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THE USAGE PERSPECTIVES OF THE CHINESE CURRENT WHEAT GERMPLASM IN THE BREEDING OF A NEW UKRAINIAN VARIETY GENERATION

Volodymyr VLASENKO[1], Olha BAKUMENKO[1], Olena OSMACHKO[1], Vasyl BILOKOPYTOV[1], Fanhua MENG[2], Oleksandr HUMENIUK[3]

[1]Sumy National Agrarian University, Sumy, G. Kondratyiva Str., 160, Sumy, 40021, Ukraine, Phone: +380994759310; Fax +30542 701055
[2]Institute of Crops Science of Chinese Academy of Agricultural Sciences, 100081, Beijing, China, Phone/Fax: + 861082108581
[3]V.M. Remeslo Myronivka Institute of Wheat NAASU, Tsentralne Village, Myronivka District, Kyiv Region, Ukraine, 08853, Phone: +380(96)6835987; Fax: +380(4574)74446

Corresponding author email: lady.bakumenko88@gmail.com

Abstract

The research results of different periods (1996-2006 and 2012-2016) as for adaptive potential of the Chinese winter wheat assortment under the conditions of the Forest-Steppe of Ukraine are given in this article. 124 samples of Chinese origin were studied under the condition of the right-bank Forest-Steppe of Ukraine (1996-2006). Jimai 24, Jimai 30, 97-13, 97-46, Dongfeng 1, Handan 4564, FAN 20, Yumai 14, 89 Zhong 108, 89 Zhong 2 showed relatively satisfactory winter resistance. A larger number of samples retained their biological peculiarity - earliness of ripening and dwarfness. As for resistance to leaf diseases the Chinese assortment was characterized negatively under the conditions of the right-bank Forest-Steppe of Ukraine. It was very non-resistant to powdery mildew. About 70% of the forms were susceptible to the pathogen. The samples were also greatly destroyed with brown rust. Only 12% of the forms were relatively more resistant at the level and above of the standard. The leave damage with septoria disease was about 50% but it was less than resistance with powdery mildew and brown rust. None of the studied forms of Chinese origin significantly exceeded the yield standard. Under the conditions of the left-bank Forest-Steppe of Ukraine (2012-2016) 50 new wheat varieties of Chinese origin were studied: ultra-early ripening - 10%; early ripening - 54%; med-early ripening - 12%; mid-ripening - 24%. All studied samples showed comparatively satisfactory index of winter resistance (score 6.4-7.9). 16% of the studied genotypes were characterized by high resistance to overwinter, to the leaf disease and the crop yield: Longzhong 2, Longzhong 3, DF 529, Longzhong 4, Longzhong 7, Shijiazhuang 8, Longzhong 10, Longzhong 12. Comparing the obtained results, it was searched out that under the conditions of the left-bank Forest-Steppe of Ukraine the Chinese winter wheat assortment realized its genetic potential better.

Key words*: varieties of bread winter wheat, groups of ripening, winter resistance, disease resistance, crop yield.*

INTRODUCTION

Wheat has been grown in China at least for 4000 years. In recent years, wheat breeding has made a significant contribution to crop production in China. The facts on more than 1,850 Chinese wheat varieties from the 1920s to 2014 were collected (Qin et al., 2015). Wheat is grown in 30 of the 31 provinces of China in 10 major agroecological zones based on the type of wheat, the vegetation period, the main biotic stresses and the variety response to temperature and photoperiod (Dodson et al., 2013). Nowadays, the climate change and its impact on agriculture is a serious problem all over the world.

A characteristic feature of recent years is a gradual, but noticeable change in climatic conditions, which requires researches as for the crop adaptability including wheat (Liu and Tao, 2013).

The modern climate of Ukraine is characterized by warming, comes amid the decrease in precipitation. The air temperature increasing will lead to changes in natural processes and the seasons of the year duration, and then in the crop vegetation period, as well as in the spread of pests and diseases (Chajka and Adamenko, 2008). The breeders are faced with the task of finding ways to stabilize the productivity of main agricultural crops, including winter wheat grains, which among eared grains are characterized by the highest adaptability (Shakirzyanov, 2004). Modern winter wheat varieties have a high biological yield potential (up to 110 t/ha), which is realized no more than

50-60% in production (Chajka and Adamenko, 2008; Shakirzyanov, 2004). The low level of implementation depends on a group of factors, among which the adaptive potential of the variety takes an important place. Due to it, when creating new varieties, not only the increasing in the potential of their productivity is significant, but also the search for ways of its full realization, and the increase in environmental plasticity.

As a result of the above mentioned, the aim of our work was:

- to study the Chinese winter wheat assortment under the conditions of the Forest-Steppe of Ukraine;
- to select advanced samples with a group of breeding and valuable traits to carry out hybridization in the subsequent work;
- to obtain the combined genetic potential of the best wheat varieties of Ukrainian and Chinese origin.

MATERIALS AND METHODS

Experimental studies had been conducted for 10 years (1996-2006) in the breeding crop rotation of the V.M. Remeslo Myronivka Institute of Wheat (MIW) of the National Academy of Agrarian Sciences of Ukraine and for 4 years (2012-2016) in scientific and industrial production plot of Sumy National Agrarian University (SNAU) of the Ministry of Education and Science of Ukraine.

The MIW is located in the southeastern part of the Kiev region on the watershed of the Dnieper, Ros and Rosava rivers. The geography of the area is a wide and wavy, rather high plateau (about 150 m above the sea level) – so-called Dnieper-Kaniv 'tongue', divided into north-eastern and north-western parts by deep gully in the country between the Ros-Rosava rivers. The geographical location - latitude 49°, longitude 30°. The microrelief of the territory is characterized by shallow lowland of elongated form in 0.2-1.0 ha. The topsoil of the MIW experimental field is represented mainly by thick low humus coarse silty and sandy loamy slightly and medium alkaline chernozem. The humus horizon thickness is 38-40 cm, the humus content is 3.58-4.18%. The carbonate layer is at a depth of 45-65 cm, subsoil waters – 50-60 m and they do not affect the soil-forming process. These soils have high and medium availability of mineral nutrition elements and are marked by slightly acidic, close to neutral soil solution (pH of salt - 5.3-6.4), which has a good effect on winter wheat productivity (Suhovetskiy, 1976; Ahroklimaticheskiy biulleten mnoholetnikh dannykh po Mironovskomu rayonu Kievskoy oblasty, 1985).

SNAU is geographically located on the outskirts of Sumy city in the northeastern part of the left-bank Forest-Steppe Ukraine. The geographical location - latitude 50°, longitude 34°. The city is located on the banks of the Psel River at the confluence of the Sumka River. Sumy occupies the part of the Central Russian Upland and the Dnieper lowland (about 143 m above the sea level). The highest point of the region is 246.2 m above the sea level. In the South, East and West, Sumy borders on Kharkiv, Poltava and Chernyhiv regions of Ukraine. The northern part of the region Novgorod-Seversky Polesye, the southern part lies within the Forest-Steppe zone. On 70% soils are represented by typical chernozem thin-humous, typical chernozem leached thin-humous heavy loamy and chernozem typical thick-humous medium loamy. The average humus content of arable soil is 4.1%. The arable soil has a high phosphorus content (15.1-15.4 mg per 100 g) of soil and an average content of mobile potassium (6.7-8.0 mg per 100 g) of soil. The acidity of the soil solution is neutral - 5.9 pH (Masalitin, 2004).

In general, it can be argued that the soil conditions in the research fields of the MIW and SNAU are typical for zones, they allow to realize the genetically determined productivity potential of winter wheat varieties and carry out breeding work with this crop.

The analysis of weather conditions 1996-2006 and 2012-2016, conducted on the basis of annual data provided by the Myronivka meteorological station of Kiev region, located on the territory of the MIW and the meteorological station of the Institute of Agriculture of the North-East National Academy of Agricultural Science, located five kilometers from the SNAU experimental field.

The specific feature of Myronivsky District climate is its moderate continentality. The average long-term air temperature over the past

50 years is about + 7.9°C with variations over the years. The length of the frost-free period is 132-215 days, the average of about 165 days. The amount of precipitation for April-July is about 300 mm, or 60% of their annual amount. The most arid was June 1999, when the amount of precipitation was half the norm. As a rule, the reserves of productive moisture in the soil arable layer at the date of winter wheat sowing were sufficient with the exception of 1999, when the indicators decreased to the insufficient level. Under those conditions, the emergence of seedlings was slowed down, and they were unharmonious.

SNAU soils are referred to the second agro-climatic region of Sumy region, which according to the long-term data is characterized by a moderate, continental climate with warm summers and not very cold winters with thaws. There are no large water reservoirs that would affect the climate as a whole or its individual elements on the territory of the region. According to the long-term average data the coldest months are January and February, and the warmest months are July and August. From year to year the absolute minimum of air temperature most often takes place in January, and the maximum in August. Average daily (annual average) air temperature during 2012-2016 ranged from +7.9 to + 9.5°C, and the length of the frost-free period was about 230 days. Over the years the precipitation is within 597-600 mm, and most of all in the warm period (April-October).

In general, the weather conditions during the vegetation period of winter wheat differed from the average long-term indicators, both in temperature, and the amount of precipitation and their distribution from month to month. It should be noted about the temperature rising to the average annual indicator, as well as a slight increasing in precipitation. In total, it contributed to a comprehensive assessment of the studied varieties.

The samples of the Chinese winter wheat varieties originated from the expeditionary gatherings conducted by V.A. Vlasenko in Sychuan, Henan, Hebei provinces in 1996-2005 and in Gansu province in 2000-2012 were the material for conducting researches. The varieties Myronivs'ka 61, Myronivs'ka rann'ostyhla and Kryzhynka were used as the standard in the study of the Chinese assortment at the MIW (1996-2006). The cultivar standard Podolyanka was used in SNAU (2012-2016) for comparison. The experiments were laid out and conducted according to the generally accepted methods (Volkodav, 2003; Dospehov, 1985; Petrenkova et al., 2018; Babayants, 2011) using field, mathematical, statistical and laboratory methods (Tsarenko et al., 2000).

RESULTS AND DISCUSSIONS

The first expedition to the North-Western Province (autonomous district) Xinjian (city of Urumqi) took place in 1996. The following expeditions took place to the central and eastern provinces: 1998 - Hebei (Beijing, Handan); 2001 - Sychuan (Changde); 2002 - Henan (Kaifeng and Anyang, Lankou). In total, 205 forms of winter (171 varieties) and spring (34 varieties) bread wheat were introduced. They were studied at the MIW. In the period from 2002 to 2012 several trips took place to the provinces of Henan and Gansu (Dinkxi City), as well as to Beijing. As a result, 50 new forms of bread winter wheat were introduced. They were studied in SNAU.

Under the conditions of MIW the samples Jimai 24, Jimai 30, 97-13, 97-46, Dongfeng 1, Handan 4564, FAN 20, Yumai 14, 89 Zhong 108, 89 Zhong 2 were distinguished by comparatively satisfactory winter resistance (they overwintered with a score of 7-9) In general, most of the samples under field conditions had an unsatisfactory assessment as for winter hardiness; many of them are among the representatives of the eastern and especially the central provinces of China.

The plant height showed large fluctuation amplitude from dwarf (51-60 cm) to medium-growth (106-120 cm) forms (Table 1).

14% of forms belong to the group 9-26 cm exceeding Myronivs'ka 61. It was determined 24% of short-stemmed samples (with a height of plants up to 85 cm). The height of plants between 86 and 105 cm is typical for the most part (52%) of the studied samples. The group of 3-gene dwarfs includes Ren 117, Ren 119, Jimai 24, CAT 9933, № 2919, 97-03, Xin Dong 20 and others.

Table 1. The distribution of the Chinese wheat according to the plant height (MIW, 1997-2005)

Groups according to the plant height (Number of dwarfness gene)	Varieties number	
	Pcs.	%
to 60 cm (3 genes of dwarfness)	12	10
61-85 cm (2 genes of dwarfness)	30	24
86-105 cm (1 genes of dwarfness)	65	52
106-120 cm	17	14
Total	124	100

Most of the samples kept their biological peculiarity – ripening and dwarfness. 27% of forms out of the entire set as early as (earning for 11-14 days before Myronivs'ka 61 and for 3 days before Myronivs'ka rann'ostyhla), were noted (Table 2). 36% of the samples formed ears 3-10 days earlier than Myronivs'ka 61 and at the level of the Myronivs'ka early-ripening. In general, the early ripening forms made for almost two thirds of the total introduced Chinese wheat assortment.

Table 2. The distribution of the Chinese wheat according to the length of the vegetation season (MIW, 1997-2005)

Years	Total sample number pcs.	Number of samples in the ripeness groups (score)					
		early ripening		middle-early ripening		mid-ripening	
		pcs.	%	pcs.	%	pcs.	%
1997	30	5	17	7	23	18	60
1999	35	17	48	10	29	8	23
2000	31	11	36	15	48	5	16
2005	28	1	4	13	46	14	50
Total	124	34	27	45	36	45	36

The Chinese material was very unstable to powdery mildew (Table 3). About 70% of the forms were susceptible to the pathogen, and in 1999-2000 the indicator approached 90%, in many samples the damage reached the ear and even the awns. The samples 97-13, 97-14, Xindong 20, Xindong 18, 90-17, 90-109 and some others turned out to be relatively resistant (score 5-6, at the level of Myronivs'ka 61). In 2005, under conditions of moderate powdery mildew spreading, when the damage was medium, not a single sample with high resistance was recorded.

Table 3. The characteristic of wheat from China as for plant disease resistance (MIW, 1997-2005)

Years	Phytopathogens	Number of samples in the groups of pathogen resistance (score)						
		high (7-9)		medium (5-6)		low (2-4)		total, pcs.
		pcs.	%	pcs.	%	pcs.	%	
1997	Powdery mildew	0	0	12	40	18	60	30
1997	Septoria disease	0	0	16	53	14	47	30
1999	Powdery mildew	0	0	4	11	31	89	35
2000	Powdery mildew	0	0	4	13	27	87	31
2000	Brown rust	1	3	0	0	30	97	31
2000	Septoria disease	0	0	1	3	30	97	31
2005	Powdery mildew	0	0	22	78	6	22	28
2005	Brown rust	0	0	7	25	21	75	28
2005	Septoria disease	0	0	25	89	3	11	28
Total	Powdery mildew	0	0	42	34	82	66	124
Total	Brown rust	1	2	7	12	51	86	59
Total	Septoria disease	0	0	42	47	47	53	89

The samples were also widely damaged with brown rust. Relatively more resistant – at the standard level and above were only 12% of the forms. The septoria disease damage turned out to be less than powdery mildew and brown rust and on the average is about 50%, but overall this is not a positive assessment. Thus, as for resistance to leaf diseases, the studied Chinese assortment was characterized negatively. However, it was possible to separate several genotypes with phytopathogen resistance.

Due to precocity, the Chinese wheat stood against July droughts under the conditions of the MIW and thus it formed a relatively grain fillness when another limiting factor didn't influence. In different years, some samples formed ears with more than 70 grains, while the standard was within the limits of 40-70. With a high grain yield, the weight of 1000 seeds did not exceed 42 g. High variability of the ear productivity parameters and low coenotic resistance to planting density point at a low adaptive capacity studied Chinese varieties and breeding forms at the MIW. Practically none of the studied forms exceeded the standard for yield significantly.

Probably, the absence of Ukrainian wheat germplasm in the studied Chinese assortment is the reason of the low adaptive capacity of the latter under the conditions of the Right-Bank Forest-Steppe of Ukraine. It would seem that the soil and climatic features of the vast areas of wheat in China had a different impact on the process of formation and the of the natural selection vector. However, in general, the studied Chinese wheat assortment quite clearly maintained the whole characteristics according to the basic breeding features. At the same time, early ripening and shortness were the main valuable signs of the Chinese wheat.

At the various stages of the breeding work at the MIW there was a significant part of numbers and lines of winter wheat, created with the participation of the genetic source diversity of valuable features from China. For instance, in the competitive varieties control, the line Lutescens 23449 and the traits Lutescens 32408, Lutescens 32948 and Lutescens 32946 created with its participation represent the best breeding sources, in particular Chinese (Table 4). However, these lines could not compete with the best traits at the MIW.

Table 4. The line characteristics of the control seed plot obtained with the participation of wheat samples from China (MIW, 2006)

Trait name	Origination	Plant height (cm)	Lodging resistance (scores)	The time of earing	Resistance (score)			Crop yield (t/ha)	Sedimentation rate (ml)
					powdery mildew	brown rust	septoria disease		
Kryzhynka	Standard	101	7	2 June	7	7	4	4.69	51
Liutestsens 35714	Yu mai 29 / Venera	104	7	2 June	7	5	6	5.88	40
Erytrospermum 35706	Myr.61 / Zhunzo 8131 // Myr. 61	102	7	27 May	6	5	5	5.04	52
Lutestsens 34916	Han "HP 4589/3 / Myr. 27 / Myr. 29 // Xin Dong 20	86	9	23 May	6	5	4	4.80	53
Lutestsens 34915	Han "HP 4589/3 / Myr. 27 / Myr. 29 // Xin Dong 20	87	9	23 May	6	5	4	4.78	49
Lutestsens 35579	Zhunzo 8131 / Myr. 62	104	7	2 June	7	5	5	4.68	64
Erytrospermum 35596	Yu mai 29 / Erytrospermum 52959	98	8	2 June	7	6	5	4.52	65
$\bar{x} \pm t_{0,05}$; S_x (for seed plot)		97 ± 7	8 ± 1	(153 ± 3)	6 ± 1	5 ± 1	5 ± 1	5 ± 0.8	53 ± 12

Note: Myr. - abbreviation for the variety - Myronivs'ka.

Summarizing the results of research at the MIW, it was observed that the main shifts in the global wheat breeding were the creation of short-stalked forms of the dwarf, semi-dwarf type, most numerous in Chinese general assortment (Vlasenko, 2008). Problem is the breeding for resistance to leaf plant diseases, especially against powdery mildew and septoria disease. Obviously, the lack of germplasm of the Ukrainian assortment in the genotypes of China, which were studied in this assortment, caused a low adaptive capacity and reduced the activity and efficiency of the breeding process. The example of successful attempts to combine the variety germplasms of Ukrainian and foreign breeding, including China wheat, is Myronivs'ka 29. The variety was originated on the basis of the spring bread wheat sample BT-2288 from Tunisia with thermal mutagenesis method. The genome particle of the original Chinese (Chino 466) paternal form in Myronivs'ka 29 variety (Figure 1) is 3.13%. Since 1990, the variety had passed the State variety testing, which after 2 years at the originator initiative was removed from further testing. However, Myronivs'ka 29 is a valuable breeding source of short-stemmed, early ripening with high varietal ability in winter wheat breeding by the method of intervarietal form hybridization with different types of development.

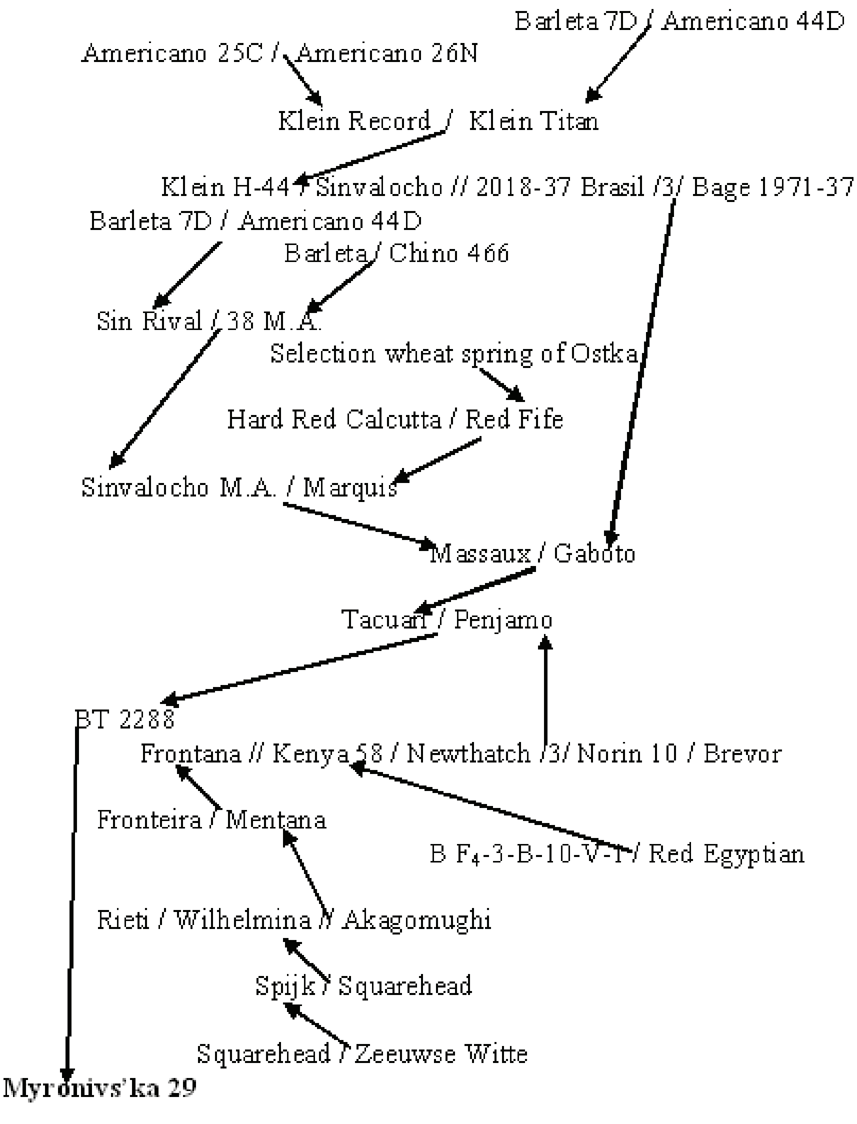


Figure 1. Background breeding of bread winter wheat Myronivs'ka 29

Besides, the germplasm presence from China in Myronivs'ka 29 variety, in our opinion, explains the positive result of its State variety testing in several provinces of China (Shansi, Hebei, Sinjiang Uygur Autonomous Region and others). This variety, as well as Myronivs'ka 808 and Kustanayskaya 56, were selected in 1996. At that time Du Zhenhua was the vice-principle of the Breeding and Plant Growing Scientific Research Institute of the China Academy Agricultural Sciences, officially bought seeds at the MIW and brought to China. However, as a result of the State variety testing, two other varieties did not show competitiveness among the Chinese breeding varieties. At the same time, Myronivs'ka 29 was also used as a new source material in breeding programs of Chinese institutions. Such continuation of breeding work in the future suggests good prospects for combining the germplasm of the best Ukrainian and Chinese varieties that can ensure their high adaptability and the possibility for commercial use in Ukraine and the People's Republic of China.

Under the condition of SNAU during 2012-2016 we had been conducted the study of new 50 winter wheat samples of the Chinese assortment obtained from the expedition gatherings in 2005-2012. In these studies, the samples were divided into four groups according to the length of the vegetation period from total germination to total earing. Then the standard cultivar (Podolyanka) was of the mid-ripening type. Its vegetation period was 229 days. The difference of the vegetation between the groups of ripeness in the studied varieties by as for time of earing was 4 days. The ultra-early ripening varieties included samples RS 412, DF 526, RS 6075, RS 526, RS 6079. Their vegetation period was 218 days or less. The early ripening varieties included the samples with a vegetation period of 219-222 days – RS 6049, RS 6076, RS 718, RS 6024, RS 6125, RS 6052, RS 6102, DF 549, DF412, DF 401, DF 529, DF 549, DF 425, DF 581, Duto 1081, Jimai 19, Jimai 22, Lankao 906, Lunxuau 518, CAO 175, Zhongmai 9, Shixin 733, Shi 4185, Jing 411, Shimai 12, Pekin KMS-2012, Jinan 17. The mid-early ripening varieties included the group of samples with a vegetation period 223-226 days – RS 987, Zhongmai 19, Jingdong 8, Longzhong 9, Longzhong 10.

The group of samples with a vegetation period 227-230 days was considered as middle-ripening – RS 6018, NSA 97-2082, Longzhong 1, Longzhong 2, Longzhong 3, Longzhong 4, Longzhong 5, Longzhong 6, Longzhong 7, Longzhong 8, Longzhong 11 Longzhong 12.

As for winter resistance (Table 5), all the groups of studied varieties were inferior to the standard. The level of winter resistance in the introduced varieties was score 6.4-7.9.

Table 5. Characteristics of the Chinese origin varieties as for winter resistance and plant height under the condition of SNAU, average 2012-2017

Group of varieties according to the vegetation season	Number of winter wheat samples (pcs.) according to the level of winter resistance			$\overline{x}$ in group (score)	Plant height, cm					
					$\overline{x}$ according to groups	Limits		Number of samples according to groups (pcs)		
	score 9-8	score 7-6	score below 4			min	max	*dwarf*	*semi-dwarf*	*growth medium*
Podolyanka, St	-			*8.0*	92.0	-				
Ultra - early ripening	1	3	1	*6.4*	53.2	42	63	1	-	4
Mid-ripening	11	1	-	*7.9*	83.5	55	100	-	9	3
Mid-early ripening	4	2	-	*7.7*	68.1	54	86	-	2	4
Early ripening	11	16	-	*7.4*	55.0	46	68	6	-	21

Note: $\overline{x}$ *– arithmetic mean*

As for the overwintering the mid-early ripening genotypes were not inferior to the standard (score<0.1). The early ripening cultivar Lankao 906 was in excess of the standard as for the adaptability to winter conditions. It had the highest winter resistance score in the experience - 9.0. The lowest winter resistance score was found in the ultra-early ripening variety RS 6075 - 3.0. In general, under the field conditions SNAU, Chinese samples had a satisfactory winter resistance compared to the standard. At the level of the standard (score 8)

52% of the studied samples overwintered: ultra-early ripening – 2%; early ripening – 20%; mid-early ripening – 8%; mid-ripening – 22%.

According to the plant height breeding trait the studied genotypes were also characterized positively. Among the Chinese samples, dwarf (30-50 cm), semi-dwarf (55-80 cm), and medium-grown (81-110 cm) forms were found. There were 22% of the studied forms at the level of medium grown cultivar Podolyanka. 64% of the studied samples related to the group of semi-dwarf forms. A smaller part (14%) of the Chinese assortment under SNAU conditions was characterized by dwarfness.

In our studies, it is affirmed that the realization of a high genetic potential of more than 8-10 t/ha provides varieties with a strong and short stem. A direct dependence was observed between: the group of ripeness (r = 0.96) → height of plants (r = 0.78) → winter resistance (r = 0.92) → group of ripeness. The varieties have a lower plant height and the winter resistance score with the vegetation period decreasing, According to the results of the calculations, the correlation parameter approaches +1, which indicates a close functional relationship between the studied traits.

With the help of analysis of variance, different reaction rates were found in varieties depending on the groups of ripeness, resistance to diseases and yield when the environmental gradient affected to wheat in different years of cultivation. Analyzing statistical indicators (Figure 2), the significance of factor contribution that influenced the manifestation of yield and resistance to disease was estimated. The genotype and ecological gradient influenced the object with a probability close to 100%, it was indicated by a confidence level which was less than 0.02%. It proves that the genotype and ecological gradient affect the yield and resistance to disease significantly.

The highest score resistance to powdery mildew (more than 6) in mid-early ripening and mid-ripening samples (6.5-7.1) was identified according to the results of the studied Chinese varieties, which were divided into four groups of ripeness. Ultra-early ripening and early ripening varieties were inferior to the standard cultivar Podolyanka with score 0.2-0.3. They also had score 0.5-0.6 lower than powdery mildew resistance from the experience average value.

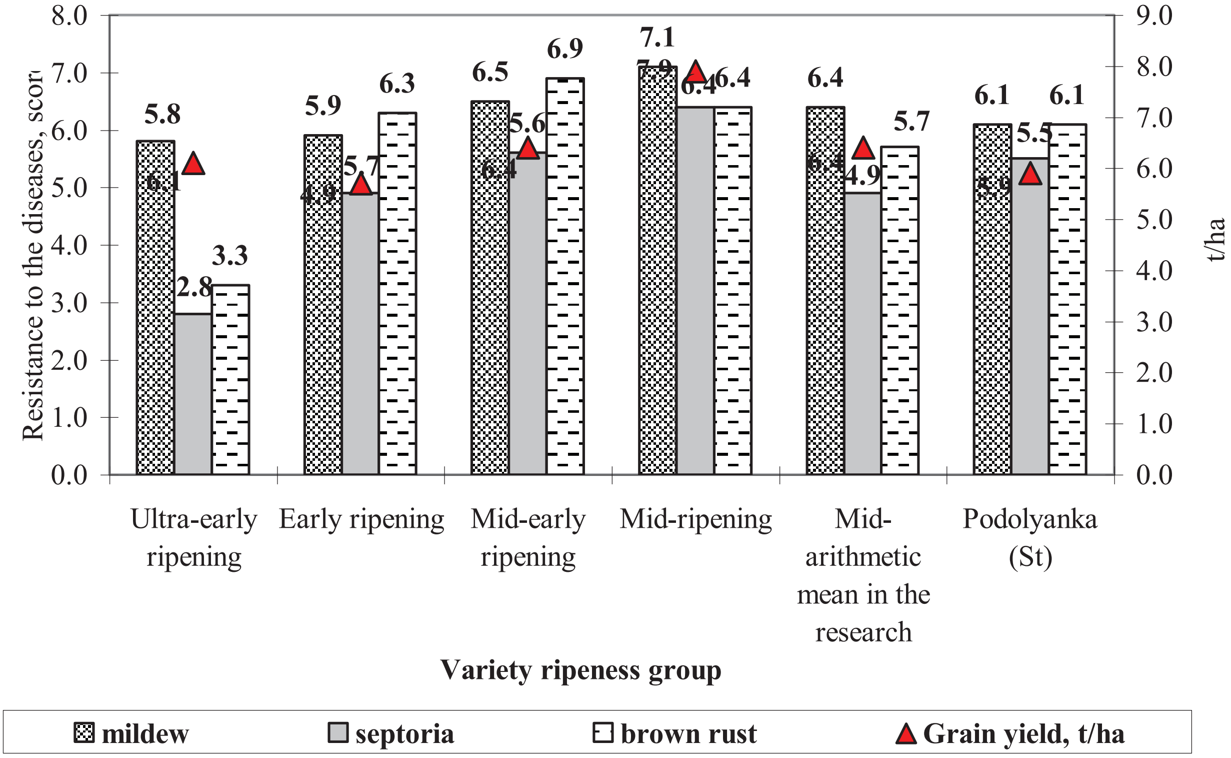
A similar situation was observed studying the resistance of the studied genotypes to septoria disease and brown rust.

The cultivar Podolyanka (St) was characterized by above the average resistance to leaf diseases. 61.5% of the studied genotypes exceeded the standard as for resistance to powdery mildew; 59% – to brown rust; 46.2% – to septoria disease.

The group of genotype ripeness did not cause high resistance to the studied diseases. The immune samples resistant to the complex of diseases are of a great value. Under the conditions of the left-bank part of the Forest-Steppe of Ukraine, the following genotypes were distinguished with a complex resistance: mid-ripening – Longzhong 1, Longzhong 7, Longzhong 2, Longzhong 4, Longzhong 12, Longzhong 3, mid-early ripening – Shijiazhuang 8, Zhongmai 19, Longzhong 10; early ripening – Jimai 22, Shi 4185, DF 529, DF 581, Lankao 906, CAO 175, Shixin 733, Zhongmai 9, Shimai 12. These genotypes are of interest for further research and may be recommended as sources of stable resistance to the group of leaf diseases.

In the studied varieties, the yield by groups varied from 6.1 to 7.9 t/ha. The lowest yield index was recorded in the group of ultra-early genotypes, the highest – in the mid-ripening group.

The average population value of the trait was 6.4 t/ha. At the same time, the cultivar standard had the average yield of 5.9 t/ha. It indicates the adaptive optimum yield of wheat introduced from China under the conditions of the left-bank North-Eastern Forest-Steppe of Ukraine. Such value points out a high potential for the varieties adaptability to research conditions. It should be noted that the groups of all varieties exceeded the yield of the standard cultivar.



		Resistance to the diseases			Grain yield. t/ha
		powdery mildew	septoria	brown rust	$\overline{X}$ according to groups
LSD05 / p	***Genotype influence***	0.54 / 0.00	0.47 / 0.00	0.69 / 0.00	0.36 / 0.00
	Eco-gradient influence	0.18 / 0.00	0.16 / 0.00	0.23 / 0.02	0.12 / 0.00
	Interaction eco-gradient + genotype	0.93 / 0.94	0.82 / 0.77	1.19 / 0.99	0.63 / 0.36

Figure 2. Characteristics of the Chinese origin varieties as for resistance to the leaf diseases and crop yield under the condition of North-East Forest-Steppe of Ukraine, average 2012-2017

In addition, mid-ripening genotypes exceeded the average population value by 2 t/ha. Among the studied samples in the early ripening – Jimai 19, DF 529; mid-early ripening – Jingdong 8, Longzhong 10, Shijiazhuang 8; mid-ripening – Longzhong 2, Longzhong 4, Longzhong 3, Longzhong 7, Longzhong 8, NSA 97-2082, Longzhong 5, Longzhong 11, Longzhong 12 the yield was significantly better in comparison with the standard. Selected varieties can be recommended for use in further experiments and the participation in the breeding process as sources of high yields.

As a result of the research, sources with a complex of valuable breeding properties were identified (Figure 3).

According to the plant height the selected samples belong to the groups of medium grown and semi-dwarf varieties. They showed complex resistance to adverse factors and had a high yield index. In total, 16% of the studied varieties were allocated, the early-ripening – DF529, the mid-early ripening – Shijiazhuang 8, the mid-ripening – Longzhong 10, Longzhong 2, Longzhong 4, Longzhong 7, Longzhong 12, Longzhong 3.

Lonzhong genotypes introduced from Gansu province, which is geographically located on platform II of the Chinese relief; according to the agricultural and climatic conditions it is closest to Ukrainian ones. The research results indicate that the genotype ability to adapt to a specific soil and climatic zone is the limiting factor of productivity.

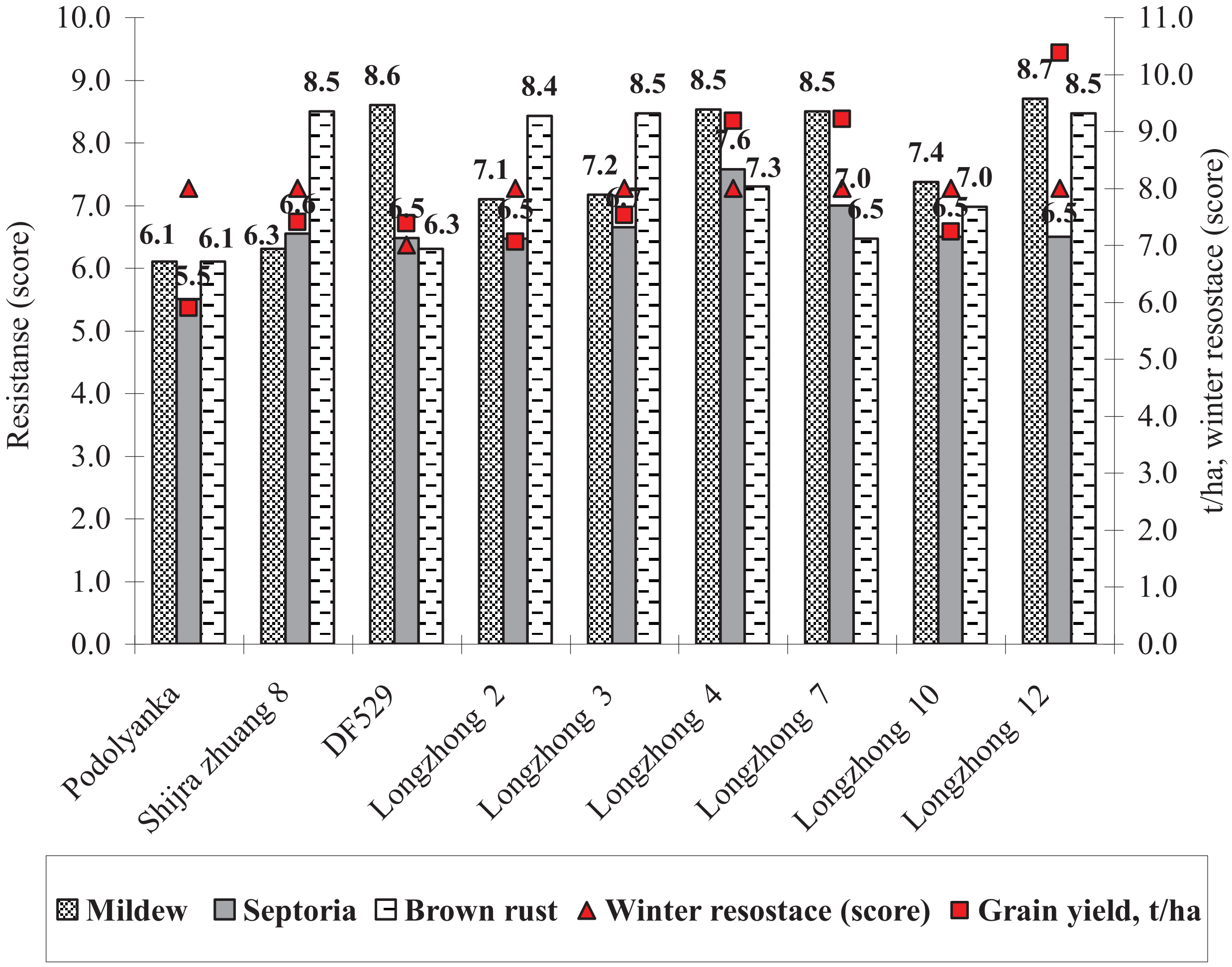


Figure 3. Wheat varieties of Chinese origin are sources of a valuable breeding complex properties (SNAU, average 2012-2016)

The obtained research results confirm the breeding value of the Chinese origin varieties. Introduced genotypes serve as donors of positive traits, that may appear when combining the wheat germplasms of Ukraine and China through hybridization.

Ukrainian breeders studying winter bread wheat and spring wheat forms introduced from China obtained both positive and negative results (Vlasenko et al., 2004; Vlasenko, 2008). It was defined that winter and frost resistance, the vegetation period, and the disease resistance are the main limiting factors under the condition of the right-bank central Forest-Steppe of Ukraine in the structure of the adaptive potential of winter wheat varieties. They determine the direction of breeding (Kolomiiets, 2007, Kolomiiets et al., 2018). According to literary sources (Vlasenko et al., 2018), under the conditions of the north-eastern Forest-Steppe of Ukraine, the Chinese wheat assortment is characterized by a positive adaptive capacity. The studied samples approved themselves as the highly intensive (b_i = 0.9-1.4) and extensive varieties (b_i = 0.3-4.5 with a “minus’ sign” in the growing region. High stability (S^2_{di} = 0.2) and homeostatism (H_{om} = 54.5-868.4) of the samples were also found under the studied conditions. It is valuable for breeding practice that most varieties of Chinese wheat contain in their genotype 1BL/1RS translocation. These varieties are carriers of the *Pm8* resistance gene and they are highly virulent to the powdery mildew population and have a stable (up to 94%) resistance manifestation (Wang et al., 2005). The studies show that translocation sources of different genetic and geographical origin are used worldwide in breeding programs to increase productivity, adaptability, and resistance to diseases and pests (Rona Mahmud et al., 2018).

So, the breeding value of winter bread wheat varieties the Chinese origin is beyond doubt. The results of research by various scientists (Sun et al., 2009, Li-feng et al., 2014, Shulin et al., 2018), including scientists from SNAU showed that in order to originate new and more adapted to the environment varieties the breeders should provide the advantage to the Chinese assortment.

CONCLUSIONS

124 samples of Chinese wheat assortment were investigated under the conditions of the right-bank Forest-Steppe of Ukraine (1997-2005). Some of them remain as the sources of breeding and valuable traits for the modern assortment creation today. It is confirmed by the results of Ukrainian breeders' work. Relatively satisfactory winter resistance (overwintered with a score 7-9) was distinguished in such samples: Jimai 24, Jimai 30, 97-13, 97-46, Dunfen 1, Handan 4564, FAN 20, Yumai 14, 89 Zhong 108, 89 Zhong 2. A large number of the studied samples maintained their biological peculiarity – early ripening and dwarfness.

Under the conditions of the left-bank Forest-Steppe of Ukraine (2012-2016) 50 new wheat varieties of Chinese origin were studied: ultra-early ripening – 10%; early ripening – 54%; med-early ripening – 12%; mid-ripening – 24%. All studied samples were distinguished by comparatively satisfactory winter resistance, the level of the index – score 6.4-7.9. 16% of the studied genotypes – Longzhong 2, Longzhong 3, DF529, Longzhong 4, Longzhong 7, Shijiazhuang 8, Longzhong 10, Longzhong 12, were characterized by high resistance to overwintering, leaf diseases and crop yields. Comparing the obtained results, it was searched out that under the conditions of the left-bank Forest-Steppe of Ukraine the Chinese assortment realized its genetic potential better.

The advanced continuation of the research is the assessment of genotypes that can provide in Ukraine the best adaptability and high level of the genetic potential realization of the grain productivity. This potential will follow the breeding requirements to the source material and prospects of its success as sources and donors of signs that appear when combining germplasms by hybridization.

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