

***DIFFERENTIATION OF TRITICUM AESTIVUM L. GENOTYPES ACCORDING TO  
COMBINATION OF YIELD AND FLOUR QUALITY INDICATORS***

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Winter bread wheat cultivars and promising breeding lines with increased yield and flour quality indicators as well as with their combinations have been selected. The selected winter bread wheat genotypes can be used in breeding to create starting materials as sources of improved flour quality, a set of studied flour quality indicators, a combination of high yield with increased flour quality.

***Key words:*** winter bread wheat, cultivar, breeding line, yield, protein content, wet gluten content, sedimentation value, gluten deformation index

**Introduction.** Food security is one of the important challenges for the global population. In current production, wheat cultivars that combine high yields with several parameters of high quality are of commercial value. The cultivar is one of the most available and effective factors that determine the yield level of agricultural crops and contribute to food industry development [1, 2]. Therefore, the breeding of wheat genotypes that are capable of yielding a lot and simultaneously having good grain quality is an important objective of today's breeding.

Wheat (*Triticum aestivum* L.) is one of the oldest crops on our planet. From published data, it is known wheat growing dates back 10,000 years BC [3, 4]. Today, wheat is one of the most common agricultural crops on the globe, as it is among major and indispensable foods for a large population [4]. Ukraine is in the top ten wheat grain producers worldwide and in the top five wheat exporters. With the annual growth of the population on the planet, it is necessary to increase agricultural production, namely of wheat [5]. Therefore, the creation of new winter wheat cultivars that would yield a lot and show good quality of grain remains an important objective of agricultural science.

Among numerous indicators characterizing bread-making properties and nutritional value of wheat, the most important are protein content, gluten content, gluten quality, sedimentation value, etc. [6, 7]. The protein content in wheat kernels can vary from 7% to 17% [8], sometimes amounting to 25% [9, 10]. Depending solubility of proteins in different solvents, they are divided into four groups: albumins, globulins, gliadins, and glutenins [11]. Albumins and globulins are easily soluble proteins, which account for 15–20% of the total amount of wheat proteins and are mainly contained in the germ and aleurone layer [12]. Gliadins and glutenins are storage or gluten proteins, accounting for up to 80–85% of the total protein content. It is gluten proteins that form dough structure and gluten quality is responsible for shape stability and crumb structure of baked bread [13]. Determination of the sedimentation value is an indirect method of evaluating bread-making properties of wheat flour [14, 15]. This index characterizes the overall quality of the protein-proteinase complex [16]. The sedimentation value is determined at all stages of breeding, especially at early stages, as it enables breeders to cull low-quality accessions and effectively breed strong wheat cultivars, significantly reducing amounts of material to be worked at [16, 17].

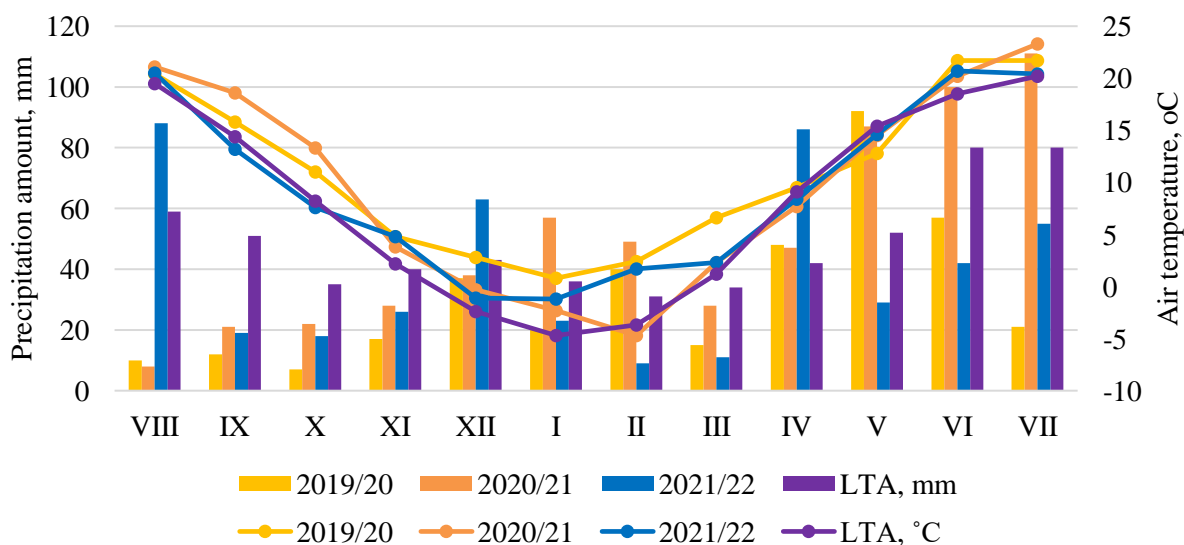
Changing conditions of cultivation of new cultivars necessitate constantly investigating peculiarities of yield and grain quality formation in winter wheat genotypes. Selection of winter wheat cultivars and breeding lines, which are able to combine increased yields with several indicators of good quality in one genotype, will contribute to obtaining valuable genetic materials

for practical breeding [18]. The purpose of this study was to identify winter bread wheat (*Triticum aestivum* L.) cultivars and breeding lines giving high yields, with improved flour quality and with their combination of these features.

**Materials and Methods.** The study was conducted at the V.M. Remeslo Myronivka Institute of Wheat (MIW) of NAAS of Ukraine in 2019/20–2021/22. Ten new winter bread wheat cultivars and four promising breeding lines were evaluated. Winter wheat was grown in accordance with routine techniques in the Forest-Steppe of Ukraine [19]. The record plot area was 10 m<sup>2</sup> in four replications.

The yields were harvested and recorded in accordance with methods of the qualification examination of plant varieties for suitability for dissemination in Ukraine [20]. Winter bread wheat grain quality was evaluated by conventional methods at the Grain Quality Laboratory of MIW [21, 22], viz: to obtain flour with an output of 70%, grain samples were ground in a laboratory mill MLU-202 (Bühler, Switzerland); the protein content (PC) in flour was determined on a SPEKTRAN 119M analyzer; the sedimentation value (SV) was measured by A.Ya. Pumpianskyi micromethod; the wet gluten content (WGC) was determined manually; the gluten deformation index (GDI) was recorded on an IDK-1M meter.

**Results and Discussion.** The study years turned out to be contrasting in terms of hydrothermal mode with an uneven distribution of precipitation by month (Fig. 1). As to rainfall, the 2020/21 vegetation year was close to the long-term average (LTA) (102.2% related to the LTA), while 2019/20 and 2021/22 had insufficient precipitation (64.5 and 80.5% related to the LTA, respectively). In the study years, the average monthly air temperature exceeded the LTA by 1.2–2.7°C. December, January, February, and March 2019/20, September and October 2020/21, February 2021/22 were abnormally warm, with the average daily air temperature 4.2–6.2 °C higher than the LTA. It should be noted significant deficit in the precipitation amounts in August 2019/20 and 2020/21 (16.9 and 13.6% related to the LTA, respectively); in January, June, and July 2019/20 and 2021/22 (26.3–71.3% related to the LTA); and in February and May 2021/22 (29.0 and 55.8% related to the LTA, respectively). The pre-sowing and sowing periods in the three study years had insufficient amounts of precipitation (23.5–62.9% related to the LTA).

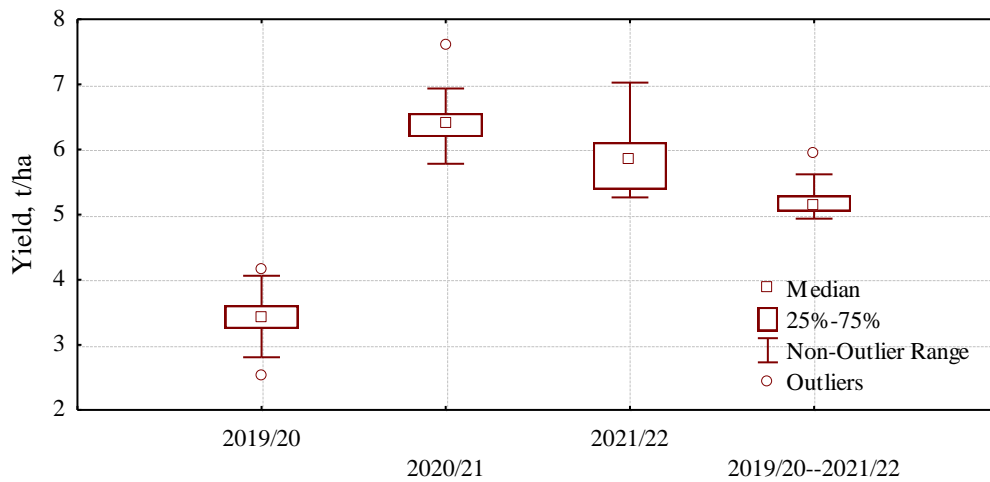


Note: LTA = long-term average (1960-2018)

**Fig. 1.** Average monthly parameters of the hydrothermal mode in the study period, 2019/20–2021/22.

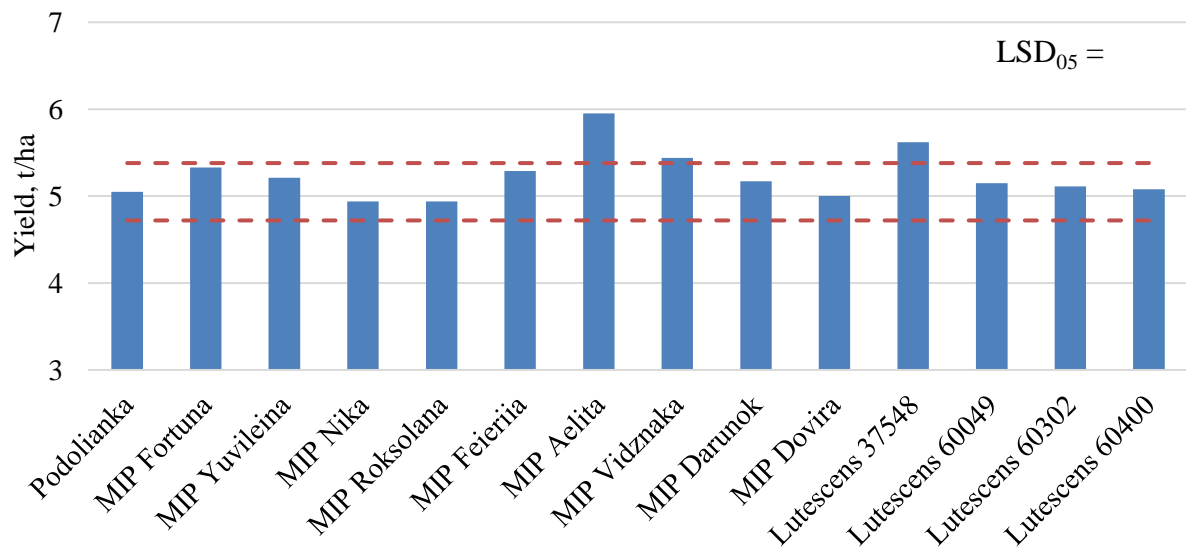
The changing weather in the growing season conditions caused a significant variability of yield and flour quality. The hydrothermal conditions during the 2019/20 growing season, which had too little precipitation and increased air temperature in most months, negatively affected the growth and development of winter wheat. Hence, the lowest yield of winter wheat (3.40 t/ha on

average) was harvested in 2019/20 (Fig. 2). The greatest (6.46 t/ha) average yield was harvested in 2020/21. In 2021/22, the average yield from the studied genotypes was 5.84 t/ha. The most inter-cultivar/breeding line variability of yield was observed in winter bread wheat in 2021/22.



**Fig. 2.** Variability of the winter bread wheat yield depending on growing conditions.

On average across the study years (Fig. 3), cv. ‘MIP Aelita’ and ‘MIP Vidznaka’ and breeding line ‘Lutescens 37548’ yielded significantly more compared to the check cultivar, Podolianka (5.05 t/ha,  $LSD_{05} = 0.33$  t/ha). Cv. ‘MIP Fortuna’, ‘MIP Yuvileina’, ‘MIP Feieria’, and ‘MIP Darunok’ and breeding lines ‘Lutescens 60049’, ‘Lutescens 60302’, and ‘Lutescens 60400’ yielded more than the check cultivar, but within the limits of the least significant difference.



**Fig. 3.** Yields of the winter bread wheat cultivars and breeding lines, average for 2019/20–2021/22.

On average across the genotype, the lowest values of the sedimentation value (59 mL), protein content (11.9%) and wet gluten content (27.4%) were recorded in the most humid growing season of 2020/21 (Table 1). The highest contents of protein (14.7%) and wet gluten (31.9%) were noted in 2019/20; the highest sedimentation value (69 mL) was noted in 2021/22. There were differences in effects of growing conditions on individual winter bread wheat cultivars and breeding lines. The coefficients of variation showed the highest variability of flour quality in 2021/22. On average for 2019/20–2021/22, the protein content variations were slight ( $CV \leq 5\%$ ); the variations of the wet gluten content and sedimentation value were moderate (5%

$\leq CV \leq 10\%$ ); and the gluten deformation index variations were considerable ( $11\% \leq CV \leq 20\%$ ).

On average across the study years, a significant (35.7%) portion of the genotypes had gluten of quality group I by gluten deformation index (58–75 units). Cv. ‘MIP Feieria’ had satisfactorily strong gluten (42 units); however, the majority (57.1%) of the genotypes had satisfactorily weak gluten (78–94 units).

Table 1

**Physical parameters of grain and flour quality in the winter bread wheat cultivars and breeding lines, average for 2019/20–2021/22**

| Cultivar/breeding line | PC, %   |         |         |      | SV, mL  |         |         |      | WGC, %  |         |         |      | GDI, units* |         |         |      |
|------------------------|---------|---------|---------|------|---------|---------|---------|------|---------|---------|---------|------|-------------|---------|---------|------|
|                        | 2019/20 | 2020/21 | 2021/22 | Mean | 2019/20 | 2020/21 | 2021/22 | Mean | 2019/20 | 2020/21 | 2021/22 | Mean | 2019/20     | 2020/21 | 2021/22 | Mean |
| Podolianka             | 14.1    | 11.9    | 13.3    | 13.1 | 68      | 56      | 72      | 65   | 32.6    | 28.9    | 30.1    | 30.5 | 75          | 82      | 87      | 81   |
| MIP Fortuna            | 14.7    | 12.5    | 13.0    | 13.4 | 59      | 56      | 60      | 58   | 29.1    | 26.8    | 25.8    | 27.2 | 79          | 77      | 85      | 80   |
| MIP Yuvileina          | 13.7    | 11.0    | 11.7    | 12.1 | 61      | 58      | 69      | 63   | 30.0    | 26.2    | 24.1    | 26.8 | 71          | 69      | 58      | 66   |
| MIP Nika               | 15.1    | 12.7    | 12.8    | 13.5 | 66      | 61      | 69      | 65   | 33.2    | 30.7    | 27.6    | 30.5 | 80          | 87      | 66      | 78   |
| MIP Roksolana          | 14.8    | 11.4    | 12.8    | 13.0 | 62      | 53      | 59      | 58   | 28.2    | 25.0    | 26.6    | 26.6 | 67          | 79      | 80      | 75   |
| MIP Feieria            | 13.5    | 10.8    | 11.4    | 11.9 | 65      | 73      | 68      | 69   | 30.6    | 25.3    | 21.2    | 25.7 | 49          | 34      | 43      | 42   |
| MIP Aelita             | 13.6    | 11.8    | 12.7    | 12.7 | 62      | 51      | 58      | 57   | 32.8    | 28.0    | 28.4    | 29.7 | 97          | 87      | 98      | 94   |
| MIP Vidznaka           | 16.5    | 11.8    | 12.2    | 13.5 | 64      | 59      | 61      | 61   | 35.4    | 27.2    | 20.8    | 27.8 | 67          | 59      | 49      | 58   |
| MIP Darunok            | 15.3    | 12.2    | 12.6    | 13.4 | 65      | 57      | 66      | 63   | 33.7    | 27.7    | 25.7    | 29.0 | 84          | 78      | 71      | 78   |
| MIP Dovira             | 15.0    | 12.6    | 13.8    | 13.8 | 60      | 57      | 62      | 60   | 31.6    | 27.4    | 26.2    | 28.4 | 83          | 86      | 87      | 85   |
| Lutescens 37548        | 15.1    | 12.1    | 15.0    | 14.1 | 67      | 64      | 81      | 71   | 34.2    | 28.5    | 34.2    | 32.3 | 83          | 91      | 97      | 90   |
| Lutescens 60049        | 15.3    | 11.4    | 13.7    | 13.5 | 74      | 63      | 85      | 74   | 32.3    | 26.9    | 31.1    | 30.1 | 48          | 53      | 75      | 59   |
| Lutescens 60302        | 13.7    | 12.3    | 14.1    | 13.4 | 66      | 64      | 81      | 70   | 31.0    | 27.9    | 32.8    | 30.6 | 74          | 66      | 94      | 78   |
| Lutescens 60400        | 15.1    | 11.8    | 14.4    | 13.8 | 63      | 53      | 73      | 63   | 32.0    | 26.6    | 32.9    | 30.5 | 73          | 85      | 87      | 82   |
| Mean                   | 14.7    | 11.9    | 13.1    | 13.2 | 64      | 59      | 69      | 64   | 31.9    | 27.4    | 27.7    | 29.0 | 74          | 74      | 77      | 75   |
| Max                    | 16.5    | 12.7    | 15.0    | 14.1 | 74      | 73      | 85      | 74   | 35.4    | 30.7    | 34.2    | 32.3 | 97          | 91      | 98      | 94   |
| Min                    | 13.5    | 10.8    | 11.4    | 11.9 | 59      | 51      | 58      | 57   | 28.2    | 25.0    | 20.8    | 25.7 | 48          | 34      | 43      | 42   |
| LSD <sub>05</sub>      | 0.4     |         |         |      | 4       |         |         |      | 0.7     |         |         |      | 4           |         |         |      |
| CV, %                  | 5.8     | 4.9     | 7.8     | 4.7  | 6.0     | 9.7     | 12.7    | 8.2  | 6.2     | 5.4     | 15.1    | 6.7  | 17.9        | 21.8    | 22.7    | 18.7 |

Note: PC = protein content, SV = sedimentation value, WGC = wet gluten content, GDI = gluten deformation index, CV = coefficient of variation. \* - units of the gluten deformation meter.

We distinguished genotypes, which on average in 2019/20–2021/22 were significantly superior to the check cultivar, Podolianka, in terms of: protein content – ‘MIP Nika’, ‘MIP Vidznaka’, ‘MIP Dovira’, ‘Lutescens 37548’, ‘Lutescens 60049’, and ‘Lutescens 60400’; sedimentation value – ‘MIP Feieria’, ‘Lutescens 37548’, ‘Lutescens 60049’, and ‘Lutescens 60302’; wet gluten content – ‘Lutescens 37548’. It should be noted that breeding line ‘Lutescens 37548’ was significantly superior to the check cultivar in all measured flour quality parameters. Therefore, the selected cultivars and breeding lines can be used in breeding as sources to improve the corresponding quality parameters and to create high-quality cultivars of winter bread wheat.

Wheat cultivars that combine high yields with increased quality parameters are most valuable for breeding and production. To identify such genotypes, we carried out some statistical

calculations were, as a result of which we obtained indicial standardized values for combinations of yield with the studied parameters of flour quality for all winter bread wheat cultivars and breeding lines (Table 2). In addition, its total score GYT (genotype by yield × trait) index is provided for each genotype.

Table 2

**Indicial standardized combinations of yield and flour quality parameters in the winter bread wheat cultivars and breeding lines, average for 2016/17–2018/19**

| Cultivar/breeding line | YLD*PC | YLD*SV | YLD*WGC | GYT index |
|------------------------|--------|--------|---------|-----------|
| Podolianka             | -0.66  | -0.12  | 0.17    | -0.20     |
| MIP Fortuna            | 0.50   | -0.85  | -0.47   | -0.27     |
| MIP Yuvileina          | -1.30  | -0.29  | -0.89   | -0.83     |
| MIP Nika               | -0.51  | -0.32  | -0.08   | -0.31     |
| MIP Roksolana          | -1.08  | -1.55  | -1.46   | -1.36     |
| MIP Feieria            | -1.35  | 0.94   | -1.13   | -0.51     |
| MIP Aelita             | 1.38   | -0.11  | 1.81    | 1.03      |
| MIP Vidznaka           | 0.93   | -0.12  | -0.03   | 0.26      |
| MIP Darunok            | -0.01  | -0.35  | -0.11   | -0.16     |
| MIP Dovira             | -0.03  | -1.16  | -0.70   | -0.63     |
| Lutescens 37548        | 2.13   | 1.96   | 2.13    | 2.08      |
| Lutescens 60049        | 0.03   | 1.58   | 0.23    | 0.61      |
| Lutescens 60302        | -0.19  | 0.86   | 0.32    | 0.33      |
| Lutescens 60400        | 0.16   | -0.46  | 0.23    | -0.02     |

Note. YLD\*PC = combination of yield with protein content, YLD\*SV = combination of yield with sedimentation value, YLD\*WGC = combination of yield with wet gluten content, GYT index = genotype's total index for combining yield with quality parameters.

Thus, a number of winter bread wheat cultivars and breeding lines were detected: they outcompeted the check cultivar (Podolianka) by combining high yields with high protein content (76.9% of the genotypes) or high yields with good values of the sedimentation value and wet gluten content (38.5% of the genotypes). By the GYT index, cv. 'MIP Aelita', 'MIP Vidznaka' and breeding lines 'Lutescens 37548', 'Lutescens 60049', and 'Lutescens 60302' were selected; they scored better than the check cultivar according to their positive values of the summarized estimate. The selected new cultivars and promising breeding lines of winter bread wheat are advisable to use in breeding as sources that combine both high yield and good quality parameters in one genotype.

**Conclusions.** 1. It was established that the hydrothermal conditions of the study years significantly affected the winter bread wheat yields and flour quality.

2. We identified the winter bread wheat cultivars and breeding lines that are recommended to use in breeding as sources to increase: protein content ('MIP Nika', 'MIP Vidznaka', 'MIP Dovira', 'Lutescens 37548', 'Lutescens 60049', and 'Lutescens 60400'); sedimentation value ('MIP Feieria', 'Lutescens 37548', 'Lutescens 60049', and 'Lutescens 60302'); wet gluten content ('Lutescens 37548').

3. Promising breeding line 'Lutescens 37548', which was characterized by several high parameters of flour quality, was singled out.

4. By combination of yields and several parameters of flour quality indicators, two new cultivars ('MIP Aelita' and 'MIP Vidznaka') and three promising breeding lines ('Lutescens 37548', 'Lutescens 60049', and 'Lutescens 60302') were selected. Therefore, one can expect to

harvest greater yields in combination with improved parameters of flour quality due to growing the selected genotypes.

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## **DIFFERENTIATION OF TRITICUM AESTIVUM L. GENOTYPES ACCORDING TO COMBINATION OF YIELD AND FLOUR QUALITY INDICATORS**

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**Purpose.** Hence, the purpose of this study was to identify winter bread wheat (*Triticum aestivum* L.) cultivars and breeding lines giving high yields, with improved flour quality and with combination of these features.

**Materials and Methods.** The study was conducted at the V.M. Remeslo Myronivka Institute of Wheat (MIW) of NAAS of Ukraine in 2019/20–2021/22. Ten new winter bread wheat cultivars and four promising breeding lines were evaluated. Winter wheat was grown in accordance with routine techniques in the Forest-Steppe of Ukraine. The yields were harvested and recorded in accordance with methods of qualification examination of plant varieties for suitability for dissemination in Ukraine. Winter bread wheat grain quality parameters were determined by conventional methods at the Grain Quality Laboratory MIW.

**Results and Discussion.** There was a significant variability of yield and flour quality parameters depending on the conditions of the study years. On average across the winter bread wheat cultivars and breeding lines, the highest contents of protein (14.7%) and wet gluten content (31.9%) were recorded in 2019/20, but the lowest yield (3.40 t/ha) was harvested that year. In 2020/21, on the contrary, the yield was higher (6.46 t/ha), while the sedimentation value (59 mL), protein content (11.9%), and wet gluten content (27.4%) were lower. Cv. ‘MIP Aelita’, ‘MIP Vidznaka’ and breeding line ‘Lutescens 37548’ yielded significantly more than the check cultivar (‘Podolianka’; 5.05 t/ha; LSD<sub>05</sub> = 0.33 t/ha). We singled out genotypes that on average in 2019/20–2021/22 were significantly superior to the check cultivar (‘Podolianka’) in term of protein content (‘MIP Nika’, ‘MIP Vidznaka’, ‘MIP Dovira’, ‘Lutescens 37548’, ‘Lutescens 60049’, and ‘Lutescens 60400’), sedimentation value (‘MIP Feieria’, ‘Lutescens 37548’, ‘Lutescens 60049’, and ‘Lutescens 60302’) and wet gluten content (‘Lutescens 375480’). It should be noted that breeding line ‘Lutescens 37548’ significantly outperformed the check cultivar in all measured flour quality parameters. Based on combinations of high yield with several parameters of flour quality, cv. ‘MIP Aelita’ and ‘MIP Vidznaka’ and breeding lines ‘Lutescens 37548’, ‘Lutescens 60049’, and ‘Lutescens 60302’ were distinguished.

**Conclusions.** The selected winter bread wheat cultivars and breeding lines can be used in breeding to create starting materials as sources of improved corresponding parameters of flour quality, a set of the investigated characteristics of flour quality and of combinations of high yield and good parameters of flour quality.

**Key words:** winter bread wheat, cultivar, breeding line, yield, protein content, wet gluten content, sedimentation value, gluten deformation index

## **ДИФЕРЕНЦІЮВАННЯ ГЕНОТИПІВ TRITICUM AESTIVUM L. ЗА ПОЄДНАННЯМ УРОЖАЙНОСТІ ТА ПОКАЗНИКІВ ЯКОСТІ БОРОШНА**

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**Мета.** Метою дослідження було виділити сорти та селекційні лінії пшениці м'якої озимої (*Triticum aestivum* L.) за високим рівнем урожайності, підвищеними показниками якості борошна та їх поєднанням.

**Матеріали та методи.** Дослідження проводили впродовж 2019/20–2021/22 рр. в Миронівському інституті пшениці імені В. М. Ремесла НААН України (МІП). Оцінювали

10 нових сортів та чотири перспективні селекційні лінії пшениці м'якої озимої. Вирощували пшеницю озиму відповідно до загальноприйнятої технології для зони Лісостепу України. Збирання та облік урожаю здійснювали згідно з методикою проведення кваліфікаційної експертизи сортів рослин на придатність до поширення в Україні. Визначення показників якості зерна пшениці м'якої озимої проводили у лабораторії якості зерна МПП відповідно до загальноприйнятих методик.

**Результати та обговорення.** Встановлено значну варіабельність урожайності та показників якості борошна залежно від умов років дослідження. У середньому за сортами та селекційними лініями пшениці м'якої озимої у 2019/20 р. отримано найвищий вміст білка (14,7 %) та клейковини (31,9 %), однак рівень урожайності у цьому році був найнижчий (3,40 т/га). У 2020/21 р. навпаки, виявлено більшу врожайність (6,46 т/га) та менші значення показника седиментації (59 мл), вмісту білка (11,9 %), вмісту клейковини (27,4 %). Сорти МПП Аеліта, МПП Відзнака та селекційна лінія Лютесценс 37548 характеризувалися істотно вищою врожайністю порівняно із сортом стандартом Подолянка (5,05 т/га,  $НР_{05} = 0,33$  т/га). Виокремлено генотипи, які у середньому за 2019/20–2021/22 рр. Вірогідно перевершували сорт стандарт Подолянка за: вмістом білка – МПП Ніка, МПП Відзнака, МПП Довіра, Лютесценс 37548, Лютесценс 60049, Лютесценс 60400; показником седиментації – МПП Феєрія, Лютесценс 37548, Лютесценс 60049, Лютесценс 60302; вмістом клейковини – Лютесценс 37548. Слід відмітити, що селекційна лінія Лютесценс 37548 істотно переважала стандарт за всіма представленими показниками якості борошна. За поєднанням урожайності з комплексом показників якості борошна виділено сорти МПП Аеліта, МПП Відзнака та селекційні лінії Лютесценс 37548, Лютесценс 60049, Лютесценс 60302.

**Висновки.** Виділені сорти та селекційні лінії пшениці м'якої озимої можуть бути використані в селекційному процесі для створення вихідного матеріалу як джерела поліпшення показників якості борошна, комплексу досліджуваних показників якості борошна, поєднання високої врожайності з високими показниками якості борошна.

**Ключові слова:** пшениця м'яка озима, сорт, селекційна лінія, урожайність, вміст білка, вміст клейковини, показник седиментації, індекс деформації клейковини