The cost recovery in the cultivation of different sunflower seed hybrids

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Abstract. Ensuring cost recovery and success in competition requires a flexible system of regulating the factors that determine it. In our opinion, one of the main such factors is the cost of seeds. It has been proven that the selection of the best hybrid in terms of productivity plays an important role in obtaining a high yield of sunflowers, as hybrids provide an increase in yield and even in excessively dry years, high yields of sunflowers can be obtained. The purpose of the research is to identify the dependence of yield on the costs of sunflower seeds and to increase their profitability by selecting the most effective hybrids. The work uses: monographic, comparative, statistical, tabular, graphic, abstract-logical methods and the method of correlation-regression analysis. It has been established that an economically beneficial factor in increasing crop yield for any cultivation technology is the quality composition of the used varietal resources. It was found that the best results in the enterprises of the Forest-Steppe zone are ensured by the use of hybrids. Thus, the highest rates of return on costs were obtained by hybrids NK Neoma and NK Kondi. The use of correlation-regression analysis allows determining the dependence of productivity on seed costs in the context of the use of hybrids that provide high return on costs.

1 Introduction

Favourable global market conditions and the expansion of domestic production capacity are the key factors that stimulate agricultural producers to grow sunflowers. At the same time, the competition between seed producers is intensifying, and the dependence of domestic producers and processors on the global market situation is increasing. Relatively low costs, unpretentious production technology and high sales price make sunflower one of the most profitable crops for cultivation in Ukraine [1].

Ukraine is one of the leading countries in the production and supply of sunflower seeds and sunflower oil, produces 30% of all sunflower oil on the planet, and provides almost 60% of global exports [2].

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This result was achieved thanks to the stable growth of production and processing capacities, the development of the industry as a whole and the supply of products to the foreign market. As a result, quite high purchase prices were formed on the Ukrainian market for sunflower seeds, which, taking into account moderate production costs, enabled agricultural producers to obtain a high level of profitability of this crop.

In ensuring the profitability of growing sunflower seeds, one of the main factors is the level of its productivity. A reliable and economically beneficial factor in increasing the yield of crops for any growing technology is the quality composition of the varietal resources used. Modern varieties and hybrids should meet intensive and industrial cultivation technologies as much as possible and be characterized by resistance to diseases and pests, adaptability to environmental conditions and high grain quality.

2 Material and Methods

Taking into account the purpose of the research, the methodology and the results of previous studies on the payback of the costs of using different sunflower hybrids, the authors established that there is a fairly close relationship between the productivity and the cost of the crop seeds.

The article uses reference materials of the Convention on Biological Diversity, the State Register of Plant Varieties Suitable for Distribution in Ukraine for 2022, the State Statistics Service of Ukraine, as well as the authors’ works [3-5].

The theoretical and methodological basis of the research was served by theoretical provisions and practical recommendations for determining the dependence of the yield of various sunflower hybrids on the cost of seeds. In the research process, general scientific and special research methods were used: monographic - to detail the structure of the production cost of 1 quintal of sunflower seeds; comparative - to compare the efficiency of different hybrids of sunflower seeds; statistical - for studying processes, factual data, identifying trends in the production of sunflower seeds; tabular – for a visual representation of the obtained results; correlation-regression analysis - to determine the closeness of the relationship between yield and seed consumption; abstract-logical – for formulating conclusions and research results. The study was based on the data of the State Statistics Service of Ukraine and the data of "GRANEKS-CHERKASY" LLC.

The article is structured as follows: the conceptual framework is presented in the previous section. After that, a critical review of the existing literature was made, which became the starting point for the study. The following are the results of a detailed analysis of the cost of production and its payback depending on different types of hybrids, conducted on the materials of the domestic agricultural enterprise "GRANEKS-CHERKASY" LLC, which is one of the leading producers of sunflower seeds in the Forest-Steppe zone. The document concludes with recommendations on the importance of considering seed costs and their payback when choosing quality hybrids.

3 Theory/calculation

The total war unleashed by Russia prompts the urgent determination of specific steps to ensure food security, therefore it is necessary to find ways and means of sustainable development for the agricultural sector. In particular, Buka S. et al. [6], when determining promising measures that can be implemented by agricultural producers within the next 5 years, consider each individual approach from a technological, financial and legal point of view.
The authors believe that despite the difficult challenges, agribusiness in Ukraine has great prospects thanks to the production of high-quality products that meet international standards, new technical and technological solutions and more sustainable logistics. Increasingly, scientists are investigating the influence of various factors on the productivity of sunflower, which is currently one of the most important agricultural crops in the world.

Thus, some foreign scientists evaluate the components of productivity and yield of sunflower according to spatial location. Based on analysis of variance and quantitative factors tested by polynomial regression, Bezerra F., Dutra A. and Pitombeira J. [7] determined that the spatial arrangement of sunflower crops affects the yield components, but does not affect the yield itself.

A large number of scientific studies are devoted to the influence of mineral fertilizer rates on the productivity of new sunflower hybrids. In particular, Chekhova, I. [8] considers the background of mineral nutrition to be an important element of sunflower cultivation technology, while emphasizing that increasing the yield of agricultural crops largely depends on the development of new varieties and hybrids resistant to various abiotic stresses and extreme environmental conditions.

A group of authors led by Dibrova A. [9] holds a similar opinion. Using the AGMEMOD partial equilibrium econometric model, they modelled the effects of changes in the cost of mineral fertilizers on the efficiency of agricultural crop production under probable scenarios. Directions for improving the mechanism of reducing the price or compensating costs for the purchase of mineral fertilizers for domestic producers are also proposed.

In the last decade, the problem of the influence of the cost of production on the efficiency of the production of agricultural crops has attracted more and more attention of scientists and practitioners, therefore there are quite a lot of studies in this direction. For example, scientists Oliynyk O. et al. [10] are researching a methodological toolkit for determining the optimal amount of costs under various conditions and forms of financing, which guarantees profit maximization taking into account the expected increase in yield due to the introduction of new varieties and hybrids.

Strategies adopted in the quest for food self-sufficiency are to provide quality seeds of new high-yielding varieties according to farmers' preferences. An important role is played by the availability of quality seeds in sufficient quantity, which are timely and easily obtained by farmers.

Sarintang M. and Suddin A. [11] emphasize the importance of using high-quality selection seeds when sowing agricultural crops. They state that when using low-quality seeds, farmers often experience significant losses, both in terms of costs and time. Therefore, despite the fact that the growth and productivity of plants are greatly influenced by climatic conditions and agricultural methods, it is important to remember the quality of the seeds used.

Orlov O. [12] believes that seeds are one of the least expensive, but most important factors that affect the yield of all agricultural crops. The author emphasizes that success in plant breeding is 50% ensured by high-quality genetics and seeds, and the other 50% by technology. According to the author, even with the application of the optimal amount of fertilizers and the use of modern technologies, a bad variety will not provide a high yield.

Pakhucha Ye. [13] emphasizes the close relationship between production costs and yields, which she believes to be directly proportional.

4 Results

It is difficult to overestimate the economic importance of sunflower, which has evolved over a long period of time to withstand soil and air droughts and high temperatures.
Ukraine is considered a global leader in sunflower production, which is one of the three most widely grown oilseeds. In 2022, its crops covered more than 5 million hectares, accounting for more than 85% of total vegetable oil production. In the oilseeds group, the share of sunflower in the sown area is 70%, and in the gross harvest - 85%. The profitability of the crop is high and is growing mainly due to the price, as it is almost impossible to reduce the cost of production due to the increase in prices for material resources, mineral fertilizers, and disease and pest control products.

Undoubtedly, one of the most important factors affecting the efficiency of sunflower cultivation is the production costs of seeds, which are the basis for cost formation and a tool for shaping the company's pricing strategy. Seed quality affects potential crop yields and profits more than any other cost component.

Therefore, this situation requires an objective assessment of the results in the field of crop production, and, as a result, there is a need to conduct a study to identify the dependence of yield on sunflower seed costs and increase the efficiency of its production by selecting the most efficient hybrids.

The crop is grown in almost all regions of our country, but the main sown areas before the full-scale Russian invasion were mainly concentrated in the central and southern regions. As a result of the occupation of a large part of the South and other major growing regions, it is necessary to increase its acreage in other areas of Ukraine, particularly in the Forest-Steppe zone.

One of the enterprises in the Forest-Steppe zone whose main activity is the production of sunflower seeds is "GRANEKS-CHERKASY" LLC.

The analysis of the company's sunflower seed acreage shows that it tends to increase in 2020-2022. Thus, in 2020, the sown area of sunflower seeds amounted to 369 hectares, and in 2022 it increased to 584 hectares, i.e. by 58.1%. The increase in the sown area with almost insignificant change in the yield had a positive impact on the significant growth of the gross harvest - by 68.1% (Table 1).

<table>
<thead>
<tr>
<th>Indicator</th>
<th>2020</th>
<th>2021</th>
<th>2022</th>
<th>2022 to 2020, %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Area, ha</td>
<td>369</td>
<td>464</td>
<td>584</td>
<td>158,1</td>
</tr>
<tr>
<td>Production, quintals</td>
<td>11153</td>
<td>17946</td>
<td>18746</td>
<td>168,1</td>
</tr>
<tr>
<td>Yield, quintals/ha</td>
<td>30,2</td>
<td>38,7</td>
<td>32,1</td>
<td>106,3</td>
</tr>
<tr>
<td>Total production costs, UAH thousand</td>
<td>10265</td>
<td>15616</td>
<td>19065</td>
<td>185,7</td>
</tr>
<tr>
<td>Costs per 1 ha, UAH</td>
<td>27795</td>
<td>33656</td>
<td>32646</td>
<td>117,5</td>
</tr>
<tr>
<td>Production cost per 1 quintal, UAH</td>
<td>920,37</td>
<td>870,17</td>
<td>1017,01</td>
<td>110,5</td>
</tr>
</tbody>
</table>

Due to the constant rise in the price of fuel and lubricants, pest and disease control products, and mineral fertilizers, production costs increased significantly over the analyzed period, by 85.7%.

Bringing costs to an optimal level should be a priority in developing a flexible cost management system. This can be achieved through the development of a regulatory framework and flow charts, which will enable us to manage costs and analyze deviations from optimal parameters. The structure of the production cost of 1 quintal of sunflower seeds is shown in Figure 1.
Thus, in 2020, in the structure of sunflower seed production costs at the studied enterprise, the predominant items were mineral fertilizers - 29%, the rest of material and other costs - 20% and 22%, respectively. Fuel also accounted for a significant share of 12%, which indicates the high cost of fuels and lubricants, which the company cannot influence.

It is worth noting that the smallest share in this structure is occupied by such cost items as depreciation and labour costs - 4% each. A negative aspect is the small share of labour costs, which reduces the level of motivation of employees engaged in growing sunflower seeds and indicates a high degree of differentiation in their income. This structure also shows that the company does not use the services of third-party organizations.

The analysis of the cost structure of 1 quintal of sunflower seeds in 2022 shows that it has not changed much compared to 2020. Thus, mineral fertilizers still account for the largest share, but already 21%, while the rest of material and other costs are 16% and 28%, respectively. Fuel also accounts for a significant share of 14%. However, in 2022, the company used the services of third-party organizations, which accounted for 5%.

The large share of material costs for sunflower seeds production is largely due to the increase in prices for industrial inputs (fertilizers, plant protection products, fuel, etc.), which indicates a growing disparity in prices for industrial and agricultural products.

An aspect that attracts attention in this study is the small share of seed costs, which is also decreasing from 9% in 2020 to 6% in 2022.

Agroexpert-Trade experts believe that the profitability of sunflower cultivation depends on the right choice of a hybrid that meets the natural and climatic conditions, soil composition and other features of the growing region. The domestic sunflower market is full of hybrids from domestic and leading global producers. The cost of hybrids from Ukrainian producers ranges from 60-80 UAH/kg. Imported seeds cost from USD 128 to USD 215 per sowing unit. The cost of seeds is determined by the cost of their purchase and delivery costs. When growing medium-late varieties of Ukrainian breeding using economical technology, the estimated seeding rate is 5.5-6 kg/ha. Given the price with delivery at 80 UAH/kg, the total cost of seeds is 480 UAH. With intensive technology in the amount of 0.43 sowing unit/ha and the price of the hybrid at 5097.19 UAH per sowing unit, the total cost of seeds is 2.19 thousand UAH [14].

One of the main factors for increasing sunflower yields is the selection of hybrids with high genetic potential. At the same time, their requirements for weather and climatic conditions in the region, tolerance to pests, and specifics of cultivation technology are taken into account.

According to scientists, proper selection of the hybrid ensures 35% of the yield, while the rest is due to agrotechnological and soil and climatic factors. High yields are achieved
when sowing seeds with a weight of at least 50 g per 1000 seeds. In addition, germination for hybrids should be at least 85%, and for varieties - at least 87-92% [15].

Previous studies show that the cost of seed stock at GRANEX-Cherkasy LLC accounts for 6-9% of total production costs. However, seed quality can affect potential crop yields and profits more than any other cost component. Since seed costs are an important factor in increasing sunflower yields, Fig. 2 shows a histogram of the distribution of such costs depending on the crop yield.

![Fig. 2. Histogram of distribution of production costs for seeds and sunflower seed yield.](image)

| y = -2.568x^2 + 20.239x - 7.0928 |
| R^2 = 0.9081 |

The equation of dependence of yield on seed costs is most reliably described by a polynomial curve of the 2nd degree (parabolic equation). The determined degree of relationship between the factor and the resultant trait is strong (R^2 = 0.9081).

Regression analysis was used to quantify the influence of the factor trait on the resultant trait and to assess its significance according to the relevant criteria.

Parameters of the one-factor model (Table 2) include: Y - sunflower seed yield, quintals/ha; X1 - cost of seeds per 1 ha of sowing, thousand UAH.

<table>
<thead>
<tr>
<th>Table 2. Results of the regression analysis of sunflower seed yield dependence on seed costs</th>
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</thead>
<tbody>
<tr>
<td><strong>Regression statistics</strong></td>
</tr>
<tr>
<td>Multiple R</td>
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<tr>
<td>R-squared</td>
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<tr>
<td>Normalized R-squared</td>
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<tr>
<td>Standard error</td>
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<tr>
<td>Observations</td>
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<tr>
<td><strong>Analysis of variance</strong></td>
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<tr>
<td>df</td>
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<tr>
<td>Regression</td>
</tr>
<tr>
<td>Balance</td>
</tr>
<tr>
<td>Total</td>
</tr>
<tr>
<td><strong>Coefficients</strong></td>
</tr>
<tr>
<td>Y</td>
</tr>
<tr>
<td>X</td>
</tr>
</tbody>
</table>

Thus, according to Fisher's criterion, the equations are statistically significant: the calculated value of 102.19 is greater than the table value of 3.47. The threshold value of the
Student's coefficient with a probability of $P = 0.95$, $T_{gr} = 2.08$. The critical limit of the coefficient of the equation (t-statistic) (10.11) exceeds the critical value of the Student's t-test. Accordingly, the coefficient of the equation of the variable $X$ is statistically significant, which with a probability of 0.95 confirms the significance of the factor's influence on the resultant attribute.

The closeness of the relationship is 0.9035 (strong), the coefficient of determination is 0.8163. That is, the yield of sunflower seeds depends on seed costs by 81.6%.

The correlation and regression dependence of yield on seed costs is as follows:

$$Y = 8.79061 + 6.47316X$$  \hspace{1cm} (1)

The value of the coefficient of the regression equation characterizes the coefficient of increase of the variable $Y$ with an increase of $X_i$ by one unit relative to the average. The results of the study show that with an increase in seed costs by 1 thousand UAH, the yield of sunflower seeds increases by 6.47 quintals/ha relative to the average values in the sample. The next stage of the study is to calculate the payback of production costs if the seeds used on the farm are replaced with hybrids that provide higher yields. Taking into account the recommendations of experts, we offer Syngenta hybrids NK Neoma and NK Kondi (Table 3).

### Table 3. Calculation of the payback of production costs when using seeds of different sunflower hybrids.

<table>
<thead>
<tr>
<th>Indicator</th>
<th>Actual data</th>
<th>Hybrid Syngenta NK Kondi</th>
<th>Hybrid Syngenta NK Neoma</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>values +, - to the fact</td>
<td>values +, - to the fact</td>
<td></td>
</tr>
<tr>
<td>Seeding rate per 1 ha, thousand seeds</td>
<td>60</td>
<td>60</td>
<td></td>
</tr>
<tr>
<td>Weight of 1000 seeds, g</td>
<td>70</td>
<td>75</td>
<td></td>
</tr>
<tr>
<td>Cost per 1 ha, kg</td>
<td>4.2</td>
<td>4.5</td>
<td></td>
</tr>
<tr>
<td>Cost of 1 kg of seeds, UAH</td>
<td>698</td>
<td>1080</td>
<td></td>
</tr>
<tr>
<td>Cost of seeds per 1 ha, UAH</td>
<td>2057</td>
<td>2932</td>
<td>875</td>
</tr>
<tr>
<td>Production costs per 1 ha, UAH</td>
<td>32646</td>
<td>35519</td>
<td>2873</td>
</tr>
<tr>
<td>Sunflower yield, quintals/ha</td>
<td>32,1</td>
<td>45,0</td>
<td>12.9</td>
</tr>
<tr>
<td>Sales price of 1 quintal, UAH</td>
<td>1390</td>
<td>1390,0</td>
<td>1390,0</td>
</tr>
<tr>
<td>Cost of harvest, UAH/ha</td>
<td>44619</td>
<td>62550</td>
<td>20931</td>
</tr>
<tr>
<td>Payback of production costs, %.</td>
<td>136,7</td>
<td>176.1</td>
<td>39.4</td>
</tr>
</tbody>
</table>

Thus, the calculations show that for the hybrid NC Kondi at a cost of 1 kg of seeds 698 UAH and its consumption per 1 ha of 4.2 kg, the cost of seeds per 1 ha will be 2932 UAH.

The yield of this variety is 45 quintals/ha, so at the actual selling price of 1 quintal of sunflower seeds of UAH 1390, the cost of the crop will be UAH 62550. That is, the return on production costs will be 1.76.

Similar calculations were made for the Syngenta NK Neoma hybrid. Thus, at a cost of 1 kg of seeds of 1080 UAH and its consumption per 1 ha of 4.5 kg, the cost of seeds per 1 ha will be 4860 UAH. The yield of this variety is 50 quintals per hectare, so at the actual selling price of 1 quintal of sunflower seeds of UAH 1390, the cost of the crop will be UAH 69500. That is, the return on production costs will be 1.85.

Thus, these hybrids are high-yielding and, according to the authors, will provide the company with higher profits.

### 5 Discussion
For several years in a row, Ukraine has been the world leader in sunflower production. Almost every farmer has this crop in their crop rotation. However, every year farmers face the problem of choosing the best among a huge number of hybrids.

The State Register of Plant Varieties of Ukraine [4] includes more than 2000 sunflower varieties and hybrids with different morphobiological characteristics. Most of the area is planted with foreign hybrids, while the rest is occupied by domestic ones.

The genetic potential of domestic sunflower hybrids is quite high. To obtain high-quality seed material, it is necessary to carefully follow the technology of its cultivation, as failure to comply with even one of its conditions during the breeding of domestic sunflower hybrids often leads to a significant decrease in yield. For example, non-compliance with spatial isolation standards leads to a significant reduction in the heterotic effect and a low level of hybridity, which results in a lower yield. The main advantage of foreign seeds is a high degree of calibration, which plays an important role in obtaining the highest possible yield. Insufficiently calibrated seed leads to overconsumption of seeds during sowing and uneven maturation of seedlings. As a result, sunflower harvesting is untimely, resulting in losses and a shortfall in yield per unit area.

A major problem for domestic producers in sunflower cultivation is the infestation of fields with broomrape, which significantly reduces crop yields. Therefore, an important factor when choosing sunflower hybrids for commercial crops is their resistance to broomrape. It should be noted that most domestic hybrids are resistant to 4-5 broomrape races A-E, while foreign sunflower hybrids are resistant to 7 races A-G. Therefore, Ukrainian farmers often prefer foreign sunflower hybrids to prevent the risk of not getting a quality harvest.

Definitely, the hybrid should be selected for a specific cultivation technology, as well as take into account the willingness of farmers to invest in a specific period of time on a specific field. The type of sunflower hybrid will ultimately determine the growing technology that the producer prefers [16].

Each sunflower hybrid is unique. It has its own set of strong traits that allow it to produce crops under certain weather and agricultural conditions. Therefore, it is recommended to grow several hybrids with different characteristics to prevent risks depending on the growing conditions.

NK Kondi is a simple hybrid with a growing season of 111-115 days and an oil content of up to 54%. It has high growth energy in the initial stages. It is characterized by excellent stability and plasticity.

NK Neoma is a mid-season hybrid whose seeds are highly resistant to most common diseases. The height of the plant reaches more than 160 cm. The oil content is up to 50%. Due to its powerful root system, the plant is highly resistant to drought.

NK Kondi and NK Neoma sunflower seeds are resistant to lodging and do not reduce yields with increased plant density. The hybrids are cultivated using Clearfield technology. Experts recommend growing sunflower seeds of these hybrids in the steppe and Forest-Steppe zones of Ukraine.

The authors believe that without the use of modern technologies, it is impossible to expect high yields of sunflower, as the natural fertility of soils is decreasing over the years, which does not guarantee growth in gross harvest of this crop, as well as other crops. Unfortunately, today the quality of domestic sunflower hybrids is inferior to foreign ones in terms of some technological indicators. In recent years, domestic sunflower hybrids have come much closer to foreign hybrids in terms of their economic value, but the gap between potential and actual yields remains significant. Seed quality and costs affect crop yields and profits more than any other cost component.

6 Conclusions
Sunflower is one of Ukraine's strategic oilseeds and is very attractive for farmers in the Forest-Steppe zone due to its low production costs, stable demand for seeds and high market value. Today, it is and will remain an urgent problem to further increase its productivity and meet the increasingly urgent need for quality seeds through the selection of hybrid composition and other factors.

It is proved that among the factors that determine sunflower productivity, one of the most important is the cost of its seeds, so regression analysis was used to quantify the influence of the factor trait on the productive trait and to assess its significance. The conducted research gives grounds to conclude that the yield of sunflower seeds depends on these costs by 81.6%.

The calculation of the payback of seed costs if the seeds used on the farm are replaced with hybrids that provide higher yields shows that these hybrids are high-yielding and can provide the enterprise with a high return on investment.

Thus, given that in the near future sunflower will be the main oilseed crop, companies with limited financial resources should introduce hybrids that provide high profitability. Today, domestic breeding companies need substantial support to create new varieties and hybrids that are not inferior to market leaders in terms of quality and price and will be more interesting for Ukrainian farmers.

The practical significance of the presented work lies in the formation of the necessary basis for further systematic study of the dependence of yield on seed costs in agricultural enterprises.

The limitation of further research is the availability of prices for sunflower seed hybrids for agricultural producers, the ability to increase their purchasing intent and satisfy their desire for profit.

This study was limited to analyzing the performance indicators of sunflower seed production on the example of a leading enterprise producing such products in the Forest-Steppe zone.

References