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METHODOLOGY FOR ANALYSIS OF THE DYNAMICS OF CROP PRODUCTION (ON THE EXAMPLE OF KHMELNITSKY REGION, UKRAINE)

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Abstract.*The structure of sown areas and productivity indicators of leading agricultural crops in the Khmelnitsky region of Ukraine for 2000-2019, as well as dynamics graphs and trend equations of land productivity indicators for the indicated period are presented. The calculations of indicators of the stability of the productivity of the main crops that have developed over the past 20 years have been performed. A methodology for assessing changes in indicators over the study period in absolute and relative measurements is presented. It is shown economic essence of land potential in agriculture; the methodology for its determination in the production of various crops is presented. The expediency of using an indicator of the level of realization of their potential, which comprehensively reflects the achieved value of land use productivity and possible reserves while increasing agricultural production, was emphasized. In carrying out this study, general scientific and special methods were used, namely, abstract-logical - to justify the methodology for calculating potential indicators of crop productivity, the graphical method - to identify trends in crop yields of cultivated crops. The above analysis of land productivity indicators in the studied region could be useful both for university students and agricultural enterprises not only in the Khmelnitsky region, but also located in other regions, using the proposed methodology to justify potential indicators of yield growth reserves and assess yield dynamics by every culture.*

Keywords:*land productivity, methodology, potential and actual productivity, trend, growth reserves, stability.*

JEL Classification: C82, Q13.
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1. Introduction.

Earth is the most important wealth of society, which is why the full use of its productive power is a national task. This provision is very relevant for the Khmelnitsky region of Ukraine, which has essentially complete development of the land fund. The impact of scientific and technological progress on land use efficiency in modern conditions is extremely important and is determined by many factors. The degree of this impact mainly depends on the capabilities of the industry; enterprises actively participate in the process of scientific and technological development, making their contribution to it, taking into account local conditions, and make maximum use of its results in practical activities in order to improve land use efficiency. These opportunities, in turn, are determined by a whole complex of terms that are combined by the general concept of "land potential".

2. Relevance of the topic and analysis of recent publications.

In modern conditions, there is a need for a wider use of the concept of "land potential", which would reflect the real productivity of land in the current conditions of production. It should be noted

that, along with the traditional indicators of land use efficiency in cultivation (the ratio of the results of production and financial activities in value or kind to the unit of land resources used), it is advisable to use an indicator of the level of realization of their potential, which will comprehensively reflect the achieved value of land use efficiency and possible reserves increasing agricultural production.

The issues of land use efficiency are considered in the economic literature from various perspectives. In particular, the issues of land potential management as the basis for the regional economic development were considered in the works of K. Vasiliev [1], S. Volkov, N. Komov, V. Khlystun [2] and other authors. Some aspects of the problem of efficient land use are devoted to the publications of V. Miloserdov, who upholds the principle of enlarging cultivated areas in agricultural enterprises [3], EV Volkova, who offers his methodological approaches to the definition of the concept of economic potential of an enterprise [4, p.12], and A. Gridyushko. - a new paradigm of the formation of resource potential [5, p.28], Among the Moldovan authors should be noted the work of candidates of economic sciences Todorici L. and Dudoglo T., respectively aimed at studying problems stably ti agricultural production [6] assessing the level of use and productivity of land regions [7].

3. Research methods.

In carrying out this study, general scientific and special methods were used, namely, abstract-logical - to justify the methodology for calculating potential indicators of crop productivity, the graphical method - to identify trends in crop yields of cultivated crops.

4. Statement of the main material.

The area of agricultural land in the Khmelnitsky region is 1568 thousand hectares, including arable land - 1255 thousand hectares. More than 3/5 of the area is allocated for grain and leguminous crops in the sowing structure, which is clearly shown in Table 1. At the same time, the share of sugar beets, potatoes, and vegetables is insignificant. More than 3/4 of the crops are in the field of grain crops and sunflower. In this regard, it is very important to identify how effectively the cultivated area occupied by these crops is used.

Due to a sharp decrease in the number of livestock over the study period, the share of the cultivated area allocated for providing livestock feed decreased from 35.8% at the beginning of the period to 11.2% by 2019, or more than 3.7 times. Over the years, the area allocated for the cultivation of sunflower as a highly profitable crop has increased 30 times. However, in the industry, the structure of the sown area was unfavorable in terms of the development of water and wind erosion of soils. So, crops of row crops - corn for grain and sunflower - occupy more than 337 thousand hectares or 36.6% of all crops. If we take into account the area of potatoes, vegetables and corn for silage and green fodder, then the total area more prone to erosion reaches almost half of the sown area - about 435 thousand ha or 47%.

Table 1. The structure of the sown area of the Khmelnitsky region for 2000 and 2019

Name of crops	2000		2019	
	thousand ha	%	thousand ha	%
Cereals and legumes	524,0	48,9	576,3	62,4
Sugar beet	72,8	6,8	27,2	2,9
Sunflower	4,7	0,4	140,2	15,1
Potatoes	73,7	6,9	66,1	7,2
Vegetables	12,9	1,2	10,8	1,2
Forage crops	383,7	35,8	103,3	11,2
Total crops	**1071,8**	**100,0**	**923,9**	**100,0**

Source: [8]

The most indicative and illustrative are the achieved levels of crop yields. Here are the yield indicators of the four leading crops in the region over the past 20 years - 2000-2019 (table 2).

Table 2. Yields of leading crops in the Khmelnitsky region for 2000-2019
(in farms of all categories, c/ha)

Year	Cereals and legumes	Sugar beet	Sunflower	Potatoes
2000	23,8	197,9	6,4	146,3
2001	21,4	185,2	6,0	124,6
2002	26,0	169,8	8,7	132,2
2003	18,9	217,2	8,0	130,8
2004	25,9	236,8	7,2	147,2
2005	22,2	277,9	6,8	128,0
2006	19,6	307,2	8,4	155,4
2007	25,7	377,1	12,3	199,6
2008	33,0	414,3	14,3	178,6
2009	31,6	326,3	15,9	187,5
2010	31,5	337,1	15,3	161,0
2011	40,3	348,9	18,3	213,6
2012	45,2	457,1	18,3	232,6
2013	50,0	430,1	18,9	192,3
2014	60,9	523,9	25,3	223,0
2015	53,0	438,8	26,4	163,6
2016	57,7	450,2	30,0	200,7
2017	62,2	554,3	30,0	209,3
2018	67,2	498,1	30,7	207,9
2019	65,9	513,3	36,6	165,9
Average	41,7	334,4	27,3	173,5
Stand rejected	17,0	121,1	9,6	34,1
Range of variation	48,3	384,5	30,6	108,0
Coefficient. of variation, %	40,8	36,2	35,3	19,6

Source:[8]

It is important to pay attention to the high instability of indicators, especially the yield of grain crops. So, over the studied 20 years, the grain yield per hectare of crops changed from 18.9 c/ha in 2003 to 67.2 c/ha in 2018, i.e. the variation range reached 48.3 c/ha, which is higher than the average annual yield. A similar trend is observed in other cultures.

During the analysis, calculations of the growth rate of productivity were carried out. In absolute terms, annual average annual increase in land productivity (Δq_a)we find by the formula:

$$\Delta q_a = \frac{q_e - q_s}{n-1} \quad (1)$$

where:

q_e and q_s - yield indicators of the final and initial period;
n – the number of years in the study period.

In a relative estimate, productivity gains are estimated according to the expression:

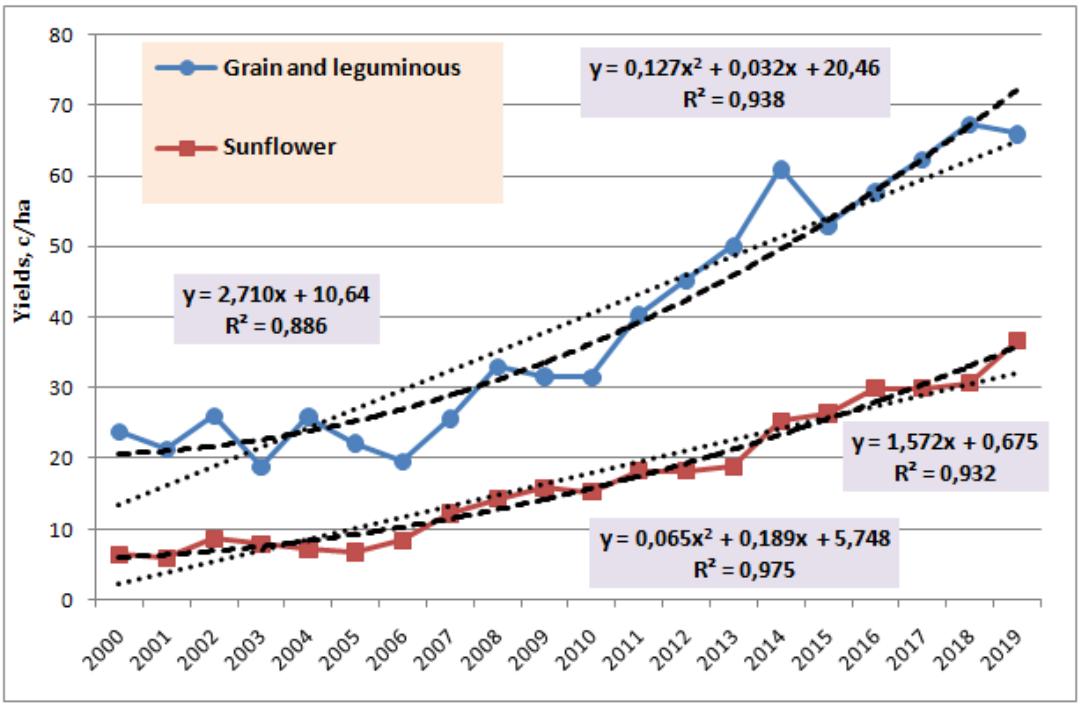
$$\Delta q_a^r = \sqrt[n-1]{\frac{q_e}{q_s}} \quad (2)$$

The yield increase in accordance with ***formula 1*** amounted to:

- grain crops $\Delta q_a = \frac{65,9-23,8}{19}$ = 2,2c/ha;
- sugar beet $\Delta q_a = \frac{513,3-197,9}{19}$ = 16,6 c/ha;
- sunflower $\Delta q_a = \frac{36,6-6,4}{19}$ = 1,6 c/ha;
- potatoes $\Delta q_a = \frac{165,9-146,3}{19}$ = 1,0 c/ha

Relative growth in accordance with ***formula 2*** by:

- grain crops $\Delta q_a^r = \sqrt[19]{\frac{65,9}{23,8}}$ = 1,055or5,5% ;
- sugar beet $\Delta q_a^r = \sqrt[19]{\frac{513,3}{197,9}}$ = 1,051 or5,1%;
- sunflower $\Delta q_a^r = \sqrt[19]{\frac{36,6}{6,4}}$ = 1,096or9,6%;
- potatoes $\Delta q_a^r = \sqrt[19]{\frac{165,9}{146,3}}$ = 1,007or0,7%.



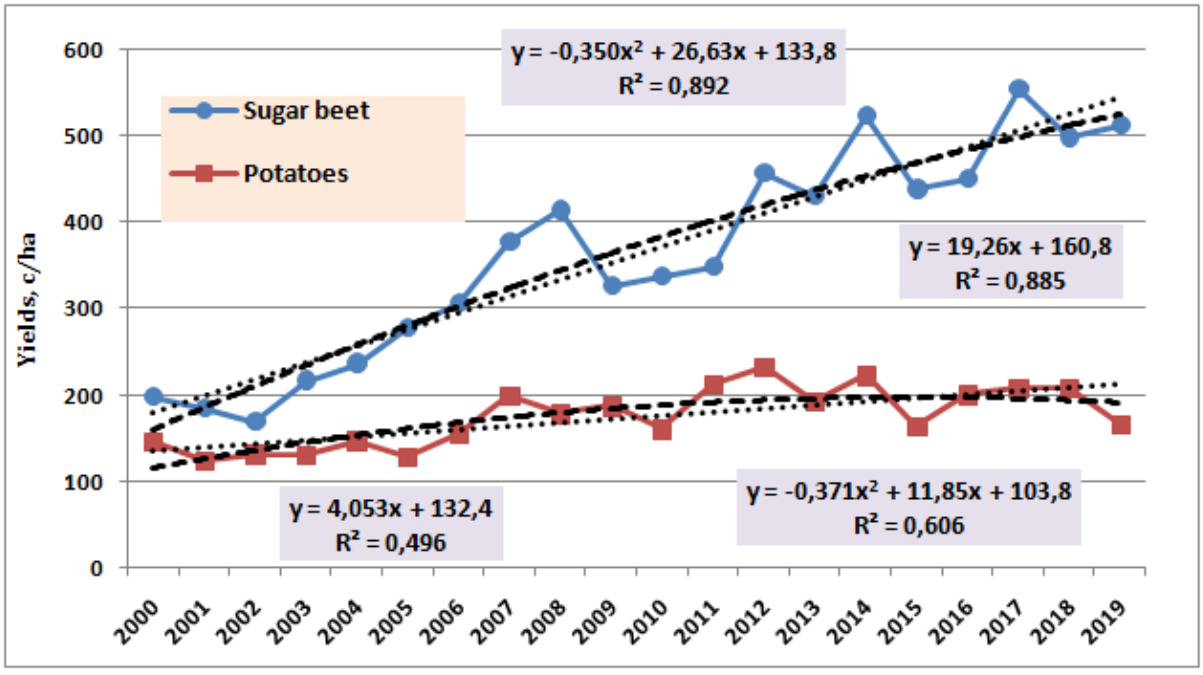
Picture 1. Dynamics of the yield of grain crops and sunflower in farms all categories of Khmelnitsky region for 2000-2019

Source: made according to table 1

It is of undoubted interest to conduct a comparative analysis of land productivity in the production of all leading crops using the graphical method of comparison. Figure 1 shows the dynamics of productivity (indicating the equations of linear and polynomial trends and approximation coefficients) of grain crops and sunflower, and Figure 2 - sugar beets and potatoes.

A brief analysis shows that there is a tendency to increase land productivity in the production of these crops, taking the form of a second-order parabola. However, while in grain crops and sunflower, the tendency tends to increase yields, in sugar beets and potatoes the dynamics of the growth of field productivity is gradually dying out. On an average annual basis, the "rate" of yield growth (in accordance with the equations of linear trends) in the cultivation of crops was 2.7 c/ha, sunflower almost 1.6 c/ha, sugar beet - 19.3 c/ha and potato - 4.0 kg/ha.

A graphical representation of the dynamics of the yield of the main crops for the studied 20-year period allows us to identify the difference in the growth rates of field productivity. So, the yield of grain and leguminous crops in the region in the first period of the study, i.e. from 2000 to 2009, it is characterized by an annual yield growth of almost 0.9 c/ha (Pic. 3), and in the second period, 2010-2019, already by 3.6 c/ha (Pic. 4). Sunflower productivity increased respectively at a rate of 1.0 kg/ha and 2.3 kg/ha. At the same time, the use of graphs reveals a decrease in the growth rate of field productivity in the production of sugar beets from 24.9 c/ha in the first period to 18.7 c/ha in the second period. In the production of potatoes from 2010 to 2019, there was a tendency for a decrease in yield by almost 0.9 c/ha on an average annual basis.



Picture 2. Dynamics of sugar beet and potato productivity in farms all categories of Khmelnitsky region for 2000-2019

Source: made according to table 1

Indicators of potential land productivity, characterizing the output of a unit of area of individual crops for a certain period, it is recommended to calculate by the formula [9]:

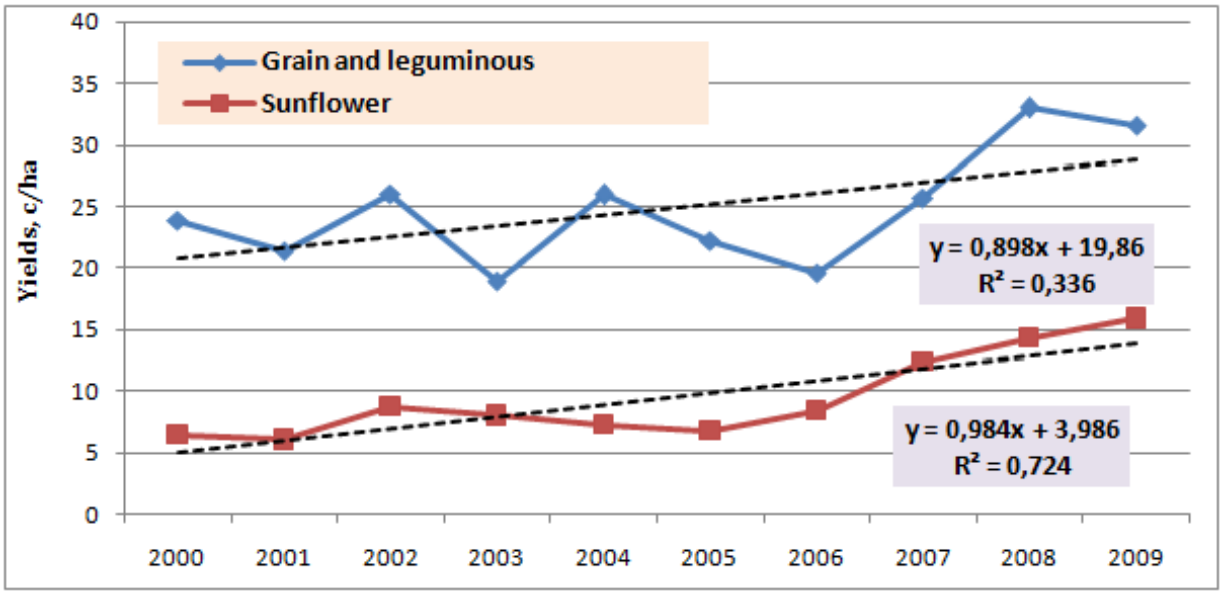
$$q_p = \sqrt[\kappa]{\Pi}, \text{ c/ha} \qquad (3)$$

where:

$\kappa = \sqrt{T}$ (T – the number of years in the analyzed period);

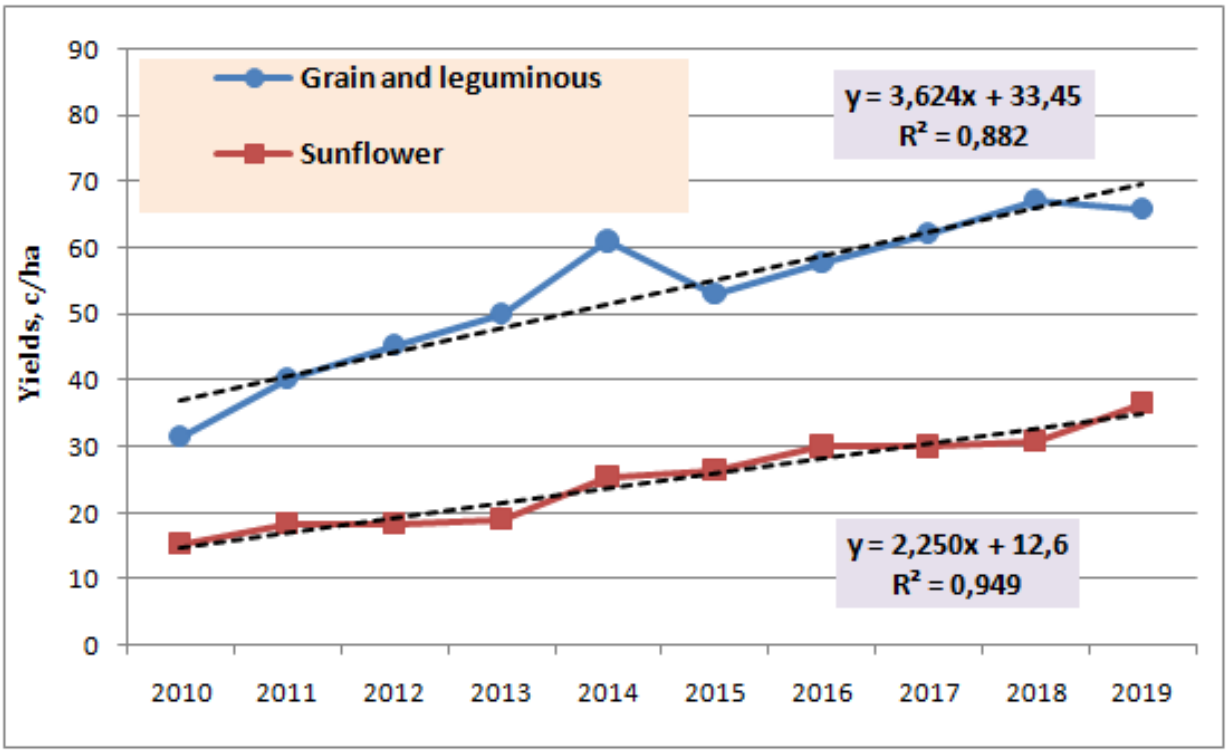
Π – product of the highest productivity indicators for «k» years.

When determining the indicators «k», the calculated values should be rounded to the nearest whole value. For example, of the 20 years analyzed, we take into account the highest rates of four years ($\kappa = \sqrt{20} = 4{,}47$).



Picture 3. Dynamics of the yield of grain crops and sunflower in farms all categories of Khmelnitsky region for 2000-2009

Source: made according to table 1



Picture4. Dynamics of the yield of grain crops and sunflower in farms all categories of the Khmelnitsky region for 2010-2019

Source: made according to table 1

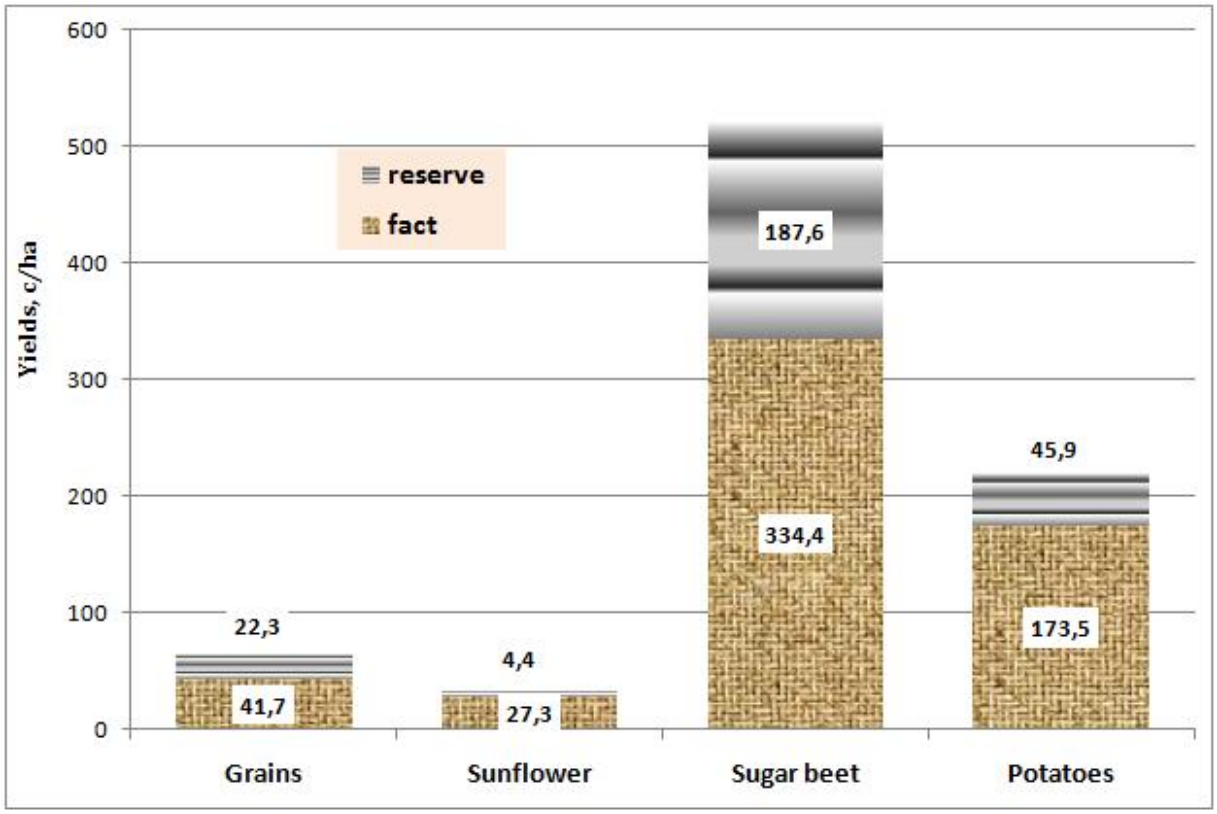
In accordance with formula 3, we determine the value of potential yield:

- cereal crops $q_p = \sqrt[4]{67,2 \cdot 65,9 \cdot 62,2 \cdot 60,9}$= 64,0c/ha;
- sunflower $q_p = \sqrt[4]{36,6 \cdot 30,7 \cdot 30,0 \cdot 30,0}$ = 31,7c/ha;
- sugar beet $q_p = \sqrt[4]{554,3 \cdot 523,9 \cdot 513,3 \cdot 498,1}$ = 522,0 c/ha;
- potato $q_p = \sqrt[4]{232,6 \cdot 223,0 \cdot 213,6 \cdot 209,3}$= 219,4c/ha;

The potential level of land productivity is defined as the sum of actual productivity (q_{act})and the real reserve for its growth (Δq):

$$q_p = q_{act} + \Delta q \quad (4)$$

The presence of indicators of potential and actual crop yields of cultivated crops allows land users to identify the available reserves for increasing land productivity and, on this basis, take measures to increase the volume of gross grain harvests, industrial and other crops. The values of the reserves of productivity are graphically presented in Picture 5.



Picture 5. Indicators of actual productivity and reserves of its growth at production of main crops in the Khmelnitsky region on average for the years 2000-2019

Source: author's calculations

In conclusion, we note that increasing the sustainability of agricultural production in modern conditions is decisively influenced by a more complete use of the potential for land fertility and the provision on this basis of a substantial increase in crop yields. It is also important for each business entity to select the optimal crop structure that provides the most favorable conditions for growing crops, and to achieve high quality of all technological operations as the basis for achieving planned yield indicators. And thereby mitigate the negative impact of adverse weather and climate conditions and / or make full use of their features in the region.

The above analysis of land productivity indicators in the studied regions could be useful both for university students and agricultural enterprises not only in the Khmelnitsky region, but also located in other regions, using the proposed methodology to justify potential indicators of yield growth reserves and assess yield dynamics by every culture.

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