The purpose of the research is to identify promising genotypes of sweet pepper source material based on the main economically valuable traits for further use in heterosis selection. Methods: Field, laboratory, measurement-weight, statistical. Results: The study highlighted that the best samples of source material for breeding sweet pepper for earliness were the genotypes: Iga, L. 183/331, Polet, Rewia, which reach technical maturity in 99–103 days. The most large-fruited samples compared to the standard variety Snihur (12; 6 cm) were: Robertina (13; 7 cm), Veronika (15; 7 cm), Ania (19; 7 cm), Herakl (16; 7 cm), Fatima (16; 7 cm), Horticolas (17; 9 cm), Enei (13; 8 cm). It was found that the highest number of fruits per plant was in samples: Druzhok (11 pcs.); L. 183/331 (12 pcs.); L. 184/332 (16 pcs.); Kurtovskakapia (11 pcs.); Oda (11 pcs.); Tsyhanskyi baron (12 pcs.); King kong (11 pcs.); Chornyi kin (11 pcs.). The samples highlighted for "average commercial fruit weight" were: Ania (197 g); Herakl (174 g); Horticolas (246 g); Bel hoii (189 g); Enei (177 g); Tonenoelloy (186 g). The highest fruit productivity of sweet pepper was observed in the genotypes: Avengo (1210 g/plant); Alexia (1205 g/plant); Druzhok (1326 g/plant); Ania (1482 g/plant); Anastasia (1320 g/plant); Iga (1246 g/plant); Herakl (1436 g/plant); Horticolas (1331 g/plant); King kong (1256 g/plant). Conclusions: Thus, the conducted breeding research allowed identifying the main genotypes that combine several important quantitative traits – these are L. 183/331, L 184/332, Ania, Herakl, Horticolas, King kong.

Keywords: sweet pepper, source material, genotypes, breeding, productivity, heterosis hybrids

Introduction. Source material for further breeding work with vegetable plant species receives much attention, as genetic diversity is the foundation for creating new varieties and heterosis hybrids. The availability of various sources of valuable economic traits provides the opportunity to model varieties and F₁ hybrids that meet the changing demands of agricultural production, processing industry, and consumer market (Sergienko, 2022; Kulikov, 2021). Considering this, foreign breeding companies offer new promising hybrids to the Ukrainian market, which have proven themselves well for fresh consumption and processing. Unfortunately, there are not enough domestic sweet pepper varieties and hybrids that could compete with foreign counterparts and possess a full range of desirable traits according to their intended use. Therefore, we have started work aimed at creating our own F₁ hybrids of sweet pepper, which will increase the potential yield and preserve the content of valuable biochemical substances.

Since the source material is the basis for the successful creation of new varieties and heterosis hybrids, breeding for heterosis requires the direct presence of desired traits in the source forms. Some researchers believe that at the initial stage of the breeding process, it is necessary to have a complete characterization of all sweet pepper samples and expand the possibilities of their most effective use (Rodriguez-Llanes, 2023; Pereira-Dias, 2019). A breeder must clearly understand what traits and features a variety or hybrid, which they are working to develop, should possess. It is not necessary for each parent plant to have a complete set of traits (it is enough for the spectrum of necessary traits to be partially present in the maternal components, and the rest in the paternal ones).

Breeding for heterosis involves the preliminary creation of targeted source material with a complex of predetermined traits for successful combination in F₁ hybrids. This is especially true for traits that are negatively correlated and challenging to combine in a single variety, such as earliness and
productivity, earliness and fruit size, productivity, and disease resistance. This is particularly important when creating new forms with high adaptive potential and resistance to major diseases and pests. Therefore, in studying the source material, significant attention is paid to the ecological-genetic approach, which allows determining the effect of the "genotype-environment" interaction.

Thus, the modern market needs varieties and F1 hybrids with a complex of useful economic traits that can form a consistently high yield from generation to generation, regardless of the conditions affecting the plants during the growing season (Pidlubenko, 2022). Along with this, the ecological orientation of modern breeding dictates the need to obtain plants with high resistance to pests, diseases, abiotic environmental factors, and increased indicators of high potential yield (Brezeanu, 2022; Kasampalis, 2022).

Analysis of recent studies and publications on the research topic. Recently, food products with beneficial properties and enhanced vitamin content have attracted increasing attention. In this regard, sweet pepper is an undisputed leader among vegetables, whose fruits have valuable nutritional and taste qualities. The fruits are rich in vitamins A and C, potassium, folic acid, fiber, as well as other minerals and antioxidants (Creola Brezeanu, 2022). Along with high taste qualities, the fruits are also valuable raw materials for the canning industry.

The constant demand for this crop requires an increase in yield and a wide variety of varieties considering different usage directions. The yield of sweet pepper depends not only on technological but also on meteorological growing conditions. Therefore, the most valuable for farmers and the consumer market are varieties and hybrids that can maximize their genotype potential in changing growing conditions.

A large number of observations by domestic and foreign scientists provide generalized material on the availability of source material with a range of desired traits for creating heterosis F1 hybrids of sweet pepper (Kulikov, 2022; Mabuza, 2022; McCoy, 2023). It is mainly noted that when creating new commercial hybrids, the presence of high-quality source material with a complex of desired traits is envisaged, which, with the correctly selected combinatorial ability, gives a high heterosis effect. Heterosis or hybrid vigor in sweet pepper is manifested in a significant increase in earliness, overall yield, improvement in the biochemical com-

position, and market qualities of the fruits, which provides undeniable advantages over ordinary varieties (Hong, 2020). Several authors argue that heterosis hybrids differ from source forms in high photosynthesis activity, content of endogenous growth regulators, as well as a high balance of the main energy-forming systems during ontogenesis (Moreno-Peris, 2020; Kondo, 2022; Esposito, 2022). The heterosis effect for yield can be considered a result of the interaction of different components: plant size, early flowering, average fruit weight, and the number of fruits per plant (Acquadro, 2020). According to Liu (2019), heterosis for yield is primarily due to the number of fruits per plant, which correlates with the average fruit weight. Predicting the heterosis effect allows identifying promising parental pairs at early stages of the breeding process, significantly reducing the workload (Pylypenko, 2020). Favorable combinations of parental pollination components result in increased quantitative and phenotypic trait indicators in the first-generation hybrids compared to the source forms.

Therefore, to expand the growing area of sweet pepper and increase its production volumes in Ukraine, it is necessary to create high-yielding and early-maturing varieties and hybrids that meet the needs of both producers and serve as important breeding material for further work. Studying the source material is one of the pressing tasks of modern breeding and a fundamentally important theoretical approach to the breeding process.

The purpose of the research is to identify source material based on the main productive indicators (earliness, average fruit weight, number of fruits per plant, productivity) for further use in the breeding process, especially for creating F1 hybrids.

Materials and Methods. The research was conducted at the Institute of Vegetable and Melon Growing NAAS, located in the Left Bank Forest-Steppe of Ukraine. The material for the 2022–2023 studies consisted of lines and varieties from the collection of the laboratory of selection of solanaceous and cucumber crops, as well as domestic and foreign breeding varieties.

Predecessor - sweet potato culture. Growing method - seedling. Seedlings were grown in a film greenhouse with heating. Sowing was carried out in the second decade of March. The first shoots were received in the third decade of March. Before transplanting, the seedlings were hardened for 8–10 days, and at the time of transplanting, they had a well-developed root system. Seedlings were planted in the second decade of May, with an age of 60
days at the time of planting. The planting scheme was (60+40) × 35 cm, with a total plot area of 200 m². Plants were transplanted without repetitions, where samples were evaluated for groups of variety types: triangular, square, rectangular, and round. Samples were compared with the zoned standard - Snihur variety, placed every 10th number.

Technological measures for growing sweet pepper in the research included weeding, fertilization, irrigation, pest, and disease control. During the growth and development of plants, regular observations and biometric measurements were conducted. Phenological indicators noted included: date of sowing, emergence, first true leaf, flowering, technical and physiological maturity; while biometric indicators included height and diameter of fruits, number of fruits per plant. Productivity accounting was determined by the method of subfractional weighing upon achieving technical maturity to determine the mass of marketable fruit.

Breeding work on studying the initial material of sweet pepper was implemented according to the methodological recommendations for selection and seed production of solanaceous crops (Horova, 2001; Kravchenko, 2002; Krutko, 2020), field research methods in vegetable growing (Bondarenko, 2001), methods for evaluating initial and breeding material (Hoptsiy, 2021). Morphological description of varieties and lines was conducted according to the methodology of testing annual peppers (sweet, hot, bell peppers, chili) (Capsicum annuum L.) for distinctness, uniformity, and stability (sops. gov. ua/vos, 2023). Collection samples were evaluated according to the catalog of morphological traits of the gene pool of the species Capsicum annuum L. (Mytenko, 2020). Statistical processing of experimental data was carried out using the Microsoft Office Excel package.

**Research results.** Analysis indicates that the duration indicators of the sweet pepper growing period are quite dynamic and often depend on the variety properties of genotypes. Thus, based on the duration of the interphase period from mass emergence to technical maturity, the initial material samples were categorized into very early (up to 100 days), early (101-120 days), mid-season (121-135 days), and late (over 135 days) (Horova, 2001). The most numerous were the samples classified as early, accounting for 87% of the entire collection material.

From the perspective of selecting initial material, very early and early samples are of practical value. Thus, for selection for earliness, samples were identified: L.B.k. (100 days) and Iga (99 days), Polet (103 days), Rewia (103 days), where the duration of the "emergence-technical maturity" period was shorter compared to the Snihur control (105 days) (Table 1).

### Table 1. Sweet pepper samples distinguished by early ripeness, average for 2022-2023

<table>
<thead>
<tr>
<th>Sample Name</th>
<th>Germination to flowering</th>
<th>Flowering to technical maturity</th>
<th>Emergence to technical maturity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Snihur - st</td>
<td>84</td>
<td>21</td>
<td>105</td>
</tr>
<tr>
<td>Iga</td>
<td>81</td>
<td>18</td>
<td>99</td>
</tr>
<tr>
<td>L. 183/331</td>
<td>81</td>
<td>19</td>
<td>100</td>
</tr>
<tr>
<td>Polet</td>
<td>84</td>
<td>19</td>
<td>103</td>
</tr>
<tr>
<td>Rewia</td>
<td>84</td>
<td>20</td>
<td>103</td>
</tr>
</tbody>
</table>

The degree of reaction of genotypes to changes in environmental conditions (ecological plasticity) was estimated by the coefficient of ecological plasticity (b) according to the Eberhart–Russell method (Eberhart & Russell, 1966).

The results. When evaluating collection samples by plant height (Table 2), it was found that this indicator had a tendency to decrease in 2023 and was on average for the collection for this year by varieties 97.4 cm, by hybrids – 98.7 cm.

The diversity of collection samples was studied based on quantitative and qualitative characteristics, including morphological descriptions of plants and biometric measurements. Each genotype was characterized by individual values of economic and biological traits.
It was noted that the positioning of fruits on the plants was predominantly pendant. The color of fruits at technical ripeness among samples varied from dark green, green, light green to yellow, and upon ripening, it ranged from red, yellow to orange. Compact medium-sized and bushy types predominated among plant types.

The investigated variety samples differed in biometric indicators such as height and fruit diameter. The most large-fruited, compared to the Snihur (12; 6 cm) were samples: Aleksii (13; 7 cm), Anya (17; 7 cm), Liudmyla (13; 7 cm), Robertina (13; 7 cm), Herakl (15; 7 cm), Vezuvii (15; 7 cm), Horticolas (17 cm; 9 cm).

One of the main requirements demanded by producers for modern varieties and hybrids is high and stable productivity. Its magnitude depends on the number of plants per unit area and the average productivity at the specified planting density. Productivity is evaluated by the weight of fruits from a single plant. We investigated the components of productivity for each variety sample - the number of fruits per plant and the weight of a single fruit (Table 2).

<table>
<thead>
<tr>
<th>Sample Name</th>
<th>Fruit Length, cm</th>
<th>Fruit Diameter, cm</th>
<th>Number of Fruits, pcs</th>
<th>Weight of 1 Fruit, g</th>
<th>Productivity, g/plant</th>
</tr>
</thead>
<tbody>
<tr>
<td>Snihur - st</td>
<td>12</td>
<td>6</td>
<td>9</td>
<td>137</td>
<td>1194</td>
</tr>
<tr>
<td>L. 183/331</td>
<td>12</td>
<td>6</td>
<td>14</td>
<td>65</td>
<td>860</td>
</tr>
<tr>
<td>L. 184/332</td>
<td>12</td>
<td>6</td>
<td>14</td>
<td>73</td>
<td>1005</td>
</tr>
<tr>
<td>Aleksiiia</td>
<td>13</td>
<td>7</td>
<td>10</td>
<td>151</td>
<td>1369</td>
</tr>
<tr>
<td>Polet</td>
<td>12</td>
<td>7</td>
<td>10</td>
<td>127</td>
<td>1190</td>
</tr>
<tr>
<td>Aivenho</td>
<td>12</td>
<td>6</td>
<td>11</td>
<td>126</td>
<td>1343</td>
</tr>
<tr>
<td>Ania</td>
<td>17</td>
<td>7</td>
<td>8</td>
<td>185</td>
<td>1414</td>
</tr>
<tr>
<td>Liudmyla</td>
<td>13</td>
<td>7</td>
<td>7</td>
<td>155</td>
<td>1056</td>
</tr>
<tr>
<td>Atlant</td>
<td>12</td>
<td>7</td>
<td>9</td>
<td>118</td>
<td>1085</td>
</tr>
<tr>
<td>Robertina</td>
<td>13</td>
<td>7</td>
<td>10</td>
<td>137</td>
<td>1304</td>
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<tr>
<td>Herakl</td>
<td>15</td>
<td>7</td>
<td>8</td>
<td>174</td>
<td>1414</td>
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<tr>
<td>Vezuvii</td>
<td>15</td>
<td>7</td>
<td>10</td>
<td>167</td>
<td>1642</td>
</tr>
<tr>
<td>Mira</td>
<td>11</td>
<td>7</td>
<td>7</td>
<td>114</td>
<td>819</td>
</tr>
<tr>
<td>Iga</td>
<td>7</td>
<td>8</td>
<td>9</td>
<td>134</td>
<td>1192</td>
</tr>
<tr>
<td>Oda</td>
<td>9</td>
<td>7</td>
<td>11</td>
<td>101</td>
<td>1046</td>
</tr>
<tr>
<td>Zolotoitelets</td>
<td>11</td>
<td>8</td>
<td>6</td>
<td>175</td>
<td>1142</td>
</tr>
<tr>
<td>Horticolas</td>
<td>17</td>
<td>9</td>
<td>5</td>
<td>320</td>
<td>1360</td>
</tr>
<tr>
<td>Rewia</td>
<td>10</td>
<td>8</td>
<td>7</td>
<td>149</td>
<td>1013</td>
</tr>
<tr>
<td>California wonder</td>
<td>9</td>
<td>8</td>
<td>7</td>
<td>189</td>
<td>1234</td>
</tr>
<tr>
<td>Ratunda</td>
<td>8</td>
<td>8</td>
<td>8</td>
<td>144</td>
<td>1129</td>
</tr>
<tr>
<td>Hladіator</td>
<td>9</td>
<td>7</td>
<td>7</td>
<td>153</td>
<td>941</td>
</tr>
<tr>
<td>HIP&lt;sub&gt;st&lt;/sub&gt;</td>
<td>1,2</td>
<td>0,4</td>
<td>1,1</td>
<td>23,4</td>
<td>93,0</td>
</tr>
</tbody>
</table>

Table 2. Sweet pepper samples distinguished by economic valuable traits, average for 2022-2023

According to the research results, samples stood out for a higher number of fruits per plant: L. 183/331 (14 pcs.), L. 184/332 (14 pcs.), Aleksii (10 pcs.), Polet (10 pcs.), Aivenho (11 pcs.), Robertina (10 pcs.), Vezuvii (10 pcs.), Oda (11 pcs.). The highest average weight of marketable fruit was noted for the samples: Aleksiiia (151 g), Anya (185 g), Liudmyla (155 g), Herakl (174 g), Vezuvii (167 g), Zolotoitelets (175 g), Horticolas (320 g), California Wonder (189 g).

Of all the important economic traits, the most attention is paid to productivity. The manifestation of this trait is ensured by a combination of genetic and natural factors, especially in unstable climatic conditions for growing sweet peppers in the Kharkiv region. The influence of natural-climatic factors is quite significant, often exceeding the effects of gen-
otype and at the same time hindering the selection and evaluation of initial material for breeding.

The productivity of the analyzed genotypes of sweet pepper varied greatly (860-1642 g/plant). The highest productivity was observed in samples: Alexia (1369 g/plant), Aivengo (1343 g/plant), Anya (1414 g/plant), Robertina (1304 g/plant), Hercules (1414 g/plant), Vesuvius (1642 g/plant), and Horticolas (1360 g/plant).

Discussion of the Topic. To obtain new forms of sweet pepper, an initial hybrid population is created that should contain a set of desirable traits for the breeder. This is only possible if these traits are present in both the maternal and paternal forms. One genotype may not always satisfy the need for certain traits. Therefore, to create new forms, especially heterozygous hybrids, it is necessary in the initial stages of the breeding process to have a complete characterization of all sweet pepper samples. Several authors argue that modeling new varieties and hybrids can only be achieved with diverse sources of valuable agronomic traits (Sergienko, 2022; Kulikov, 2021).

Increasing market relations raise demands for the quality and potential yield of sweet pepper fruits. Thus, modern markets require varieties and hybrids with a complex expression of beneficial agronomic traits capable of consistently producing high yields across generations regardless of the conditions affecting plants during the growing season (Pidlubenko, 2022). This leads to the development of new varieties and hybrids with potentially high performance indicators: yield, fruit parameters, content of valuable biochemical substances, and resistance to diseases. To expand the possibilities of effectively utilizing genotypes, it is essential in the early stages of the selection process to have a complete characterization of all sweet pepper samples (Rodriguez-Llanes, 2023; Pereira-Dias, 2019).

Our research aims not only at creating promising varieties of sweet pepper but also heterozygous hybrids. However, achieving worthy results is only possible with high-quality initial materials combining agronomically valuable traits such as early ripening, productivity, pericarp thickness, attractive appearance, and good taste qualities.

At the same time, the ecological orientation of modern breeding dictates the necessity of obtaining plants with high resistance to pests, diseases, abiotic environmental factors, and increasing the potential yield. This forms the primary aspect of our further research (Brezeanu, 2022; Kasampalis, 2022).

Conclusions. As the starting material for further breeding work with sweet pepper, based on a complex of valuable agronomic traits, the following genotypes are recommended: for creating early-ripening varieties: L. 183/331, L 184/332, Veronika, Nail, Bohdan; for higher fruit count per plant: Druzhok, L. 183/33, L. 184/332, Kurtovskaiapia, Oda, Tsyhanskyi baron and King Kong; for the highest average weight of marketable fruit: Ania, Herakl, Horticolas, Bel Goy, Eney, Tennonelo; for the highest plant productivity: Aivengo, Aleksia, Ania, Anastasiiia, Iga, Herakl, Horticolas and King Kong.

Thus, the most valuable samples that combine several important traits are genotypes L. 183/331, L 184/332, Ania, Herakl, Horticolas and King Kong.

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Conflict of interest. The authors declare that there is no conflict of interest.

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ВИХІДНИЙ МАТЕРІАЛ ДЛЯ ГЕТЕРОЗИСНОЇ СЕЛЕКЦІЇ ПЕРЦЮ СОЛОДКОГО

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Мета досліджень полягає у виділені перспективних генотипів вихідного матеріалу перцю солодкого за основними господарсько-цінними показниками з метою подальшого використання в гетерозисній селекції. Методи. Польові, лабораторні, вимірювально-вагові, статистичні. Результати. Висвітлено результати досліджень, які доводять, що найкращими зразками вихідного матеріалу для селекції перцю солодкого на ранньостиглість були генотипи: Iga, Л. 183/331, Полет, Rewia, у яких через 99–103 доби настає технічна стиглість. Найбільш великоплідними в порівнянні із стандартом сортом Снігур (12; 6 см) були наступні зразки: Robertina (13; 7 см), Вероніка (15; 7 см), Аня (19; 7 см), Геракл (16; 7 см), Лай дак бэлл (13; 7 см), Фатима (16; 7 см), Horticolas (17; 9 см), Еней (13; 8 см). Встановлено, що найбільша кількість плодів на рослині була у зразків: Дружок (11 шт.); Л. 183/331 (12 шт.); Л. 184/332 (16 шт.); Куртовська (11 шт.); Oda (11 шт.); Циганський барон (12 шт.); Кингконг (11 шт.); Чорний кінь (11 шт.). За показником «середня вага товарного плоду» виділено зразки: Аня (197 г); Геракл (174 г); Horticolas (246 г); Бел гой (189 г); Еней (177 г); Tonenoelloy (186 г). Продуктивність плодів перцю солодкого була найвищою у генотипів: Айвенго (1210 г/росл.); Алексис (1205 г/росл.); Дружок (1326 г/росл.); Аня (1482 г/росл.); Анастасия (1320 г/росл.); Iga (1246 г/росл.); Геракл (1436 г/росл.); Horticolas (1331 г/росл.); Кингконг (1256 г/росл.). Висновки. Таким чином, проведені селекційні дослідження дозволили виділити основні генотипи, які поєднують в собі декілька важливих кількісних ознак – це Л. 183/331, Л 184/332, Аня, Геракл, Horticolas, Кинг-конг.

Ключові слова: перць солодкий, вихідний матеріал, генотипи, селекція, продуктивність, гетерозисні гібриди.