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The characteristics of wheat collection samples created by *Triticum aestivum* L/*Triticum spelta* L hybridisation

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Abstract. The aim of our research was to create, analyzes, and systematise wheat collection samples for the selection of valuable initial forms, to involve them in breeding process, and to create new productive cultivars. For this purpose the hybridisation of soft and spelt wheat was carried out, along with an evaluation of the hybrids that were obtained, between 2006 and 2018 (F_5–F_{10}). A collection of wheat samples, containing more than a thousand numbered items, was formed from the obtained diversity of samples. The economically-valuable and morphological characteristics of newly-developed materials were analysed. According to the results of our research, we selected forms of spelt, soft wheat, and speltoid samples which have high levels of productivity and high gluten and protein contents in grains.
Spelt wheat sample 1817 contains 45.2% gluten, 22.3% protein, and has a yield capacity of 6.55 t ha^{-1}. Soft wheat sample 1689 has 32.4% gluten, 15.8% protein, and a yield capacity of 7.19 t ha^{-1}. These samples were submitted for state scientific and technical expert evaluation in 2018. The created varieties of European spelt wheat and Artemisia soft wheat were included in the 'State Register of Plant Varieties Suitable for Distribution in Ukraine'.
The varieties, Artaniia and Artaplot, were submitted for state scientific and technical expert evaluation.

Key words: initial material, hexaploid species, speltoid hybrids, protein content, gluten content, ear density.

INTRODUCTION

The main task of wheat breeding consists of the creation of highly-productive varieties with excellent grain quality (Guzman et al., 2016).

However, in recent years there has been a tendency to increase yield capacity along with a noticeable deterioration in the quality of grain (Nazarova & Zhdanova, 2017).

Therefore a number of scientific institutions are working on developing wheat varieties with high productivity levels, resistance to unfavourable environmental factors, and high grain quality. The department of genetics, plant breeding, and biotechnology at Uman National University of Horticulture (Ukraine) has been conducting research into winter wheat breeding, applying the methods of intraspecific and remote hybridisation.

Worldwide practice has shown that an effective breeding method is the crossing of geographically remote forms, but success significantly depends upon a proper selection of hybridisation components - that is, the initial material (Xie et al., 2015; Longin et al., 2016). It is appropriate to use genetically remote forms to create new wheat varieties that would meet the demands of contemporary agricultural production (Polyanetska, 2012). In this respect wild, semi-wild, and now-forgotten forms act as donors of high protein content, gluten, lysine, and resistance to diseases and pests. It is reasonable to use spelt wheat as a donor of economically valuable characteristics.

It is a hexaploid species with genomic structure, A^uBD; therefore its hybridisation with a soft wheat of the same genomic structure is easy to carry out, although there are certain problems which are related to the morphological structure of plants and flowering time (spelt wheat is high-growing, while varieties that are used in hybridisation are mainly low-growing or semi-dwarf). At present this wheat species is used in breeding programmes because it is a donor of high protein content, and contains almost all of the nutrients in a balanced state that are necessary for the human body (Ikanović et al., 2016; Rapp et al., 2017).

Research by Ukrainian and foreign breeders has shown a positive effect in crossing soft wheat with spelt, in particular a substantial expansion of existing genetic diversity in the wheat and creating new forms that combine a high protein content and gluten from spelt and high productivity levels from soft wheat (Guzman et al., 2012; Polyanetska, 2012). However, according to the opinion of Rybalko (2011), these crossovers are undesirable because they lead to a deterioration in the grain quality of spelt and the inheritance of complicated grain threshing problems and soft wheat's 'fragile ear'.

Breeders from many countries deal with the improvement of the quality parameters of wheat grain by means of hybridisation with spelt. In this field some achievements were achieved in Switzerland, Austria, and Serbia, where the following spelt varieties were created: Bauländer, Schwabenkorn, Frankenkorn (Austria), Nirvana (Serbia), Altgold Rotkorn (Sweden) (Dvorak et al., 2012). In Ukraine a profound area of research in this area is being conducted at Uman National University of Horticulture, the All-Ukrainian Scientific Institute of Breeding, the plant production institute which was named in memory of V. Ya. Yuryev.

A number of research on the hybridisation of soft wheat and spelt have been conducted at the Uman National University of Horticulture, which allows a collection of samples to be created from obtained varieties of breeding materials which is unique in terms of morphological, biological, and biochemical characteristics. This is the source of valuable genetic plasma which can be use to improve existing varieties of wheat and to create new ones.

The objective of our research was to create new materials through the hybridisation of *Triticum aestivum* L/*Triticum spelta* L, and to systemise the collection wheat samples with the aim of selecting valuable initial forms with high levels of grain quality, using them in the breeding of highly-productive varieties.

MATERIALS AND METHODS

Specialists at Uman National University of Horticulture (Ukraine) carried out a number of studies on soft wheat and spelt hybridisation. Wheat variety samples were created by using the methods of intraspecific and remote hybridisation with multiple individual selection. The creation of a collection of wheat samples began in 2006 under the guidance of F M Parii, doctor of biology. Zoned soft winter wheat varieties, Favorytka, Smuglianka, Podolianka, Zolotokolosa, Harus, Bilotserkivska semi-dwarf, Murhad, Kruzhunka, Farandol, Ermak, Selyanka, Panna, Olesya, Olvia, Poverna, Slavna, Krasnodarska 99, Panna, and samples of spelt wheat from local breeding in the foothills of the Carpathians were involved as initial material in species crossovers. When the research began (in 2006) there were no spelt wheat varieties in Ukraine. Hybridisation was carried out by the manual castration of female flowers and the subsequent forced pollination of the male parent.

The $F_{2\text{-}5}$ hybrid progenies were analysed according to the manifestation of morphobiological traits and economically valuable parameters (such as plant height, length, colour, and the density of the ear, the threshability of the grain, the weight of grain from the main ear, the weight of a thousand grains, the content of protein and gluten in the grain, gluten quality, yield capacity, and so on). In the fifth generation (F_5), when splitting was no longer observed, and when considering plant habitus and the morphological structure of the ear, all of the materials created were divided into soft wheat, spelt wheat, and intermediate (speltoid) forms. The best samples which had economically valuable parameters were selected from each group for further testing. The testing of the selected samples was carried out during 2012–2017 (F_5–F_{10}).

All analysis and observations were conducted in accordance with the 'Ukraine state methodology for the testing of agricultural crops' (2011). The gluten content was detected by using the methodology of the state scientific and technical expert evaluation of plant varieties (2011). The height of the plants was measured in the field prior to harvesting. The grouping of wheat samples was carried out according to the height of the plants, using the procedure which had been drawn up by Dorofeyev et al. (1987). Harvesting and the recording of grain yields was carried out during the firm ripening stage. The soft winter wheat variety, Podolianka, was used as a standard for the soft wheat group, while the winter spelt wheat, Zoria Ukrainy, was used as a standard for the spelt wheat group, and for the intermediary group both of the aforementioned varieties were used as standards.

A method involving the systematic placement of plots with an accounting area of 10 m^2 was used in experiment. Numbered plants were placed in blocks with a plant density of 400,000 units for each hectare. Experiments were conducted in repetitions of five. Plant biometrics were determined for fifty plants, each of which were selected from each plot in two nonadjacent repetitions. The threshing of grain was carried out and yield capacity was defined after all measurements had been taken. The credibility of the research, the degree of variation of the characteristics, and the significance of differences from the parameters of productivity in the experiments were all evaluated by making use of the methodology which had been developed by Ermantraut et al. (2000), using MS Excel.

RESULTS AND DISCUSSION

Hybridisation between highly productive zoned winter soft wheat varieties and spelt wheat samples of our own selection was carried out during the process of our research. The descendant samples that were obtained were self-pollinated or re-crossed with parental forms. Individual family selection amongst descendants was used to select the samples, with these being characterised by a significant diversity according to economically-valuable characteristics, and morphological and biological properties. Today the wheat collection includes more than a thousand samples. The collection consists of sample varieties of soft wheat, spelt wheat, and speltoid hybrids with a set of valuable properties, such as early ripeness, dwarfness, and high winter resistance. Some materials surpassed the initial varieties in terms of yield capacity, and the protein and gluten content.

All of the materials created beginning from the fifth generation (F_5), while considering plant habitus and the morphological structure of the ear, were divided into soft wheat, spelt wheat, and intermediary (speltoid) forms. The soft wheat group includes samples with a medium-dense or dense ear (between 16–28 spikelets for each 10 cm of ear), with normal glume levels and easy grain threshing. The spelt wheat group comprises forms with a long, loose ear (< 16 spikelets for each 10 cm of ear), plus rough glume, and a complicated grain threshing. The samples which, according to their ear morphological structure, had an intermediary position amongst the parental forms, were classified in the speltoid wheat group.

The collection includes a wide range of forms which are categorised according to their height. The height variability of the plants ranges between 52–129 cm. The samples created were grouped according to the Dorofeeev classification (1987) into tall-growing (> 120 cm), medium-growing (105–119 cm), low-growing (85–104 cm), semi-dwarfs (60–84 cm) and dwarfs (< 60 cm). The most numerous and productive examples were low-growing and semi-dwarf samples.

Spelt wheat is a tall-growing species. This is why reducing plant height with a resultant saving of high protein and gluten content is an important task for plant breeding. The height of spelt wheat plants varies within the range of 75–127 cm, the variation coefficient exceeding 20% (V = 36%), which indicates a significant variation in the samples created according to this parameter. A significant decrease in plant height when compared to the standard height was recorded in ten samples (Table 1).

The semi-dwarf 1559 and dwarf 1817 samples of spelt wheat, which are characterised by high yields for this type of wheat (6.36 and 6.55 t ha^{-1} respectively), both were selected.

The main purpose behind the hybridisation of soft wheat with spelt wheat was to create new wheat forms which produced high levels of protein and gluten content. The gluten content in soft wheat grain varies between 26–30%, and protein levels vary between 12–14%. For spelt wheat grain these indicators are significantly higher: the gluten content reaches 45–50% and the protein content is over 20%.

In those spelt wheat samples which have been created, the protein content varied between 16.4–24.0%, while the gluten content fell within 35.1–48.8% depending upon the genotype. The high values of variation coefficient indicate a significant range of variability in terms of the content of protein and gluten. Samples of spelt wheat surpassed the forms of soft wheat and speltoid hybrids in this parameter. The highest content of protein and gluten were in varieties of spelt wheat, 1721 and 1691. Their protein content consisted of 24.0% and 22.8% respectively, while their gluten content was at 47.8% and 48.8%, which slightly exceeded the standard.

The negative features of spelt wheat are its low yield and difficult grain threshing. It was expected that its hybridisation with soft wheat would allow new forms of spelt wheat to be created with improved threshing qualities and higher productivity levels. As the result of this research, those forms were selected which surpassed the standard in yield capacity (samples 1695, 1691, 1755, 1559, 1674, 1817 and 1786). At the same time samples 1559 and 1817 showed high parameters of grain quality – in particular their protein content which reached 21.2% and 22.3% respectively, and a gluten content of 44.5% and 45.2%.

Table 1. Economically valuable parameters for collection samples of spelt wheat, average for 2012–2017

Breeding material	Origin	Plant height, cm	Grain weight of the head ear, g	Ear length, cm	1,000 grains weight, g	Gluten content, %	Protein content, %	Yield capacity, t ha^{-1}
Zorya Ukrainy (st)	ASIB*	116	1.82	15.8	50.5	48.2	23.7	5.52
1730	Favoritka × spelt	127	1.74	15.7	45.5	37.7	15.8	4.81
1695	Farandol × spelt	129	2.72	16.1	50.8	40.8	19.2	6.52
1691	Krasnodarska 99 × spelt	120	2.08	15.8	55.1	47.8	22.8	5.81
1719	Panna ×spelt	109	1.87	16.8	52.1	42.2	20.1	5.74
1721	Panna ×spelt	106	1.62	17.6	43.8	48.8	24.0	4.83
1725	Kopylivchanka × spelt	110	1.36	17.2	44.2	40.4	18.7	4.42
1755	Panna × spelt	98	2.33	17.5	51.2	39.2	18.1	6.04
1731	Favoritka × spelt	100	1.66	17.6	42.8	40.2	19.2	4.93
1559	Kryzhynka × spelt	87	2.45	18.3	65.0	44.5	21.2	6.36
1694	Farandol × spelt	98	1.78	18.1	43.4	41.2	19.4	5.15
1674	Farandol × spelt	89	2.06	15.0	55.5	35.1	16.4	5.86
1817	Kharys × spelt	75	2.67	18.3	50.2	45.2	22.3	6.55
1786	Favoritka × spelt	82	2.05	15.1	51.7	42.4	20.7	5.84
LSD_{05}		3	0.07	0.4	1.67	1.4	0.7	0.19
$x \pm S_x$		102.0 ± 10.1	2.03 ± 0.25	16.9 ± 0.7	50.1 ± 3.8	42.0 ± 2.3	19.8 ± 1.4	5.60 ± 0.42
Min		75.0	1.36	15.0	42.8	35.1	15.8	4.42
Max		129.0	2.72	18.3	65.0	48.8	24.0	6.55
V, %		36	8.55	8.4	79.6	35.4	28.7	8.88
S_x, %		4.6	0.06	2.0	3.5	2.5	3.3	0.03

* ASIB – All-Ukrainian Scientific Institute of Breeding - the originator of each variety.

The problem of reducing plant height for speltoid forms is also relevant, since this feature can manifest itself in intermediary forms which are similar to spelt. According to the height of the plants, significant variation was observed in speltoid forms (V = 28%) (see Table 2).

Table 2. Economically-valuable parameters for spelt-like samples, average for 2012–2017

Breeding material	Origin	Plant height, cm	Grain weight from the head ear, g	Ear length, cm	1,000 grains weight, g	Gluten content, %	Protein content, %	Yield capacity, t ha^{-1}
Podolyanka (st)	IPPG*	85	2.32	9.8	52.4	29.4	13.8	6.78
Zorya Ukrainy (st)	ASIB*	116	1.82	15.8	50.5	48.2	23.7	5.52
1669	Panna × spelt	99	1.45	14.0	45.8	33.6	16.2	4.95
1766	Favoritka × spelt	97	1.88	13.6	42.4	34.9	16.5	5.65
1710	Zolotokolosa × spelt	100	1.99	14.0	59.2	35.8	17.0	5.87
1626	Ermak × spelt	87	1.75	14.1	50.5	30.4	14.3	5.41
1561	Kryzhynka × spelt	102	2.27	14.6	51.4	36.4	17.5	6.45
1694	Selyanka × spelt	80	1.45	12.3	50.2	32.1	15.6	4.87
1809	Kopulivchanka × spelt	78	1.65	14.0	45.7	39.1	18.1	5.98
1800	Kharus × spelt	75	1.48	12.8	50.1	35.0	16.5	4.80
1628	Ermak × spelt	58	1.28	12.5	43.7	44.3	21.4	4.68
1635	Podolyanka × spelt	55	1.49	12.7	45.7	35.1	16.7	5.01
LSD_{05}		3	0.06	0.4	1.7	1.2	0.6	0.18
$x \pm S_x$		83.1 ± 12	1.67 ± 0.21	13.5 ± 0.6	48.5 ± 3.4	35.3 ± 2.6	16.9 ± 1.3	5.27 ± 0.40
Min		55.0	1.28	12.3	42.4	30.4	14.3	4.68
Max		102.0	2.27	14.6	59.2	44.3	21.4	6.45
V, %		28.1	4.14	5.4	49.2	38.2	20.6	5.09
S_x, %		6.5	5.76	1.9	3.2	3.3	3.4	3.41

*IPPG – Institute of Plant Physiology and Genetics NAS of Ukraine; *ASIB – All-Ukrainian Scientific Institute of Breeding.

Speltoid forms are significantly inferior to the Zoria Ukrainy variety in terms of plant height, and samples 1809, 1800, 1628, and 1635 are significantly inferior to both standards. Significant variation was recorded in the weight of a thousand grains within 42.4–59.2 g. There was a considerable decrease in the weight of a thousand grains in speltoid forms when compared to the standard Podolyanka variety. The only exception was sample 1710 with a weight for a thousand grains at the level of 59.2 g, which is the highest index in the experiment. In speltoid materials, only the low-growing sample 1561 is characterised by a combination of high productivity levels and an increased gluten content in its yield capacity, in which it approached the Podolyanka variety (6.45 t ha^{-1}) and considerably surpassed it in terms of its content of gluten (36.4%) and protein (17.5%).

There were no high-growing samples in the soft wheat group. Two medium-growing samples were selected, although they failed to show high parameters in productivity and grain quality. The height of plants in this group varied between 52–100 cm, and in this case the variation coefficient reached 28%, which indicates a considerable variation in this feature (Table 3).

Table 3. Economically-valuable parameters for the collection of soft wheat samples, average for 2012–2017

Breeding material	Origin	Plant height, cm	Grain weight from the head ear, g	Ear length, cm	1,000 grains weight, g	Gluten content, %	Protein content, %	Yield capacity, t ha^{-1}
Podolyanka (st)	IPPG	8	2.32	9.8	52.4	29.4	13.8	6.78
1692	Krasnodarska 99 × spelt	100	2.45	8.5	55.2	30.1	14.2	7.02
1687	Myrchad × spelt	87	2.12	9.8	53.1	29.7	13.7	6.45
1688	Myrchad × spelt	89	1.55	6.4	48.7	35.4	16.5	5.49
1684	Ermak × spelt	90	1.78	8.8	45.7	38.1	17.8	5.74
1685	Ermak × spelt	95	2.35	9.8	52.0	30.2	14.2	6.87
1682	Selyanka× spelt	90	2.10	9.4	50.8	27.5	12.9	6.36
1694	Smuglianka × spelt	80	2.02	9.5	52.5	34.6	16.1	5.97
1689	Zolotokolosa × spelt	80	2.52	9.0	53.4	32.1	15.8	7.19
1686	Kharus × spelt	77	2.10	8.7	50.1	31.7	15.2	6.40
1681	Kharus × spelt	75	1.58	6.4	46.5	36.4	17.1	5.38
1675	Selyanka × spelt	60	1.98	9.5	48.9	33.4	16.1	5.80
1678	Selyanka × spelt	58	2.22	8.8	46.8	32.2	16.0	6.30
1514	BCNK × spelt	55	2.01	8.0	48.2	28.8	13.5	6.74
1598	Podolyanka × spelt	52	1.85	9.4	47.8	33.8	16.4	5.95
LSD_{05}		3	0.07	0.3	1.7	1.1	0.5	0.22
$x \pm S_x$		77.7 ± 9	2.0 ± 0.17	8.7 ± 0.6	50.0 ± 1.7	32.4 ± 1.8	15.4 ± 0.8	6.26 ± 0.32
min		52.0	1.6	6.4	45.7	27.5	12.9	5.38
max		100.0	2.5	9.8	55.2	38.1	17.8	7.19
V, %		31.1	4.14	13.7	17.1	28.6	14.2	5.09
S_x, %		5.4	3.80	3.4	1.6	2.5	2.5	2.41

*IPPG – Institute of Plant Physiology and Genetics NAS of Ukraine.

In this group of plants there was a significant variation (V = 28.6%) in terms of gluten content. The range of variability fell between 27.5–38.1 g. A significant increase in gluten and protein content when compared to the standard was recorded in all samples, except 1692, 1687, 1682, and 1514, which have these indicators at the level of the control variant.

The forms with a different ear shape were selected for the seed plot. Considering the ear morphological structure, all of the materials obtained were divided into six morphological types: spelt (Fig 1, a), speltoid forms (Fig 1, b), forms with the typical ear for a soft wheat (Fig 1, c), squareheads (Fig 1, d), subcompactoids (Fig 1, e), and compactoids (Fig 1, f).

Figure 1. Wheat morphotypes by ear shape.

The characteristics of each morphotype are given in Table 4.

Table 4. The morphotype characteristics of wheat collection samples by ear shape

Morphotype	Sample	Ear density, pcs. of spikelets/ 10 cm of ear	Ear length, cm	Characteristics
Spelts	1786, 1817, 1674, 1559, 1731, 1755, 1725, 1721, 1719, 1691, 1695, 1730	< 16	> 15	Long, loose ear with tough glume and difficult grain threshing of the ear
Speltoides	1635, 1628, 1800, 1809, 1561, 1626, 1710, 1766, 1669	< 16, 17–22	12–15	Elongated, loose or medium dense ear with difficult grain threshing
Typical soft wheat	1598, 1514, 1675, 1686, 1682, 1685, 1684, 1692	17–22	8–12	Medium dense ear with soft glume and easy grain threshing
Squareheads	1689, 1687, 1678	17–22, 23–28	8–12	Compacted upper part of ear
Subcompactoids	1688, 1675	23–28, > 28	6–8	Shortened ear with compacted upper and middle part
Compactoids	1598, 1693	> 28	< 6	Short very dense ear

From the practical point of view, speltoids with the typical ear of a soft wheat and squareheads are the most valuable, because these forms have a well-grained ear with an easy grain threshing which insures high crop yields. In our studies these forms were the most productive. In particular, the squarehead samples 1689 and 1692 with the typical ear of a soft wheat produced the highest yield in the trial (with 7.19 and 7.02 t ha^{-1}).

Spelt doesn't have a high ear grain content and, as a result, its productivity levels are lower. However, the main obstacle to the large-scale introduction into manufacture of spelt is the difficult threshing of its ear grain (the threshing capacity of grain makes up about 60% of the total), which complicates the process of mechanically gathering their crops.

Among the collection samples, the most productive spelt wheat forms were samples 1695, 1755, 1559 and 1817, which all showed high yield capacity for this wheat species: 6.04–6.55 t ha^{-1}, with these results significantly exceeding the Zorya Ukrainy variety (5,52 t ha^{-1}) at $LSD_{0.05}$ = 0.19. Forms with a long, loose ear have a number of advantages, in particular their rapid ear drying after rain, which helps to lower their susceptibility to disease, plus they are able to form large grains which have better technological qualities.

High fertility levels of the pollen and a better yield capacity were recorded in these forms. Therefore the aforementioned samples which have a long ear and high yields can be used for wheat breeding improvement programmes according to a number of economically valuable properties.

In subcompactoid and compactoid forms the number of grains in the head ear can reach up to 70 pcs, but their grain is shrunken and small, which negatively influences productivity. In our studies two subcompactoid samples were selected, 1688 and 1681, with a yield of 5.38–5.49 t ha^{-1} and with a short (6.4 cm), well-grained (54 pcs) ear. Eleven compactoid samples were also created, with grain levels of 70 pcs per ear, but their productivity levels remain low (about 5.0 t ha^{-1}).

Grain weight from the head ear is an important parameter. It positively correlates with yield capacity and can be used in selecting high-yielding genotypes at early stages of breeding work. In wheat collection samples, grain weight from the head ear varied between 1.28–2.72 g. Spelt wheat samples 1695, 1755, 1559 and 1817, soft wheat samples 1692, 1685, and 1689, and speltoid sample 1561 were the best varieties according to this indicator and they all exceeded the standard figures. The samples created differed significantly according to the duration of their vegetation period.

Spelt wheat ripens between 7–10 days later than soft wheat. The collection includes spelt wheat samples which have the same ear formation and maturation period as early ripening soft wheat varieties. Samples 1674 and 1719 have a vegetation period of between 280–285 days, and the yield capacity of grain significantly exceeded the standard (5.76–5.84 t ha^{-1}). Early-ripening genotypes were also selected from the soft wheat group and speltoid forms. These are samples 1685 and 1710 with a vegetation period of between 280–285 days, which ripened 7–10 days earlier than the Podolyanka variety.

In certain years of the research (between 2013–2015) there was a significant spreading of brown rust in wheat crops. Up to 80% of plants were damaged by this pathogenic agent. During this period spelt wheat samples 1674 and 1721 and soft wheat samples 1685 and 1692 showed high resistance to this pathogen. The intensity of damage to the material was less than 5% of the leaf surface, which corresponds to scores of 8–9 according to the scale of resistance. These samples can be used in the wheat breeding process as donors of brown rust resistance genes.

Collection samples are constantly tested, and the search has been successfully conducted for new donor forms which exhibit valuable traits. The highest yield capacity and parameters for ear productivity were recorded in soft wheat. Amongst the fourteen samples from this group, two considerably exceeded the standard according to yield capacity and two samples equalled the standard in this parameter. It is worth noting that spelt wheat samples 1695 and 1817 combined a high gluten content (> 40%) and protein (about 20%) with yield capacity.

As a result of the research, the Europe spelt wheat variety and the soft wheat varieties Artemisia, Artaniia, and Artaplot were created, while the Europe and Artemisiia varieties were also included in the State Register of Plant Varieties Suitable for Distribution in Ukraine, while the Artaniia and Artaplot varieties were submitted for state scientific and technical expert evaluation.

The varieties created had the following characteristics during the period in which the state scientific and technical expert evaluation was being carried out (over the course of three years) in various soil and climatic zones across Ukraine:

- Europe spelt winter wheat (breeding sample 1725). An awned form of spelt wheat, with 90% of grain separating from glume during threshing. The height of the plant is 110 cm. Average yield during testing reached 5.8 t ha^{-1} (2012–2015). Gluten content is 40%, and protein is 18%. The weight of a thousand grains is 45 g. Grain unit is 670 g L^{-1}. This variety is characterised by resistance to brown rust, powdery mildew, and snow mould, and a tolerance to yellow spotting, fusarium head blight, and root rot. Since 2015 this variety has been included in the State Register of Plant Varieties Suitable for Distribution in Ukraine;
- Artemisiia soft winter wheat (breeding sample 1686). The height of the plant is 79 cm. Average yield during testing was 6.5 t ha^{-1} (2012–2015). Gluten content is 38%, and protein is 16%. The weight of a thousand grains is 43 g. The grain unit is 690 g L^{-1}. This variety has resistance to powdery mildew and snow mould, and a tolerance to root rot, yellow spotting, and fusarium blight. This variety is frost and drought-resistant. Since 2015 i t has been included in the State Register of Plant Varieties Suitable for Distribution in Ukraine;
- Artaniia soft winter wheat (breeding sample 1684). The height of the plant is 80 cm. The ear is awnless. The average yield in the experiment was 5.5 t ha^{-1} (2015–2017). Gluten content is 38%, and protein content is 18%. The weight of a thousand grains is 45 g. The grain unit is 725 g L^{-1}. Resistant to powdery mildew, root rot, and snow mould;
- Artaplot soft winter wheat (breeding sample 1809). The height of the plant is 78 cm. The ear is awned. The average yield in the experiment was 6.4 t ha^{-1} (2015–2017). Gluten content is 39%, and protein content is 18%. The weight of a thousand grains is 45 g. The grain unit is 690 g L^{-1}. Resistant to fusarium and septoria blight, and also powdery mildew, and is tolerant to root rot and brown rust.

CONCLUSIONS

1. The collection of wheat samples which consisted of a thousand numbered items was created by the remote hybridisation of soft winter wheat and spelt wheat. Samples were analysed according to economically-valuable parameters and suitability for wheat breeding improvement. The collection includes unique recombinant forms which differ in terms of economically-valuable parameters, and in morphological and biochemical traits.
2. Spelt wheat forms, and soft wheat and speltoid samples were selected which combine high productivity levels with high gluten and protein content. These include spelt wheat sample 1817 with a gluten content of 45.2%, a protein content of 22.3%, and a yield capacity of 6.55 t ha^{-1}, and soft wheat sample 1689 which contains 32.4% gluten and 15.8% protein, and shows yields of 7.19 t ha^{-1}. These samples will be submitted to the State Scientific and Technical Expertise body in 2018.
3. The Europe spelt variety and the Artemisia soft wheat variety were created and were included in the State Register of Plant Varieties Suitable for Distribution in Ukraine, and the varieties, Artania and Artaplot, were submitted to the Ukraine State Scientific and Technical Expert Evaluation.

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