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# PHENOTYPIC VARIABILITY OF PRODUCTIVITY ELEMENTS OF WINTER WHEAT VARIETIES DEPENDING ON GROWING TECHNOLOGIES IN THE WESTERN FOREST-STEPPE OF UKRAINE

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# ФЕНОТИПИЧЕСКАЯ ИЗМЕНЧИВОСТЬ ЭЛЕМЕНТОВ ПРОДУКТИВНОСТИ СОРТОВ ОЗИМОЙ ПШЕНИЦЫ В ЗАВИСИМОСТИ ОТ ТЕХНОЛОГИИ ВЫРАЩИВАНИЯ В ЗАПАДНОЙ ЛЕСОСТЕПИ УКРАИНЫ

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*Стратегическое значение семенной продуктивности зерновых культур раскрывается через систему функционирования и развития зернового хозяйства страны. Уровень продуктивности и качество выращиваемой продукции будет зависеть от обеспечения хозяйств каждого региона качественным семенным материалом. Одним из важных направлений семеноводства зерновых культур является преобразование национальной схемы сертификации высококачественных семян в международную схему сертификации Организации экономического сотрудничества и развития (ОЭСР). Введение в Украине сертификации сортов семян распространяется на все государства-члены этой организации, члены ООН и ВТО, которые присоединились к схемам, и выдача единых сортовых документов на семена позволяет нашему государству участвовать в международной торговле. Поэтому для усиления контроля за качеством производимой и реализуемой продукции в семеноводстве зерновых культур были разработаны и законодательно утверждены Государственные стандарты Украины: ДСТУ 2240-93, ДСТУ 2949-94, ДСТУ 4138-2002. Установлено, что продуктивность сортов озимой пшеницы в зоне Западной Лесостепи Украины обеспечивается их биологическими свойствами положительно реагировать на погодные факторы как одни из составляющих технологии выращивания сельскохозяйственных культур. Доказано, что чем выше температура и меньше осадков в период созревания, тем ниже урожай зерна. В 2014 г. высокие урожаи семян не сформировались. Продуктивность сортов степного экологического типа была ниже, чем у лесостепных, во всех технологиях выращивания. Наивысшие показатели урожайности семян, репродуктивности, урожайности кондиционированных семян, массы 1000 семян, энергии прорастания, лабораторной всхожести и фракционного состава семян были получены при биологизированной технологии.*

***Ключевые слова:*** *экотип, урожай семян, посевные качества, сорт, озимая пшеница.*

*The strategic importance of seed production of grain crops is revealed through the system of functioning and development of the country's grain farming. The level of productivity and product quality of grown products will depend on providing farms of each region with high-quality seed material. One of the important ways of seed production of grain crops is the transformation of the national certification scheme for high-quality seeds to the international certification scheme of the Organization for Economic Cooperation and Development (OECD). Introduction in Ukraine variety certification for seeds applies to all member states of this organization, members of the OON and the WTO that have joined to schemes and issuing uniform varietal documents for seeds allows our state to participate in international trade. Therefore, in order to increase control over the quality of the produced and sold products in the seed industry of grain crops, the State Standards of Ukraine were developed and legally approved: DSTU 2240-93, DSTU 2949-94, DSTU 4138-2002.*

*It has been established that the productivity of winter wheat varieties in the zone of the Western Forest-Steppe of Ukraine is ensured by their biological properties to respond positively to weather factors that comprise the technology of growing crops. It is proved that the higher the temperature and the lesser amount of precipitation during the ripening period, the grain harvest in 2014 hid the formation of high seed yields. The productivity of steppe ecological type varieties was lower compared to forest-steppe for all growing technologies. The highest indicators: seed yield, reproduction rate, the yield of conditioned seeds, 1000 seed mass, germination energy, laboratory germination and fractional composition of seeds provided the biologized technology.*

***Key words:*** *ecotype, seed yield, sowing qualities, variety, winter wheat.*

## Introduction

The importance of producing high-quality seeds is growing with the constant use of new types fertilizers, means of protection, biological preparations, etc., as well as the introduction of new varieties into production, which differ in morphological and biological properties from those in production. All this requires the development of effective agrotechnological methods of cultivation, the complex of which is the varietal technology of winter wheat. Nonobservance of technological processes, violations, or simplification of the recommended elements of agricultural technologies leads to a decrease in the yield of varieties, product quality and profitability [9, s. 3–9; 10, s. 21–22; 13, s. 44–49; 14, s. 16–19; 17, s. 24–26; 18, s. 5–10; 22, s. 36–39; 26, s. 56–61; 27, s. 54–57; 28, 351 s.].

One of the most important links of agriculture, which forms the basis of the economic and social development of Ukraine and determines its food security are varietal resources [1, s. 170–178; 6, s. 56–62; 7,

s. 86–90; 8, s. 61–66). The varieties created by native science are characterized by high productivity, more economical consumption of energy and nutrients for production and provided 25–30 % yield increase [2, s. 12–14; 12, s. 157–159; 16, s. 146–160; 20, s. 44–47]. However, the potential of a variety can be fully realized under the conditions of compliance agrotechnology its cultivation to biological characteristics in particular: if it has a potential yield of 7–10 t/ha, winter- and drought-resistant, well responds to high agrotechnics, resistant to disease and lodging [3, s. 38–40; 5, s. 56–63; 11, s. 20; 15, 588 s.].

The reaction of varieties to the same growing conditions is different, therefore, due to taking into account the biologically genetic potential of modern varieties and their proper selection, the farmer or private owner has all the opportunities to ensure a constant increase in the production of grain - both quantitatively and qualitatively [19, s. 1–5; 21, s. 75–79; 23, s. 3–17; 24, s. 50–53; 25, s. 82–88].

The purpose of the research was to determine the characteristics of the formation of seed productivity and sowing qualities of seeds and the realization of the genetic potential of the productivity varieties depending on the intensification of the cultivation technology and the influence of weather factors.

**Main part**

Twelve winter wheat varieties of various originator institutions of Ukraine were taken for research. The experiments were carried out in the crop rotation of the seed studies laboratory of the Institute of Agriculture of Carpathian Region of National Academy of Agrarian Sciences of Ukraine, during 2013–2017, by field and laboratory methods. The total area of the experimental plot was 60 $m^2$, accounting – 50 $m^2$, placement of variants were systematic, with three replication.

The soil of the research plots is forest gray, superficially gleyed, and silty loamy, which was characterized by the following indicators: humus content (by Tyurin) – 1.9 %, salt extract pH (potentiometric method) – 4.8, hydrolytic acidity (by Kappen-Hilkovits) – 2.91 mg eq./100 g of soil, the content of mobile phosphorus and potassium (by Kirsanov) – 98 and 85 mg per 1 kg of soil, easily hydrolyzed nitrogen (by Cornfield) – 87 mg per 1 kg of soil.

The basic technology for growing winter wheat seeds included: presowing seed treatment with Vitavaks 200 FF, 34 % w.s.c. (3.0 l/t), the application of mineral fertilizers in the rate $N_{30}P_{90}K_{90}$ under sowing and the phased application of nitrogen $N_{30}$ in the IV and VII stages of organogenesis, chemical protection from weeds, diseases and pests: herbicides – Grodyl Maxi, 37.5 % o.d. (0.09–0.11 l/ha) + Zenkor Liquid, 60 % c.s. (0.1–0.4 l/ha), fungicide – Lamardor PRO, 18 % f.c.s. (0.5–0.6 l/ha), insecticide – Fastak, 10 % c.s. (0.1–0.25 l/ha).

Energy saturated technology based on the maximum concentration and high-intensive use of the material and technical resources, in particular, the highest rate of mineral fertilizers $N_{120}P_{120}K_{120}$ with a phased application of nitrogen, the use of pesticides: Grodyl Maxi, 37.5% o. d. (0.09-0.11 l/ha) + Zenkor Liquid, 60 % c.s. (0.1–0.4 l/ha) in the tillering stage; the first treatment of sowings Rex Duo, 49.7 % c.e. (0.6 l/ha in the phase tillering – booting). The second treatment of sowing was with Karamba (1.25 l/ha in the phase booting – earing), insecticide Fastak, 10 % c.s. (0.1–0.25 l/ha), retardants Chlormequat-chloride (stabilan), 75 % f.c.s. (0.8–2.0 l/ha) at the beginning of the booting.

Biologized technology included the use of biological preparations and micronutrients to reduce the negative effects on the plant of chemicals. Pre-sowing seed treatment was carried out with Vympel-K growth stimulator (500 g/t) + Oracle seed micronutrient (1.0 l/t). The level of mineral nutrition of plants was $N_{30}P_{90}K_{90}$ under seeding for the application of nitrogen $N_{30}$ in IV and VII stages of organogenesis and foliar application of growth regulator Vympel (1.0 l/ha) with microfertilizer Oracle multicomplex (1.0–2.0 l/ha) on VII stage of organogenesis. Protection against weeds and diseases included: Grodyl Maxi, 37.5 % o.d. (0.09–0.11 l/ha) + Zenkor Liquid, 60 % c.s. (0.1–0.4 l/ha) in the tillering stage and the first treatment of sowing with the Oracle multicomplex preparation (1.5 l/ha) in the tillering phase – entering the tube, the second is the Oracle colofermyn copper (1.0 l/ha ) + growth regulator Vympel-2 (0.5 l/ha) in the phase booting – earing plants).

The seeding rate was 5.5 million viable seeds/ha. The sowing qualities of the seeds of winter wheat varieties sown over the years corresponded to DSTU 4138-2002 (State Standard of Ukraine). The studies were conducted according to generally accepted methods. Processing and synthesis of research results were performed using Microsoft Excel. The obtained data were processed by the method of dispersion and correlation analysis [4, s. 6].

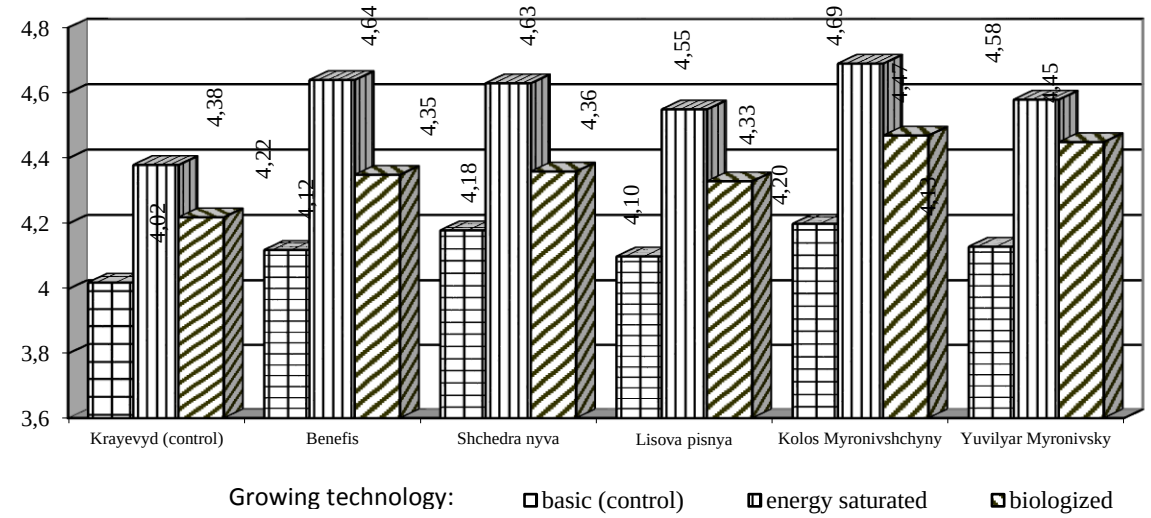
The main requirement of production for a variety is its high performance in a wide range of environmental conditions. The inseparably linked factors in increasing and stabilizing yields are the "genotype of the variety – seeds – cultivation technology". Only with the proper selection of varieties for a particular zone, subzone, level of technological support of the farm can be obtained the high yields and product quality.

Analyzing this most important economic indicator in our experiments, it should be noted that the grain productivity of varieties depended on the process of productivity formation, the effect of technological elements and weather factors. Weather conditions that developed during the period of seed formation had a direct impact on the level of seed yield. In 2013, for the sums of active temperatures of the III decade of June – II July 61.4 ° C and precipitation 552 mm (average perennial norm is 521 mm), the yield of winter wheat varieties on variants of intensive basic growing technology ranged from 3.61–4.17 t/ha. The varieties of forest-steppe ecotype ensured a higher seed yield by 0.28 t/ha.

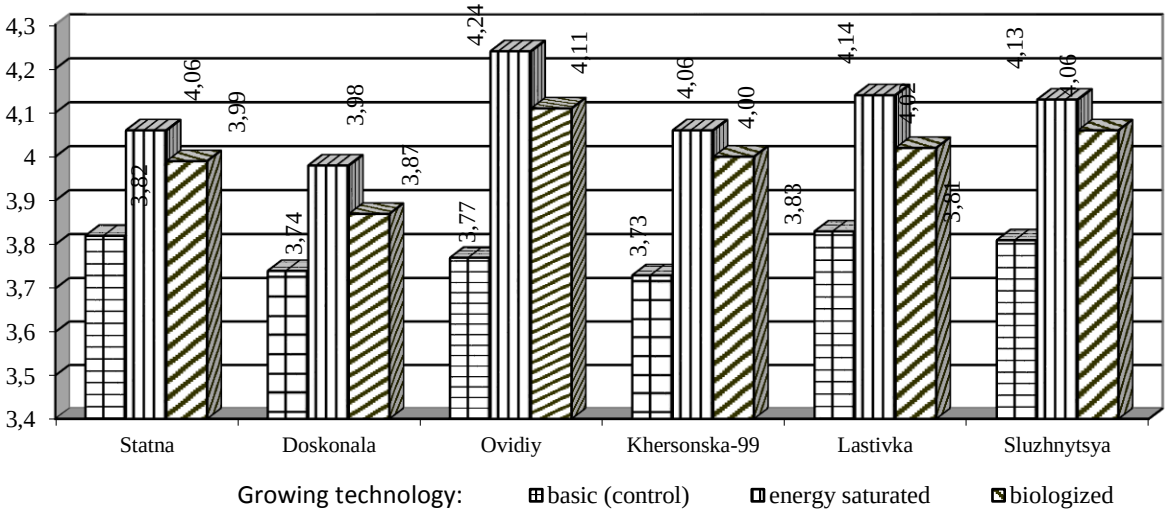
In 2014, the sum of effective temperatures for the period of filling and ripening of grain was significantly higher and amounted to 104.2 ° C, and the amount of precipitation within the previous year (558 mm), which contributed to obtaining of higher seed yield of 3.86–4.16 t/ha, or by 0.15–0.16 t/ha compared with the previous year. The weather conditions in 2015 formed the sum of active temperatures of 76.7 ° C and the amount of precipitation of 549 mm. Under these conditions, the highest seed yield was in varieties: Kolos Myronivshchyny (4.23 t/ha), Shchedra nyva (4.21 t/ha), and the lowest one was in the Khersonska-99 (3.69 t/ha). For the more precipitation by 12 mm, and temperatures by 8.8 ° C in 2016, the average yields amounted in the forest-steppe ecological types 4.25 t/ha, steppe – 3.93 t/ha, with a reliable difference between them 0, 32 t/ha The average yield of seeds by varieties of forest-steppe ecological type in 2017 was 3.94 t/ha, steppe – 3.85 t/ha with a difference of 0.09 t/ha.

Similar conformity influence of external factors on the seed productivity of winter wheat varieties was observed for energy-saturated and biologized growing technologies.

In terms of energy-intensive cultivation of winter wheat varieties in 2013, seed yield ranged from 3.83 t/ha in the Doskonala variety to 4.56 t/ha in the Shchedra nyva variety. The difference between varieties by ecotype was 0.50 t / ha. More favorable weather conditions in 2014 led to a higher seed yield compared to the previous year by 0.32–0.36 t/ha. In 2015, the average index of forest-steppe varieties was lower by 0.28 t/ha compared to 2014, and steppe – by 0.2 t/ha. A slight increase in average indicators for the ecotype of 0.05–0.12 t/ha was observed in 2016 and a decrease by 0.23–0.29 t/ha was in 2017. The general pattern of the formation of the seeds yield of winter wheat varieties depending on the influence of weather conditions on biologized technology of cultivation was preserved compared with the basic and energy-saturated. The yield of seeds in 2013 ranged from 3.71–4.40 t/ha, in 2014 – 4.02-4.62, 2015 – 3.76-4.53, 2016 – 4, 02-4.57, 2017 – 3.71-4.23 t/ha. Average data are presented in Fig. 1 (a, b) confirms that the varieties responded differently to external factors, which led to discrepancies in seed yields.




a) Forest-Steppe ecotype



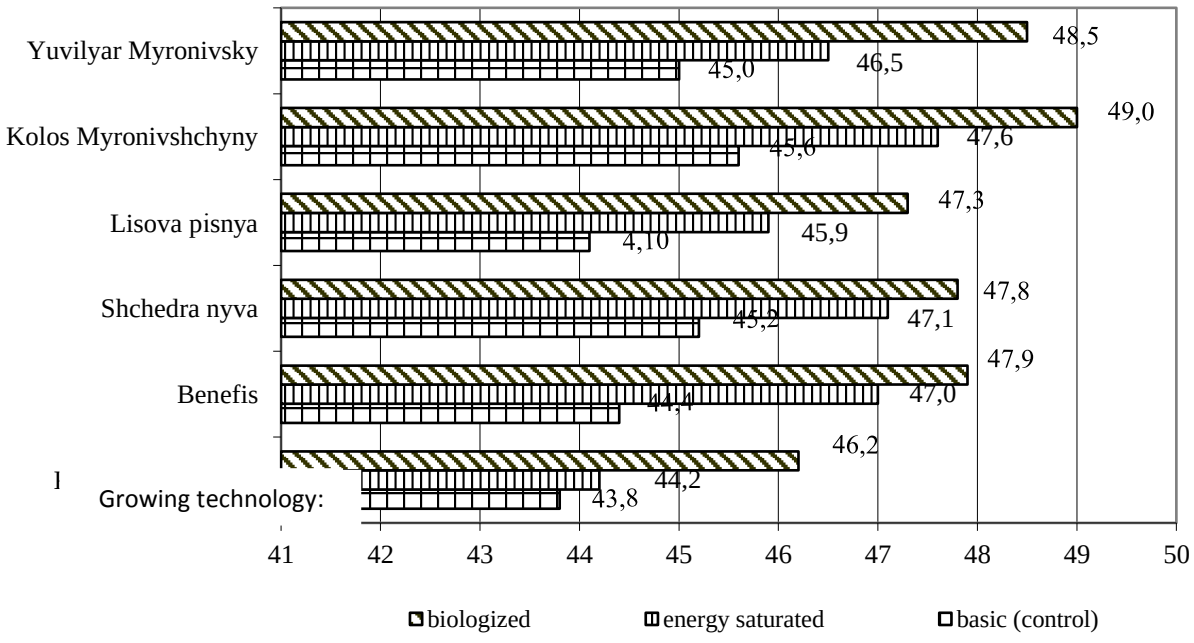

b) Steppe ecotype

Fig. 1. Yield of seeds of winter wheat varieties depending on growing technologies (2013–2017), t/ha

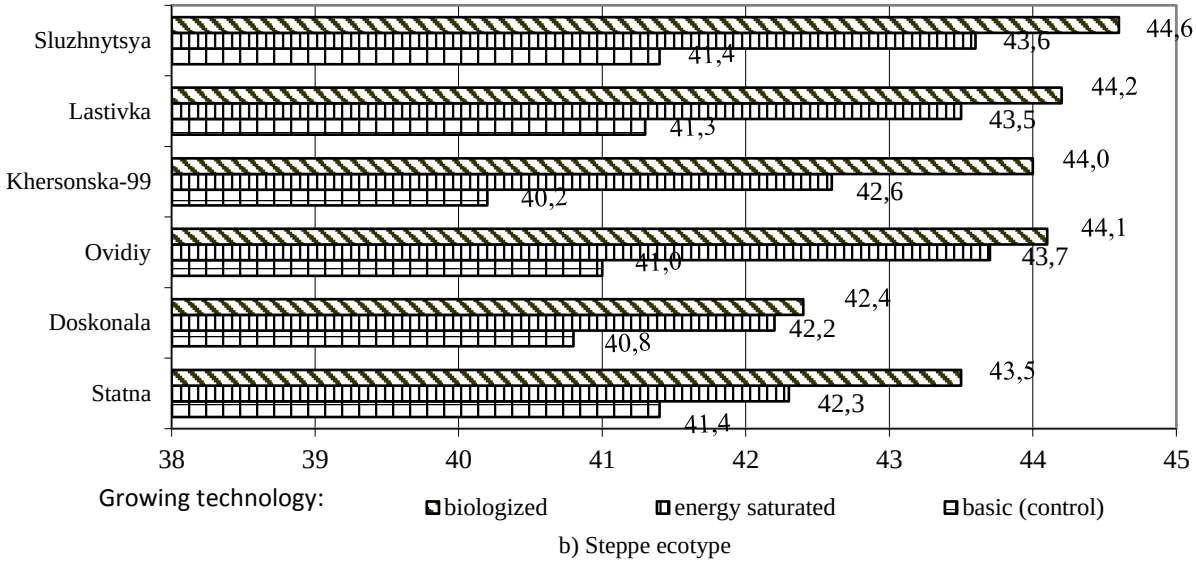
For the basic technology of growing winter wheat, which mobilized natural and technological factors, the highest seed yield ranged from 4.20 t/ha – in the variety Kolos Myronivshchyny to 3.73 t/ha – in the variety Khersonska-99. According to $LSD_{05}$, the difference between varieties was essential and amounted to 0.08–0.29. The high yield of seeds was formed by the varieties of the forest-steppe ecological type, such as Shchedra nyva – 4.18 t / ha, Yuvilyar muronivsky – 4.13 t/ha, Benefis – 4.12 t/ha. This indicator was lower for varieties of steppe ecological types: Statna – 3.82 t/ha, Lastivka – 3.83, Sluzhnytsia – 3.81 t/ha. According to seed yield, the average difference in the type of varieties varied within 4.12–3.68 t/ha and amounted to 0.44 t/ha.

The energy-saturated cultivation technology of winter wheat varieties has contributed to the higher productivity of the varieties. Compared to the Kraevyd control variety, the highest yields were formed by the varieties: Kolos Myronivshchyny – 4.69 t/ha, Benefis – 4.64 t/ha, Shchedra nyva – 4.63 t/ha, and the lowest ones – Doskonala (3.98 t/ha), Statna (4.06 t/ha), Khersonska-99 (4.06 t/ha). The average yield of forest-steppe ecological type varieties was 4.57 t/ha, steppe one - 4.10 t/ha, with an ecotype difference of 0.40 t/ha. Somewhat lower the yield of the steppe ecotype varieties was determined at the genetic level to respond to natural factors that consisted of the years of research. The intensity of varieties for energy-saturating contributed to a reliable difference in yield gain (0.19–0.28 t/ha). For the biologized technology of cultivating winter wheat, the yield of seed varieties varied from 4.47 t/ha in the variety Kolos Myronivshchyny to 3.87 t/ha, in Doskonala variety with a difference between the varieties of 0.11–0.35 t/ha. The high productivity was provided by the forest-steppe ecological varieties of the following types: Yuvilyar muronivsky – 4.46 t/ha, Shchedra nyva – 4.36 t/ha, Benefis – 4.35 t/ha. According to the variety type, the difference was 0.14–0.22 t/ha.

The formed seed yield determined the mass of 1000 seeds. With intensive base technology, this indicator was 40.2 g (variety Khersonska-99) – 45.6 g Kolos Myronivschyny (Fig. 2 (a, b)). In varieties of forest-steppe ecological type, the average indicator was at the level of 44.7 g, steppe ones – 41.0 g, or lower by 3.7 g. Depending on the genetically determined parameters, the difference between the varieties was essential 0.3–3.6 g.




a) Forest-Steppe ecotype




b) Steppe ecotype

Fig. 2. 1000 seeds mass of winter wheat varieties depending on growing technologies (2013–2017), g

For the energy-saturated technology, the mass of 1000 seeds ranged from 42.2 g (variety Doskonala) to 47.6 g (Kolos Myronivshchyny), 47.1 g (Shchedra nyva), 47.0 g (Benefis). The difference for this index between the varieties of the forest-steppe ecotype was 1.7–3.4 g, steppe ones – 0.5–2.0 g ($LSD_{05}$ 1.0). According to this cultivation technology, compared to the previous one, the mass of 1000 seeds was more by 1.7 g (forest-steppe ecotype) – 1.9 g (steppe one), the difference between the ecotype was 0.2 g. For the biologized technology the mass of 1000 seeds was the highest and amounted to 42.4 g (variety Doskonala) – 49.0 g (variety Kolos Myronivshchyny). The average indicator of forest-steppe ecotype varieties was 47.8 g, of the steppe varieties – 43.8 g with a difference between them of 4.0 g.

From the data of Table, it can be seen that, depending on the technology of growing winter wheat and the biological properties of a particular variety, the fractional composition of the collected seeds was different. So, with the basic technology, the yield of a large fraction of seeds (2.5–2.8 mm) was 55.3–62.3 %, the average (2.2–2.5 mm) – 28.0–33.3 %, small (2.0–2.2 mm) – 9.7–11.4 %. For energy-saturated technology, a decrease in the yield of a large fraction of 2.6–2.9 %, an average of 0.8–3.5 %, and an increase in the fine fraction of 3.7–5.8 % were observed. The highest yield of a large fraction of seeds was provided by the biologized technology of growing varieties – 64.5–68.9 %, the percentage of the average fraction was lower by 1.9–2.4 %, small, respectively, by 7.1–9.5 %.

The uniformity of seeds of forest-steppe ecological type cultivars for the biologized cultivation technology contributed to the obtaining of 4.4 % of the large fraction and 3.1 % average compared with the steppe ecotype.

Table. **Fractional composition of seeds of winter wheat varieties depending on growing technologies (2013–2017), %**

| Variety | Growing technology | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | basic (control) | | | energy saturated | | | biologized | | |
| | seed fraction, mm | | | | | | | | |
| | 2.5–2.8 | 2.2–2.5 | 2.0–2.2 | 2.5–2.8 | 2.2–2.5 | 2.0–2.2 | 2.5–2.8 | 2.2–2.5 | 2.0–2.2 |
| Forest-Steppe ecotype | | | | | | | | | |
| Krayevyd (control) | 6.0 | 30.3 | 9.7 | 55.4 | 27.5 | 17.2 | 65.2 | 26.6 | 8.2 |
| Benefis | 61.1 | 28.6 | 10.3 | 59.1 | 25.0 | 15.9 | 68.1 | 25.2 | 6.7 |
| Shchedra nyva | 63.3 | 25.8 | 10.9 | 60.6 | 27.2 | 12.2 | 69.5 | 25.0 | 5.5 |
| Lisova pisnya | 61.7 | 27.5 | 10.8 | 58.6 | 29.4 | 12.0 | 68.8 | 25.4 | 5.8 |
| Kolos Myronivshchyny | 64.0 | 28.0 | 8.0 | 61.9 | 27.1 | 11.0 | 71.2 | 23.5 | 5.3 |
| Yuvilyar myronivsky | 63.6 | 27.9 | 8.5 | 61.0 | 27.1 | 11.9 | 70.5 | 23.0 | 5.5 |
| Average | 62.3 | 28.0 | 9.7 | 59.4 | 27.2 | 13.4 | 68.9 | 24.8 | 6.3 |
| Steppe ecotype | | | | | | | | | |
| Statna | 54.8 | 33.6 | 11.6 | 54.0 | 29.3 | 16.7 | 63.5 | 28.6 | 7.9 |
| Doskonala | 55.1 | 33.0 | 11.9 | 54.1 | 29.6 | 16.3 | 64.1 | 28.2 | 7.7 |
| Ovidiy | 55.8 | 33.2 | 11.0 | 53.0 | 29.8 | 17.2 | 64.8 | 28.1 | 7.1 |
| Khersonska-99 | 54.2 | 34.3 | 11.5 | 52.1 | 29.9 | 18.0 | 63.2 | 28.8 | 8.0 |
| Lastivka | 55.9 | 32.9 | 11.2 | 52.6 | 30.0 | 17.4 | 64.6 | 27.8 | 7.6 |
| Sluzhnytsya | 56.2 | 32.7 | 11.1 | 52.1 | 30.2 | 17.7 | 66.7 | 26.0 | 7.3 |
| Average | 55.3 | 33.3 | 11.4 | 52.7 | 29.8 | 17.2 | 64.5 | 27.9 | 7.6 |
| Min-max between ecotypes | 55,3-62,3 | 28,0-33,3 | 9,7-11,4 | 52,7-59,4 | 27,2-29,8 | 13,4-17,2 | 64,5-68,9 | 24, 8-27,9 | 6,3-7,6 |
| Ecotype difference | 7,0 | 5,3 | 1,7 | 6,7 | 2,6 | 3,8 | 4,4 | 3,1 | 1,3 |
| Factor | | Impact force | | $LSD_{0.05}$ | | | | | |
| A (grade) | | 0.15 | | 0.92 | | | | | |
| B (seed fraction) | | 0.05 | | 0.46 | | | | | |

| | | | |
|---|---|---|---|
| C (growing technology) | 0.63 | 0.46 | |
| AB | 0.06 | 1.60 | |
| AC | 0.05 | 1.60 | |
| BC | 0.03 | 0.80 | |
| Balance (error) | 0.02 | 2.77 | |
| Experience accuracy = 2.92% | Data variation = 63.07% | | |

Genetically incorporated indicator of high mass of 1000 seeds in varieties: Kolos Myronivshchyny, Yuvilyar muronivsky, Shchedra nyva, Benefis provided a high yield of large and medium fractions of seeds.

**Conclusion**

Weather factors and growing technologies had a direct impact on the seed productivity of winter wheat. With a higher sum of active temperatures and lesser precipitation of the period formation - seed ripening, the highest seed yield was formed by varieties in 2014. Depending on the ecological plasticity of varieties, they positively respond to weather factors and growing technologies, the difference in seed yield between the varieties of forest-steppe and steppe ecotypes varied from 3.68 to 4.12 t / ha at basic; 4.10–4.57 t / ha – energy-saturated and 4.06–4.36 – biologized technologies.

Compared with the basic technology, the energy-saturated (the highest rate of use of mineral fertilizers and a large number of chemical treatments), the index of 1000 seeds mass grew by 1.8–2.2 g. In biologized technology – a balanced complex of biologically active substances in nutrition and plant protection from diseases contributed to the formation the higher by 2.8–3.1 g mass of 1000 seeds, which ensured a high yield of large (2.5–2.8 mm) and medium (2.2–2.5 mm) seed fractions, respectively 93.7 % (varieties of forest-steppe ecotype) and 92.4 % (steppe).

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