UDC 633.11:631.525:575

USING GENE POOL OF RELATED SPECIES FOR BREEDING IMPROVEMENT OF WHEAT BY GRAIN QUALITY

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The possibility of using natural and artificially created species and synthetic amphidiploids to expand genetic diversity and to enrich gene pool of bread wheat by new original hereditary material was shown. It is advisable to involve wheat introgressive forms with genetic material from related species for breeding improvement of wheat by grain quality. Just the lines with genetic material derived from *T. dicoccum, T. polonicum, T. sphaerococcum, T. turgidum, T. compactum* and amphidiploids WAeAH *(T. dicoccum / Ae. tauschii),* AD 221-4 *(T. persicum / Ae. tauschii),* AS 7 *(T. durum / Ae. tauschii),* and *Ae. cylindrica* possessed the highest rates of sedimentation, gluten and protein content.

Key words: *wheat, wheat species, amphidiploids, wide hybridization, grain quality*

Introduction. The potential of modern wheat varieties productivity reaches 10-ton mark, but production of high quality food grains remains difficult task of the state level. Creation of modern varieties with high protein content in grain needs new genetic sources, because the gene pool of domestic bread winter wheat varieties for this trait is very limited. Most introduced sources are not adapted to the climate conditions of zone of Right-Bank Forest-Steppe, have low frost resistance and are affected with diseases being common in the region. To solve actual tasks of modern breeding, available genetic diversity of bread wheat is insufficient, so the researchers have to involve gene pool of cultivated and wild species of the tribe *Triticeae* Dum. in crossbreeding. Some of them have related genomes and are able to transfer

traits by common crossing. For the prevailing wild species it is necessary to use special methods of conversion of alian genetic material into a form being more accessible to initiate recombination processes and obtaining lines with translocations or substitution of chromosome and entire sub genomes.

Analysis of literature, formulation of the problem. During the 20th century breeders in many countries worldwide are trying to apply genetic pool of cereal related species and genera and to improve existing methods of introgression of hereditary material into bread wheat genome in order to enrich its gene pool [1-4]. Such studies contribute to progress in breeding this important food crop [5]. Creation and use of artificial amphidiploids is one of the effective methods [6-7]. They are mostly the same level of ploidy as bread wheat has and when crossing are able to produce viable offspring without use of *in vitro* embryo rescue technique.

Answering the high requirements for the current generation of commercial varieties of cereal crops, climate changes, and the emergence of new races of pathogens the opportunity to reconstruct genome of bread wheat by introgression of genetic material of related species and genera is of great importance in modern breeding. Recently a new trend in wheat breeding– creation of varieties for special purposes (pasta, confectionery or industrial use) based on the original genetic material is being successfully developed [8].

The purpose of the research is to expand genetic diversity by means of introgression of chromosomal material from alien species and to create new genetic sources capable of improving the existing gene pool of bread winter wheat by individual components of important trait, such the grain and flour quality is.

Material and methods of researches. The study was conducted with lines of bread winter wheat that we have created by wide hybridization in years earlier. Bread winter wheat varieties Podolianka, Myronivska 65, Myronivska 61, Lybid, Pyvna, Vesta, Snizhana, Donetska 66, Perlyna Lisostepu as well as durum winter wheat varieties Tytan, Zolote runo were involved into wide crossing. Artificially created species *T. kiharae* Dorof. et Migusch. (*T. timopheevii / Ae. tauschii*) 2n=42, *T. miguschovae* Zhir. (*T. militinae / Ae. tauschii*) 2n=42, synthetic amphidiploids obtained from the National Center for Plant Genetic Resources of Ukraine, namely, wheat-aegilops amphiploid hybrid WAeAH (*T. dicoccum / Ae. tauschii*) 2n = 42, AD (*Ae. ventricosa / T. dicoccum*) 2n=56, AD 221-4 (*T. persicum / Ae. tauschii*) 2n=42, wheat amphiploid hybrid WAH-39 (*T. dicoccum / T. sinskajae*) 2n=42, and species *T. sphaerococcum* Persiv., *T. polonicum* L., *T. durum* Desf., *T. turanicum* Yakubz., *T. turgidum* L., *T. spelta* L., *T. compactum, T. dicoccum*, genome-substitution form Avrotyka and two

Aegilops Ae. cylindrica Host, *Ae. tauschii* Coss. were used as pollinators. Productivity of lines was evaluated in plots of breeding and control nurseries as well as preliminary and competitive strain testing. In hybridization twirl-method of female plant pollination [9] was used. Indices of grain quality were determined in accordance with common methods.

Results and discussion. Works on introgressive hybridization at the Laboratory of Genetics have been being carried out during twenty years. It has been proved that introgressive crossbreeding induces powerful formative process which performs in successive series of generations, thus providing great opportunities to conduct targeted selection of material to be involved in breeding for high level of productivity [10-11], frost resistance [12], resistance against diseases (powdery mildew, brown rust, common bunt) [13-14], and indices of grain and flour quality [15-17].

Cultivated and wild wheat relatives and amphidiploids developed with their participation *per se* cannot be donors for use in breeding practice because they do not meet requirements for them. They are crossed with difficulty, have low fertility and are associated with a number of negative traits. Therefore, as the first step in our long-term work various genetically stable high fertile material was created based on wide crosses. On the second, equally important stage the material with a complex of agronomic traits was identified through the use of morphological, cytological, and electrophoretic analyses, evaluation of productivity, disease resistance, grain and flour quality, frost resistance and winter hardiness among the huge diversity of forms created. On the last stage donor properties of the best lines with a high level of manifestation of valuable traits were tested in the system of simple and diallel crosses.

Some wheat relatives were remarkable for high protein content in grain, valuable properties of gluten complex and were able to improve the quality indices of breeding material. Since 2011 based on F_3 hybrid combinations of introgressive origin the individual head selections were conducted in order to obtain more constant material. In 2014-2015, the 40 lines thus obtained were evaluated for indices of grain and flour quality, and the best of them were passed to nursery collection of MIW as sources of these traits (Table 1).

Lines derived from hybrid combinations Favorit / Avrotyka // Myronivska 61 / Podolianka were the most high-protein; moreover some of them had 16.6% protein content on average over two years. Selected lines from hybrid combination Myronivska 61/ *Ae. cylindrica* // Podolianka were the best by sedimentation indices being 60-74 ml in 2014 and 71-77 ml in 2015, whereas selected lines from combination Favorit / *T. durum // T. polonicum* / Podolianka were the best by wet gluten content (40.4-45.4%).

Table 1

Grain quality characteristics of the best introgressive lines of bread winter wheat (2014-2015)

Origin	Protein content, %	Sedimentation index, ml	Protein content, %	Sedimentation index, ml	Wet gluten, content %	GDI, unit
	2014		2015			
Podolianka, St	12.1	52	13.6	52	33.4	83
Lybid / AS-7 // Vesta	14.7	46	13.7	43	31.8	92
Favorit / *T. compactum* // Myronivska 61 / Vesta	13.7	60	14.3	64	36.7	98
	15.8	51	17.4	59	46.7	105
	14.5	71	15.3	56	38.2	83
Favorit / *T. compactum* // Myronivska 61 / Pyvna	14.5	71	13.4	65	33.4	112
	13.7	66	13.6	64	35.5	98
	13.6	60	13.8	67	34.2	86
Favorit / Avrotyka // Myronivska 61 / Podolianka	13.2	61	14.6	69	36.1	79
	13.0	64	14.9	70	39.1	102
	12.3	63	14.9	69	38.7	98
	12.8	62	15.6	78	37.7	88
Favorit / *T. durum* // *T. polonicum* / Podolianka	13.0	51	15.9	68	40.4	91
	13.6	58	16.9	64	45.4	102
	14.3	64	16.5	69	43.4	91
Myronivska 61 / *Ae. cylindrica* // Podolianka	13.6	64	16.0	71	42.1	98
	12.4	60	16.2	75	42.4	76
	13.2	64	14.8	71	35.6	83
	13.9	74	16.0	77	42.1	91

In 2015 grain protein content for 40 lines obtained by distant crosses varied within 10.9-17.4%. For 29 lines (72%) of them protein content was 13% and above thus exceeding standard Podolianka (12.8%), whereas 11 lines (28%) were characterized with the level of the standard or lower. Distribution of winter wheat introgressive lines by protein content in 2014-2015 is shown in Figure 1.

Sedimentation index ranged from 36 to 78 ml. Half (20) of the lines tested met the requirements of strong wheat category for this trait, and 9 lines inferior standard Podolianka (48 ml). Distribution of winter wheat introgressive lines by sedimentation index in 2014-2015 is shown in Figure 2.

By wet gluten content significant part (78%) of introgressive lines studied belonged to the category of strong wheat, moreover 65% of them exceeded the value of standard (30.9%). Figure 3 presents the distribution of winter wheat introgressive lines for this index (2015).

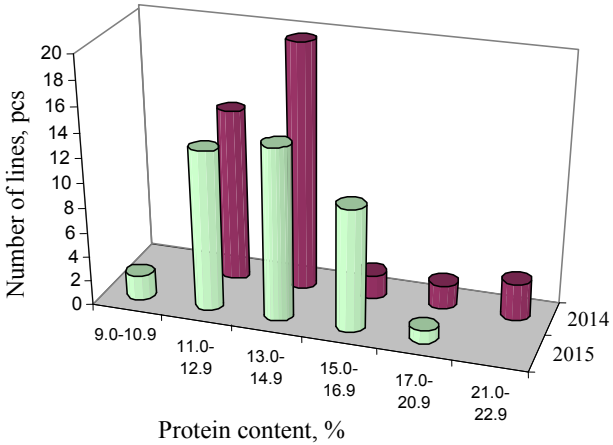

Fig. 1. Distribution of winter wheat introgressive lines for protein content

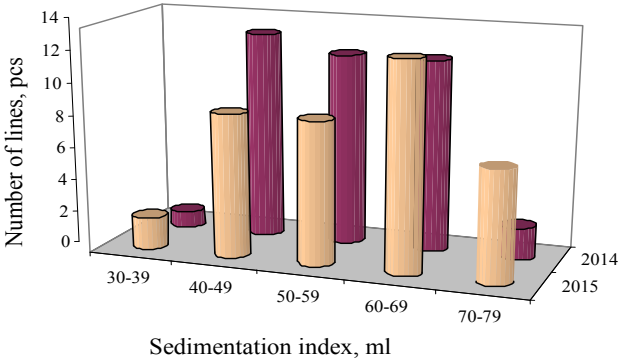

Fig. 2. Distribution of introgressive lines by sedimentation index

The introgressive lines that combine high productivity with other important economic traits are especially valuable ones. They annually are tested in various nurseries and used in breeding programs of MIW as sources of useful traits. 292 lines of introgressive origin were transferred to breeding nursery

of the Laboratory of Winter Wheat Breeding in 2014, and 187 lines were transferred in 2015. Some of them (49 lines) that distinguished by high level of crop capacity combined with other valuable traits were sown for further study in the control nursery. The best of them were obtained involving wheat species *T. spelta, T. polonicum, T. turanicum* and *T. sphaerococcum* (Table 2).

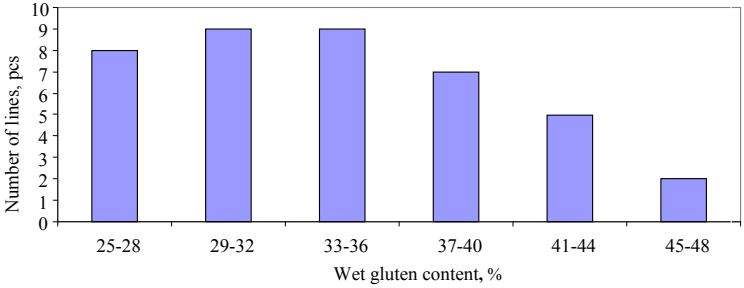

Fig. 3. Distribution of introgressive lines by content of wet gluten (2015)

Table 2

Characteristics of the best introgressive lines of breeding nursery (MIW, 2015)

Origin	Crop capacity per plot, 0.55 m²	1000 kernel weight g	Protein content, %	Sedimentation index, ml	Wet gluten, content %	GDI, unit	Group of quality
Podolianka, St	300	45.3	12.8	69	30.9	68	I
Line 246 (Favorit / *T. durum* // *T. polonicum* / Podolianka)	395	47.1	12.8	51	26.6	66	I
Line 196 / Pyvna	388	49.1	14.1	60	35.6	88	II
Perlyna Lisostepu / Favorit // Avrotyka	386	52.2	11.9	60	26.0	76	I
T. turgidum / T. miguschovae	375	46.7	12.6	65	32.1	88	II
Podolianka / Favorit / Tytan // *T. turanicum / T. sphaerococcum*	374	51.6	12.4	48	28.0	66	I
Myronivska 65 / SHH–190/99	364	45.2	11.6	53	23.9	59	I
Line 131 / Pyvna	355	54.6	12.7	60	30.6	80	II
Line 193 (Favorit / *T. spelta* // Myronivska 61 / Podolianka)	348	49.2	12.6	59	29.4	70	II
Line 193 / Pyvna	339	50.1	14.0	76	35.3	76	I
Line 106 / Donetska 66 // AS-7	304	52.1	13.1	71	31.1	62	I

Annually productivity of lines obtained by wide crossings was evaluated on the plots of breeding and control nurseries, preliminary and competitive strain test. Thus, in breeding nursery introgressive Line 246 created on base of hybrid combination Favorit / *T. durum* // *T. polonicum* / Podolianka was among the best by productivity, with high grain quality and substantial resistance to diseases (see Table 2).

Combination Line 196 / Pyvna was selected by productivity and protein content and wet gluten content, combination Line 131 / Pyvna was selected by 1000 kernel weight, and line *T. turgidum* / *T. miguschovae* was singled out for resistance to powdery mildew and Septoria leaf etc. Moreover, other indices of these lines were also quite high. The overall comparison of the best lines relative to the standard is shown in Figure 4. The indices are presented in percentage relation to the average by the experiment which is taken as 100%.

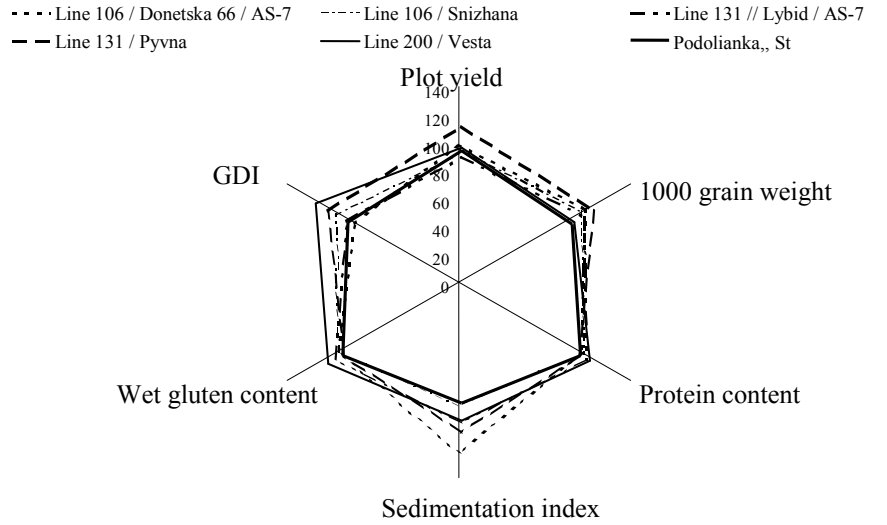

Fig. 4. Characteristics of some introgressive lines (MIW, 2015)

As Figure 4 shows, introgressive lines we have created exceeded the standard Podolianka practically by all given indices. They were sown in the control nursery for further study.

In 2015 in the competitive strain testing of Laboratory of Winter Wheat Breeding line Lutestsens 37292 which was obtained through wide hybridization exceeded in crop capacity standard Podolianka by predecessor rape on

0.39 t/ha, by maize on 0.14 t/ha, having positive characteristics by grain quality and resistance to biotic and abiotic environmental factors. Three better lines obtained involving species *T. turanicum, T. sphaerococcum* and genome substituted form Avrotyka also were sown to be harvested in 2016. Breeding work is conducted successfully when involving created through introgressive hybridization lines which resulted in determination of level of manifestation of agronomic traits and better examples with high productivity and resistance to biotic and abiotic environmental factors have been singled out.

The lines with genetic material from *T. dicoccum, T. polonicum, T. sphaerococcum, T. turgidum, T. compactum*, amphidiploids WAeAH (*T. dicoccum / Ae. tauschii*), AD 221-4 (*T. persicum / Ae. tauschii*), AS 7 (*T. durum / Ae. tauschii*) and *Ae. cylindrica* were remarkable for the highest indices of sedimentation, gluten and protein content.

Conclusions. 1. The use in wide crossings natural and artificial created species, synthetic amphidiploids pushes the limits of genetic diversity and enriches the gene pool of bread wheat by genetic material from related forms.

2. The best introgressive lines annually are tested in various links of breeding process and used in breeding programs of the Institute.

3. 40 winter wheat lines obtained on basis of wide crosses have been transferred to the collection nursery of MIW as sources of high quality of grain and flour.

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ВИКОРИСТАННЯ ГЕНОФОНДУ СПОРІДНЕНИХ ВИДІВ ДЛЯ СЕЛЕКЦІЙНОГО ВДОСКОНАЛЕННЯ ПШЕНИЦІ ЗА ЯКІСТЮ ЗЕРНА

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Мета. Розширити генетичну різноманітність шляхом інтрогресії хромосомного матеріалу з-за меж виду та створення на цій основі нових генетичних джерел, здатних поліпшити генофонд озимої м'якої пшениці за окремими складовими такої важливої багатокомпонентної ознаки, якою є якість зерна і борошна.

Матеріал і методи. Досліджували лінії пшениці озимої м'якої, отримані нами раніше методом віддаленої гібридизації. У віддалені схрещування залучали сорти озимої м'якої пшениці Подолянка, Миронівська 65,

Миронівська 61, Либідь, Пивна, Веста, Сніжана, Донецька 66, Перлина Лісостепу, озимої твердої пшениці – Титан, Золоте руно. Запилювачами слугували штучно створені види *T. kiharae* Dorof. et Migusch., *T. miguschovae* Zhir., синтетичні амфідиплоїди з Національного центру генетичних ресурсів рослин України ПЕАГ (AD *T. dicoccum / Ae. tauschii*), AD (*Ae. ventricosa / T. dicoccum*), AD 221-4, ПАГ-39), а також види *T. sphaerococcum* Persiv., *T. polonicum* L., *T. durum* Desf., *T. turanicum* Yakubz., *T. turgidum* L., *T. spelta* L., *T. compactum, T. dicoccum*, геномнозаміщена форма Авротика та егілопси *Ae. cylindrica* Host, *Ae. tauschii* Coss. При гібридизації використовували твел-метод запилення рослин. Показники якості зерна визначали згідно із загальноприйнятими методиками. Продуктивність ліній оцінювали на ділянках селекційного, контрольного розсадників, попереднього та конкурсного сортовипробувань.

Результати. Інтрогресивні схрещування викликають потужний формотворчий процес, який реалізується в ряді поколінь, надаючи великі можливості цілеспрямованого добору матеріалу для селекції на високий рівень продуктивності, морозостійкості, стійкості проти фітопатогенів. Проводиться успішна селекційна робота з використанням ліній, створених нами методом інтрогресивної гібридизації, в результаті якої визначено рівень прояву цінних господарських ознак та виділено кращі форми з високою продуктивністю і стійкістю до біотичних та абіотичних факторів зовнішнього середовища.

Нами створено серію високоякісних ліній озимої м'якої пшениці. Найбільш високі показники седиментації і вмісту клейковини та білка мали лінії з генетичним матеріалом від *T. dicoccum, T. polonicum, T. sphaerococcum, T. turgidum, T. compactum*, амфідиплоїдів ПЕАГ (*T. dicoccum / Ae. tauschii*), AD 221-4 (*T. persicum / Ae. tauschii*), AS 7 (*T. durum / Ae. tauschii*) і *Ae. cylindrica*.

Висновки. 1. Використання у віддалених схрещуваннях природних і штучно створених видів, синтетичних амфідиплоїдів розширює межі генетичного різноманіття та сприяє збагаченню генофонду м'якої пшениці генетичним матеріалом від споріднених форм.

2. Кращі інтрогресивні лінії щорічно проходять випробування в різних ланках селекційного процесу і використовуються в селекційних програмах МІП.

3. У колекційний розсадник МІП як джерела ознак якості зерна та борошна передано 40 ліній озимої пшениці, отриманих на основі віддалених схрещувань.

Ключові слова: *пшениця, види пшениці, амфідиплоїди, віддалена гібридизація, якість зерна*

ИСПОЛЬЗОВАНИЕ ГЕНОФОНДА РОДСТВЕННЫХ ВИДОВ ДЛЯ СЕЛЕКЦИОННОГО УСОВЕРШЕНСТВОВАНИЯ ПШЕНИЦЫ ПО КАЧЕСТВУ ЗЕРНА

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Цель. Расширить генетическое разнообразие путем интрогрессии хромосомного материала из-за пределов вида и создание на этой основе новых генетических источников, способных улучшить генофонд озимой мягкой пшеницы по отдельным составляющим такого важного многокомпонентного признака, каковым является качество зерна и муки.

Материал и методы. Исследовали линии озимой мягкой пшеницы, полученные нами ранее методом отдаленной гибридизации. В отдаленные скрещивания привлекали сорта озимой мягкой пшеницы Подолянка, Миронівська 65, Миронівська 61, Либідь, Пивна, Веста, Сніжана, Донецька 66, Перлина Лісостепу, озимой твердой пшеницы – Титан, Золоте руно. Опылителями служили искусственно созданные виды *T. kiharae* Dorof. et Migusch., *T. miguschovae* Zhir., синтетические амфидиплоиды из Национального центра генетических ресурсов растений Украины ПЭАГ (*T. dicoccum / Ae. tauschii*), AD (*Ae. ventricosa / T. dicoccum*), AD 221-4, ПАГ-39, а также виды *T. sphaerococcum* Persiv., *T. polonicum* L., *T. durum* Desf., *T. turanicum* Yakubz., *T. turgidum* L., *T. spelta* L., *T. compactum, T. dicoccum*, геномнозамещенная форма Авротика и эгилопсы *Ae. cylindrica* Host, *Ae. tauschii* Coss. При гибридизации использовали твел-метод опыления растений. Показатели качества зерна определяли согласно с общепринятыми методиками. Продуктивность линий оценивали на делянках селекционного, контрольного питомников, предварительного и конкурсного сортоиспытаний.

Результаты. Интрогрессивные скрещивания вызывают мощный формообразовательный процесс, который реализуется в ряду поколений, предоставляя большие возможности целенаправленного отбора материала для селекции на высокий уровень продуктивности, морозостойкости, устойчивости к фитопатогенам. Проводится успешная селекционная работа с использованием линий, созданных нами методом интрогрессивной гибридизации, в результате которой определен уровень проявления хозяйственно ценных признаков и выделены луч-

шие формы с высокой продуктивностью и устойчивостью к биотическим и абиотическим факторам внешней среды.

Нами создана серия высококачественных линий озимой мягкой пшеницы. Наиболее высокие показатели седиментации и содержания клейковины и белка имели линии з генетическим материалом от *T. dicoccum, T. polonicum, T. sphaerococcum, T. turgidum, T. compactum*, амфидиплоидов ПЭАГ (*T. dicoccum / Ae. tauschii*), AD 221-4 (*T. persicum / Ae. tauschii*), AS 7 (*T. durum / Ae. tauschii*) и *Ae. cylindrica*.

Выводы. 1. Использование в отдаленных скрещиваниях естественных и искусственно созданных видов, синтетических амфидиплоидов расширяет границы генетического разнообразия и способствует обогащению генофонда мягкой пшеницы генетическим материалом от родственных форм.

2. Лучшие интрогрессивные линии ежегодно проходят испытания в разных звеньях селекционного процесса и используются в селекционных программах МИП.

3. В коллекционный питомник МИП как источники признаков качества зерна и муки переданы 40 линий озимой пшеницы, полученных на основе отдаленных скрещиваний.

Ключевые слова: *пшеница, виды пшеницы, амфидиплоиды, отдаленная гибридизация, качество зерна*

USING GENE POOL OF RELATED SPECIES FOR BREEDING IMPROVEMENT OF WHEAT BY GRAIN QUALITY

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Aim. To expand genetic diversity by means of introgression of chromosomal material from alien species and to create new genetic sources capable of improving the existing gene pool of bread winter wheat by individual components of important trait, such the grain and flour quality is.

Material and methods. Lines of bread winter wheat that we have created by wide hybridization were studied. Bread winter wheat varieties Podolianka, Myronivska 65, Myronivska 61, Lybid, Pyvna, Vesta, Snizhana,

Donetska 66, Perlyna Lisostepu as well as durum winter wheat varieties Tytan, Zolote runo were involved into wide crossing. Artificially created species *T. kiharae* Dorof. et Migusch. (*T. timopheevii / Ae. tauschii*) 2n=42, *T. miguschovae* Zhir. (*T. militinae / Ae. tauschii*) 2n=42, synthetic amphidiploids obtained from the National Center for Plant Genetic Resources of Ukraine, namely, wheat-aegilops amphiploid hybrid WAeAH (*T. dicoccum / Ae. tauschii*) 2n = 42, AD (*Ae. ventricosa / T. dicoccum*) 2n=56, AD 221-4 (*T. persicum / Ae. tauschii*) 2n=42, wheat amphiploid hybrid WAH-39 (*T. dicoccum / T. sinskajae*) 2n=42, and species *T. sphaerococcum* Persiv., *T. polonicum* L., *T. durum* Desf., *T. turanicum* Yakubz., *T. turgidum* L., *T. spelta* L., *T. compactum*, *T. dicoccum*, genome-substitution form Avrotyka and two Aegilops *Ae. cylindrica* Host, *Ae. tauschii* Coss. were used as pollinators. In hybridization twirl-method of female plant pollination was used. Indices of grain quality were determined in accordance with conventional methods. Line productivity was estimated in plots of breeding and control nurseries as well as preliminary and competitive strain testing.

Results. Introgressive crossbreeding induces powerful formative process which performs in successive series of generations, thus providing great opportunities to conduct targeted selection of material to be involved in breeding for high level of productivity, frost resistance, and disease resistance. Breeding work is conducted successfully when involving created through introgressive hybridization lines which resulted in determination of level of manifestation of agronomic traits and better examples with high productivity and resistance to biotic and abiotic environmental factors have been singled out.

Series of high-quality lines of bread winter wheat has been created. Lines with genetic material from *T. dicoccum, T. polonicum, T. sphaerococcum, T. turgidum, T. compactum* and amphidiploids WAeAH (*T. dicoccum / Ae. tauschii*), AD 221-4 (*T. persicum / Ae. tauschii*), AS 7 (*T. durum / Ae. tauschii*) and *Ae. cylindrica* appeared to have the highest indices of sedimentation, gluten and protein content.

Conclusions. The use in wide crossings natural and artificial created species, synthetic amphidiploids pushes the limits of genetic diversity and enriches the gene pool of bread wheat by genetic material from related forms.

2. The best introgressive lines annually are tested in various links of breeding process and used in breeding programs of the Institute.

3. 40 winter wheat lines obtained on basis of wide crosses have been transferred to the collection nursery of MIW as sources of high quality of grain and flour.

Key words: *wheat, wheat species, amphidiploids, wide hybridization*