybridization of *Triticum aestivum* L. / *Elytrigia intermedia* (Host) Nevski, the grain yield was only 1.06–1.32 × 10^3 kg/ha. The protein content in the grain was very high, which indicated the need for further selection improvement of this crop.

Table 7. Protein content in the grain of different cereal crops, %.

Species	Year of research*			Average over three years
	2017	**2018**	**2019**	
Kalancha	12,6 ± 0,2	12,0 ± 0,2	11,7 ± 0,2	12,1 ± 0,5
Zoria Ukrainy	21,6 ± 0,2	22,4 ± 0,2	22,2 ± 0,2	22,1 ± 0,4
Kernza	24,1 ± 0,2	25,1 ± 0,2	24,5 ± 0,1	24,6 ± 0,5
Khors	22,3 ± 0,2	22,6 ± 0,2	22,4 ± 0,2	22,4 ± 0,2

p=0,003
Note. * – Insignificant variation.

Spelt wheat in the conditions of the Right-Bank Forest-Steppe of Ukraine has more advantages in comparison with intermediate wheatgrass as it forms higher yield capacity of high-protein grain. Such advantages of spelt wheat compared to soft wheat were also confirmed by the studies by domestic (Moskalets et al., 2019) and foreign scientists (Koenig et al., 2015). However, intermediate wheatgrass is a promising crop for cultivation in the field crop rotation for two years to improve the soil structure and its microbiological activity in the layer up to 100 cm (Duchene, 2020). Today it is also relevant in the conditions of moisture deficit and high air temperature (Dong-Su et al., 2020).

Conclusion

The main agrobiological properties of spelt wheat and intermediate wheatgrass were studied. It was found that spelt wheat and intermediate wheatgrass had a high stability of crop formation and its quality in the conditions of the Right-Bank Forest-Steppe of Ukraine. The main stages of development in spelt wheat occurred on average 10–15 days later than in soft wheat. Plants of intermediate wheatgrass in the first year of growing had slower growth. The main phases of development in the plants of intermediate wheatgrass of the second and third year of growth occurred like in soft wheat. It was studied that these crops significantly prevailed over soft wheat in plant height. The height of the plants was over 100 cm in the earing phase. Plants of spelt wheat and intermediate wheatgrass had a high index of stability in formation of dry mass and grain yield. It should be noted that intermediate wheatgrass formed a high vegetative mass even in the earing phase. The vegetative mass in spelt wheat was formed during the phase of earing – full ripeness of grain. These crops were significantly superior to soft wheat in terms of protein content, so it was recommended to involve them in the selection programs to create species with high productivity. However, spelt wheat was less and intermediate wheatgrass was more inferior to soft wheat in terms of grain yield. The strong influence of "species of cereal crop", "year of research" and "development phase" factors on the formation of height and dry mass by the plants of cereal crops was established significantly ($p \geq 0.05$).

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