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Anatolii Kucher

V. N. Karazin Kharkiv National University
NSC «Institute for Soil Science and Agrochemistry Research named after O. N. Sokolovsky»
Ukraine

SOIL FERTILITY, FINANCIAL SUPPORT, AND SUSTAINABLE COMPETITIVENESS: EVIDENCE FROM UKRAINE

Purpose. *The purpose of this paper was to highlight the results of the study of the influence of the soil fertility and financial support on the formation of sustainable competitiveness of Ukrainian agricultural enterprises.*

Methodology / approach. *To achieve the purpose, we used such methods: correlation analysis (to identify and assess the close relationship between the ecological-agrochemical assessment of soils, financial support per hectare, and the sustainable competitiveness); econometric modeling (to develop a mathematical model of the dependence of the subindex of competitiveness by the yield on the ecological-agrochemical assessment of soils and the financial support per hectare); economic-statistical and monographic (for the assessment and analysis of the influence of the ecological-agrochemical assessment of soils and financial support per hectare on the formation of sustainable competitiveness); abstract-and-logical (for generalization and analysis of the research results); graphical (for the visual representation of the revealed dependencies). The study was performed on a selected sample of agricultural enterprises of districts of Kharkiv, Volyn and Chernihiv region, which represent all the soil-climatic zones of Ukraine. The time range of this research covers the years 2010–2016. The database of the 189 observations in Kharkiv region, 93 – in Volyn region and 88 – in Chernihiv region was as the empirical basis.*

Results. *This paper presents empirical evidence for the impact of the soil fertility and financial support on the formation of sustainable competitiveness of enterprises. The obtained results prove the hypothesis of a positive relationship between the ecological-agrochemical assessment of soils, financial support per hectare, and the sustainable competitiveness of subjects, however, the level of impact of soil fertility differs significantly in different soil-climatic conditions. It is shown that soil fertility and financial support can sometimes act as substitutes, for example, in a zone of insufficient moisture or low soil fertility. Increasing the financial support for agricultural production per hectare may be a strategy to increase productivity when soils are less fertile.*

Originality / scientific novelty. *For the first time, one- and two-factor linear and quadratic econometric models were developed, which made it possible to carry out quantitative assessment of the impact of the ecological-agrochemical assessment of soils and the financial support per hectare on the formation of the subindex of competitiveness by the yield in various soil-climatic zones of Ukraine. The provision on the formation of the subindex of competitiveness by the yield under the conditions of the economic law of diminishing returns, was further developed.*

Practical value / implications. *The main results of the study can be used for (i) estimation and forecasting of the level of competitiveness depending on the ecological-agrochemical assessment of soils and the financial support per hectare; (ii) determining the effect of measures to improve the soil fertility on the competitiveness; (iii) determining the impact of soil degradation on competitiveness of agribusiness entities; (iv) identification of reserves to improve competitiveness.*

Key words: *ecological-agrochemical assessment of soils, operating expenses, sustainable competitiveness, agricultural enterprises, Ukraine.*

Introduction and review of literature. Soil fertility is one of the keys to future global food security. Scientists believe that «In addition to providing humanity with 98.8 % of its food, soils provide a broad range of other services, from carbon storage and greenhouse gas regulation, to flood mitigation and providing support for our cities» [1]. But «... the current intensification of agricultural practices is already resulting in the unsustainable degradation of soils» [1]. Improved soil quality is required to sustainably achieve global food security [2]. Recently, numerous studies were devoted to the problem of assessing soil quality in different countries (Baliuk et al. [3]; Bartolomei et al. [4]; Colantoni et al. [5]; Huera-Lucero et al. [6]; Salvati et al. [7]; Vashisht et al. [8]) and innovative measures to improve (i) soil quality under different land use systems and (ii) food security under conservation agriculture (Abdul Rahman et al. [9]; Fantappiè et al. [10]; Mgolozeli et al. [11]; Pan et al. [2]). The results of studies indicate that «although the recycling of organic materials to fields is considered a key practice for improving soil quality, the effects of this procedure was found to reduce farm profitability due to increases in material costs and labour» [2]. However, the analysis reveals that the yield capacity of maize and wheat on average is higher under a larger content of organic carbon in the soil [12].

Foreign scientists pay much attention to the issues of knowledge of local farmers about soil quality, practice of sustainable management of fertility and indexes of land degradation (Ansong Omari et al. [13]; de Souza Mello Bicalho and dos Guimarães Peixoto [14]; Kuria et al. [15]). Results of the theoretical analysis of empiric researches on the impact of ecological standards on competitiveness of enterprises demonstrate they can influence both negatively and positively, in particular stimulating introduction of ecological innovations [16]. Australian scientists report a strong positive association between environmental performance and financial performance during the pre-financial crisis period (2001–2007) and no relationship between environmental performance and financial performance during the financial crisis (2008–2010) [17]. Foreign researchers emphasize the relations of agricultural landscapes, ecosystem services and regional competitiveness being extended behind the agriculture [18], as well as the relationship between soil fertility, biological diversity of agricultural crops and income of the farmers in Italy [19]. The study of competitiveness of the agricultural enterprises in Slovak Republic highlights that better results are found in the group of enterprises, which run their activities under better soil and natural conditions [20]. In two regions (i.e. Brest and Minsk) and in Belarus generally, the correlation dependence between the yield capacity and the rating of soil fertility is very strong, whereas in the other regions it is at the average level [21]. The works by A. Issanchou and coauthors provide the most detailed study of the economic issue of soil quality management in terms of maintenance of competitiveness and sustainable agriculture, as well as its impact on French farms' profitability [22–25].

In Ukraine, works by the scientists deal with the problems of (i) balancing of the economic conditions of farming on the land of different quality [26]; (ii) assessing the impact of land quality on the yield capacity of winter wheat grain [27]; (iii) correlation analysis of dependence between the land evaluation in points and yield capacity of agricultural crops [28]. However, in Ukraine there are no studies on the impact of soil fertility, soil and land quality on the sustainable competitiveness of agricultural enterprises. Based on the analysis of articles on sustainable competitiveness published in journals indexed by Scopus during 1981 and 2019 (Fig. 1), we identified (i) a trend towards a rapid increase (especially since 2010) in the number of publications in the world (leaders – China, USA and United Kingdom), and (ii) research gaps in Ukrainian literature (only 59 documents were published during the analyzed period), that have not yet been addressed.

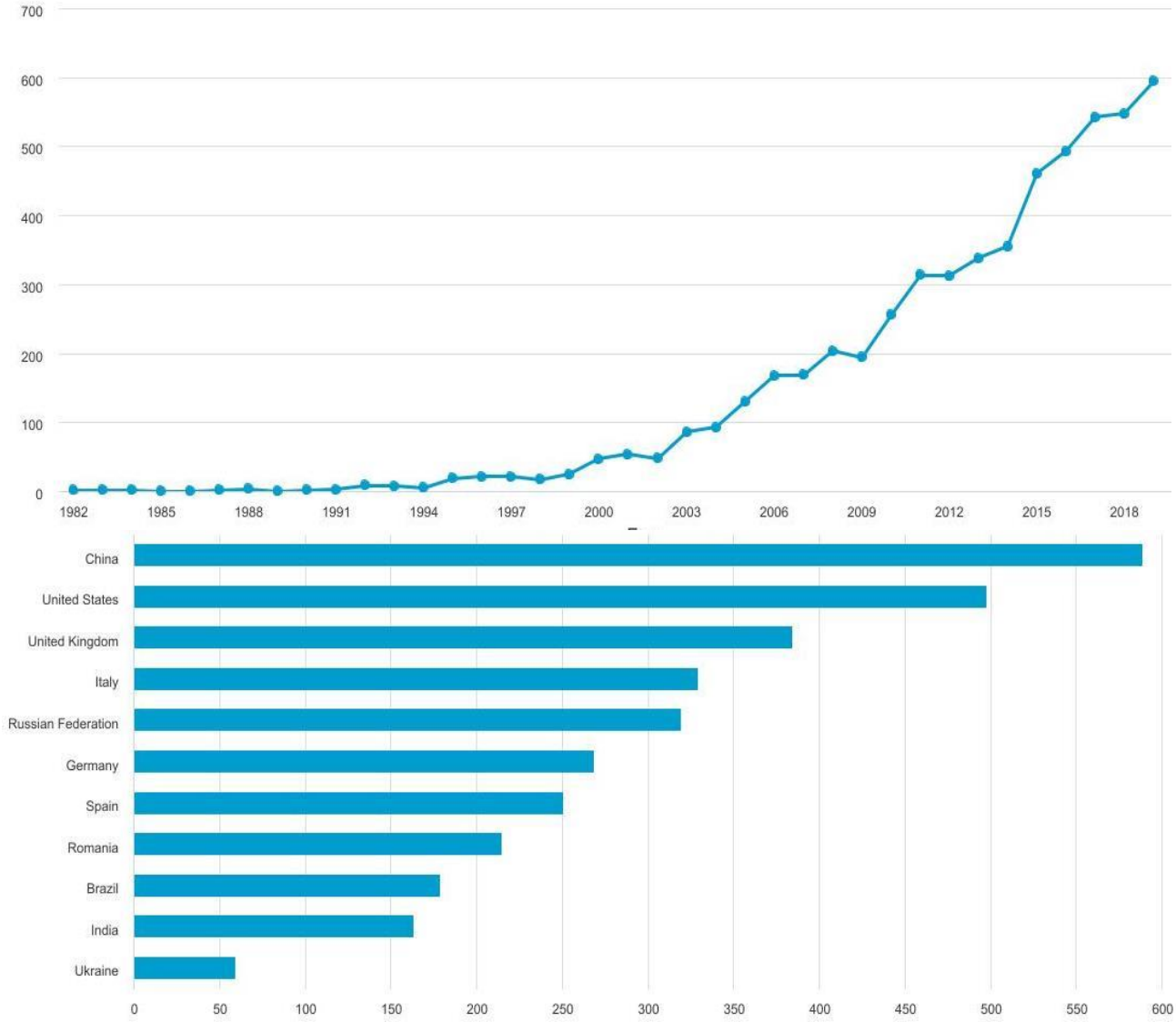


Fig. 1. Number of documents on sustainable competitiveness published in journals indexed by Scopus in dynamics and in the TOP-10 countries and Ukraine

Source: built by the author according to the search and analysis of the documents in Scopus (https://www.scopus.com).

In our previous studies, taking into account the concept of sustainable development, the concept of «sustainable competitiveness of agricultural enterprises» was introduced into scientific circulation, a methodology for assessing the sustainable competitiveness of agricultural enterprises was proposed and tested [29]; the holistic conception of the formation of sustainable competitiveness of agricultural enterprises based on sustainable soil management was developed [30]; assessment and cluster analysis of the sustainable competitiveness of agricultural enterprises carried out [31]; the impact of land quality and balance of soil organic carbon on the formation of sustainable competitiveness of agricultural enterprises was evaluated [32; 33].

On the other hand, many papers have highlighted the need for improve financial support of Ukrainian agricultural enterprises [34–39]. However, the problem of assessing the simultaneous effect of soil fertility and financial support on the competitiveness of agricultural enterprises in Ukraine is still poorly studied. So, the above indicates the relevance, scientific novelty and practical value of the problem of assessing the influence of the soil fertility and financial support on the formation of sustainable competitiveness of agricultural enterprises, therefore, the proposed article is a logical continuation of the author's systematic scientific research on this topic.

The purpose of the article. The purpose of this paper was to highlight the results of the study of the influence of the soil fertility and financial support on the formation of sustainable competitiveness of Ukrainian agricultural enterprises.

Methodology. The hypothesis of the research is based on the assumptions that: (i) there is positive relations between the ecological-agrochemical assessment of soils and subindexes of sustainable competitiveness of agricultural enterprises; (ii) the dependence between the level of financial support (investments of costs (expenditures) per hectare) and the subindexes of sustainable competitiveness of agricultural enterprises is positive nature.

Considering zonal features of formation of sustainable competitiveness of agricultural enterprises [40], our research was carried out on the example of agricultural enterprises of districts of Kharkiv, Volyn and Chernihiv region, which represent all the soil-climatic zones of Ukraine (Fig. 2). The study area, Kharkiv, Volyn and Chernihiv region, is one of the typical agroindustrial regions in Ukraine.

To achieve the purpose, we used such methods: correlation analysis (to identify and assess the close relationship between the ecological-agrochemical assessment of soils, financial support per hectare, and the sustainable competitiveness); econometric modeling (to develop a mathematical model of the dependence of the subindex of competitiveness by the yield on the ecological-agrochemical assessment of soils and the financial support per hectare); economic-statistical and monographic (for the assessment and analysis of the influence of the ecological-agrochemical assessment of soils and financial support per hectare on the formation of sustainable competitiveness); abstract-and-logical (for theoretical generalization and analysis of the research results); graphical (for the visual representation of the revealed dependencies). This study was performed on a selected sample of agricultural enterprises of districts of Kharkiv, Volyn and Chernihiv region. The time range of

this research covers the years 2010–2016. To receive the results, the statistical software package STATISTICA is used.

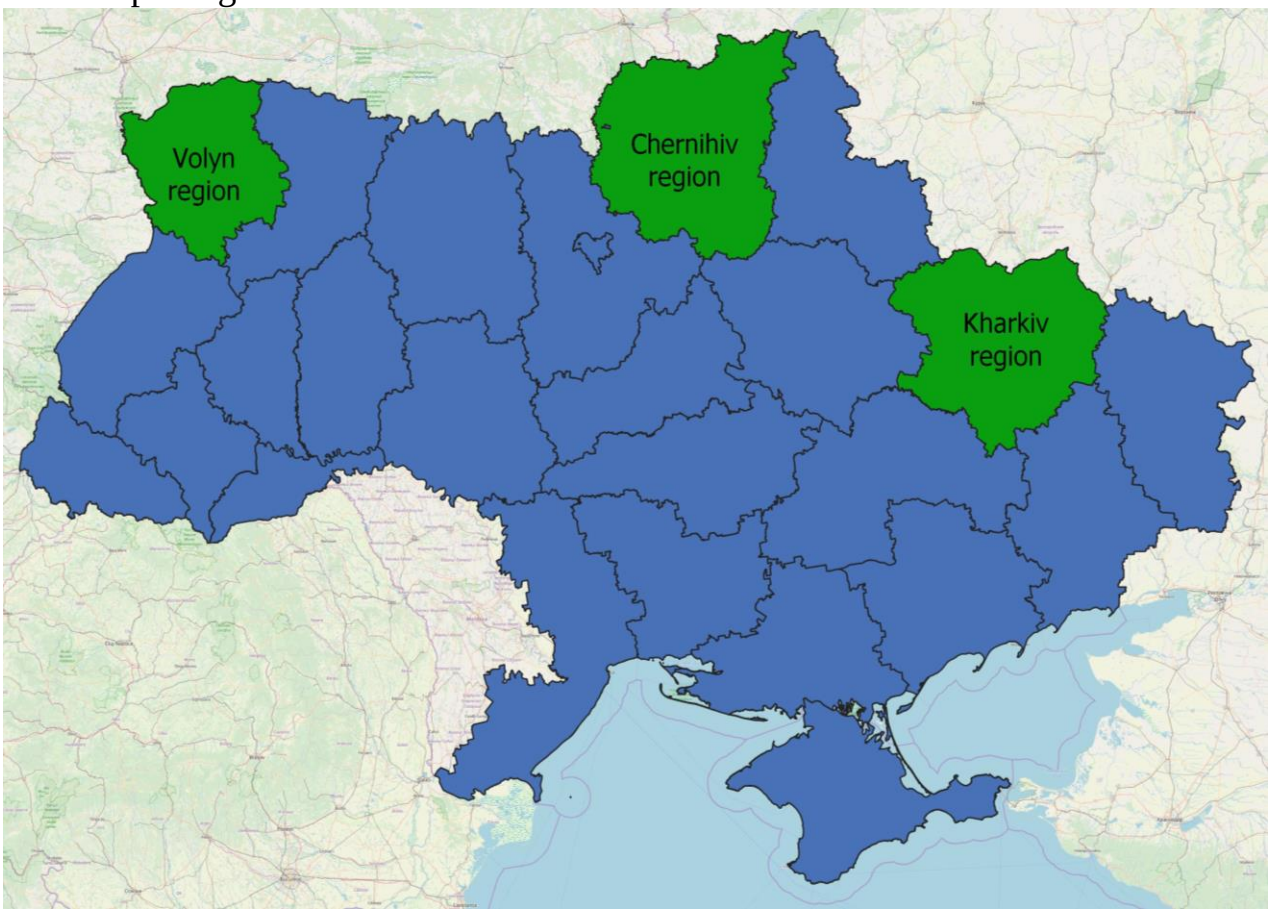


Fig. 2. Map of Ukraine showing the boundary of the study area

Source: compiled by the author.

This study is based on statistical and empirical monitoring data for the years 2010–2016 at the level of administrative districts of Kharkiv, Volyn and Chernihiv regions of Ukraine. The amount of financial support per hectare and subindexes of sustainable competitiveness calculated according to the information of the regional affiliates of the State Statistics Service of Ukraine (form No. 50-s.g.). The database of the average ecological-agrochemical assessment of soils of arable land in the administrative districts of the analyzed regions of Ukraine, was used as the empirical basis on soil fertility. This data was obtained from the State Institution «Soils Protection Institute of Ukraine» [41] and its regional affiliates. The database of the 189 observations in Kharkiv region, 93 – in Volyn region and 88 – in Chernihiv region was as the empirical basis.

Results and discussion. At the first stage, the research assessed relations between the average ecological-agrochemical assessment of soils of arable land and subindexes of sustainable competitiveness of agricultural enterprises (Tables 1–3). In the system of correlation relationships between the ecological-agrochemical assessment of soils and the main subindexes of sustainable competitiveness of agricultural enterprises in Kharkiv region, it is the most clearly observed at the low and moderate level with the subindexes of competitiveness by the selling price per

1 centner of maize grain and sunflower. In other cases, this relationship was absent or statistically unreliable.

Table 1

Linear coefficients of pair correlation between ecological-agrochemical assessment of soils and main subindexes of sustainable competitiveness of agricultural enterprises of the districts of Kharkiv region

Indicators	Years							On average for the years 2010–2016
	2010	2011	2012	2013	2014	2015	2016	
Competitiveness subindex by the yield								
Grains, total	0.043	-0.069	-0.229	-0.008	-0.301	0.005	-0.181	-0.121
Winter wheat grain	0.144	-0.292	-0.224	-0.017	-0.384	0.073	-0.072	-0.104
Maize for grain	0.271	0.141	-0.174	-0.065	-0.103	-0.102	-0.127	-0.026
Sunflower	0.186	0.083	0.012	-0.178	-0.333	-0.067	0.106	-0.046
Competitiveness subindex by the production cost per 1 centner								
Grains, total	-0.099	-0.011	0.107	-0.011	0.090	0.0002	0.290	-0.055
Winter wheat grain	-0.115	0.066	0.100	-0.134	0.195	-0.114	0.133	0.045
Maize for grain	-0.273	-0.067	0.131	-0.070	-0.059	0.287	0.082	-0.009
Sunflower	0.231	-0.055	0.350	0.011	0.176	0.074	-0.054	-0.154
Competitiveness subindex by the selling price per 1 centner								
Grains, total	0.434	-0.183	0.017	-0.207	0.085	0.005	-0.049	0.157
Winter wheat grain	-0.128	-0.261	0.015	-0.109	0.054	0.108	-0.071	-0.076
Maize for grain	0.468	-0.058	0.074	-0.124	0.062	-0.187	-0.093	0.202
Sunflower	0.509	-0.001	0.069	0.048	0.019	0.322	0.204	0.521
Competitiveness subindex by the covering of production expenses with cash revenue								
Grains, total	0.338	-0.026	-0.089	-0.046	0.031	0.018	-0.324	0.051
Winter wheat grain	0.098	-0.119	-0.039	0.045	-0.104	0.143	-0.200	0.021
Maize for grain	0.509	0.028	-0.140	-0.006	0.147	-0.317	-0.100	0.087
Sunflower	0.388	0.056	-0.359	0.001	-0.091	0.044	0.024	0.040

Source: author's calculations based on data of the State Institution «Soils Protection Institute of Ukraine» and data of the form No. 50-s.g.

By contrast with Kharkiv region, in Volyn region, on the basis of the average indexes in the studied period we identified availability of mainly a high direct correlation relation between the ecological-agrochemical assessment of soils and the main subindexes of competitiveness by the yield of grains in total ($r = 0.799$ average for seven years) and winter wheat grain particularly ($r = 0.802$ average for seven years), and the average direct correlation with the competitiveness by the yield of maize for grain ($r = 0.550$ average for seven years). In the variant of potato, the correlation relation was low for the seven-year period. The research identifies a moderate direct correlation relation between the ecological-agrochemical assessment of soils and the subindexes of competitiveness by the production cost per 1 centner of grains ($r = 0.478$) and potato ($r = 0.402$) for the seven-year period. The ecological-agrochemical assessment of soils is characterized by a direct correlation relation with the subindexes of competitiveness by the covering of production expenses with cash revenue for grains at the level of average strength of relationship ($r = 0.540$), and

moderate strength of relationship for grain of winter wheat (r = 0.457), grain of maize (r = 0.367) and potato (r = 0.482) for the seven-year period.

Table 2

Linear coefficients of pair correlation between ecological-agrochemical assessment of soils and main subindexes of sustainable competitiveness of agricultural enterprises of the districts of Volyn region

Indicators	Years							On average for the years 2010–2016
	2010	2011	2012	2013	2014	2015	2016	
Competitiveness subindex by the yield								
Grains, total	0.856	0.785	0.781	0.762	0.722	0.786	0.685	0.799
Winter wheat grain	0.863	0.861	0.834	0.763	0.738	0.755	0.612	0.802
Maize for grain	0.759	0.510	0.683	0.742	0.706	0.597	0.408	0.550
Potato	-0.019	0.031	0.428	0.468	0.687	0.291	0.116	0.246
Competitiveness subindex by the production cost per 1 centner								
Grains, total	0.546	0.445	0.502	0.478	0.437	0.134	0.087	0.478
Winter wheat grain	0.646	0.370	0.451	0.482	0.385	0.218	-0.383	-0.244
Maize for grain	0.159	0.038	0.179	0.270	0.240	0.253	0.179	0.287
Potato	-0.009	0.112	0.030	0.742	0.650	0.093	0.241	0.402
Competitiveness subindex by the selling price per 1 centner								
Grains, total	0.482	-0.185	0.167	-0.052	0.112	0.572	0.549	0.484
Winter wheat grain	0.120	0.020	0.228	0.151	0.393	0.461	0.335	0.343
Maize for grain	-0.581	-0.150	0.067	0.109	-0.181	0.392	-0.161	-0.184
Potato	0.082	-0.029	-0.042	-0.017	-0.180	0.100	-0.338	-0.186
Competitiveness subindex by the covering of production expenses with cash revenue								
Grains, total	0.595	0.412	0.488	0.396	0.424	0.444	0.345	0.540
Winter wheat grain	0.543	0.399	0.498	0.520	0.517	0.418	0.313	0.457
Maize for grain	-0.150	0.243	0.255	0.538	0.176	0.373	0.165	0.367
Potato	0.036	0.506	0.484	0.695	0.298	0.182	0.082	0.482

Source: author's calculations based on data of the State Institution «Soils Protection Institute of Ukraine» and data of the form No. 50-s.g.

Similar correlation relations are found in Chernihiv region. Thus, in the system of relationship between the ecological-agrochemical assessment of soil and analyzed subindexes, the relation with competitiveness by the yield of grains (r = 0.680 average for seven years) and sunflower (r = 0.769) was the highest by the degree strength and resistance in time. Although there was no clear tendency in the dynamics of changes of the mentioned coefficients of pair correlation, the general trend can be characterized as positive, at least because its value in the sample period was higher than in the basic one. The subindex of competitiveness by the yield of potato was characterized by an inverse correlation relation with the ecological-agrochemical assessment of soil. It is probably related with other factors of its formation, particularly such as weather-climatic conditions in the year and financial support of production. The subindexes of competitiveness by the production costs of 1 c of grains in total, including winter wheat, directly correlated with the ecological-agrochemical assessment of soils at the level of a moderate strength of the relation. In

other cases, that relation was weak and/or inverse, or totally absent. The coefficients of pair correlation between the subindexes of competitiveness by the sale price of 1 c significantly fluctuated in the dynamics and, by the average figures for the seven-year period, confirmed a direct moderate relation on the example of maize grain (r = 0.350), and weak correlation concerning the grain of winter wheat (r = 0.158) and potato (r = 0.214). Increasing of the ecological-agrochemical assessment of soil positively and moderately correlated with the subindexes of competitiveness by the recovery of production costs by means of income of all kinds of products, but not for sunflower. Thus, an increase of the ecological-agrochemical assessment of soil secured a successful competition at the market of grains due to obtaining of larger amounts of products from 1 ha and leadership by the costs, whereas at the market of sunflower – due to a higher yield capacity, and at the market of potato – due to its better quality (a higher sale price) and better covering of production expenses with cash revenue.

Table 3

Linear coefficients of pair correlation between ecological-agrochemical assessment of soils and main subindexes of sustainable competitiveness of agricultural enterprises of the districts of Chernihiv region

Indicators	Years							On average for the years 2010–2016
	2010	2011	2012	2013	2014	2015	2016	
Competitiveness subindex by the yield								
Grains, total	0.517	0.671	0.679	0.610	0.658	0.685	0.699	0.680
Sunflower	0.310	0.602	0.407	0.710	0.714	0.636	0.598	0.769
Potato	-0.130	-0.561	-0.472	-0.130	-0.484	-0.309	-0.373	-0.466
Competitiveness subindex by the production cost per 1 centner								
Grains, total	0.340	0.494	0.262	-0.023	N/d	N/d	N/d	0.307
Winter wheat grain	0.167	0.281	0.275	0.200	N/d	N/d	N/d	0.303
Maize for grain	0.234	0.017	-0.216	-0.102	N/d	N/d	N/d	-0.169
Sunflower	-0.271	0.421	-0.198	0.060	N/d	N/d	N/d	-0.171
Potato	0.370	-0.282	-0.131	0.201	N/d	N/d	N/d	0.023
Competitiveness subindex by the selling price per 1 centner								
Grains, total	0.289	-0.350	0.124	0.027	0.086	-0.144	-0.025	0.029
Winter wheat grain	0.430	0.329	0.194	-0.329	-0.131	0.373	0.316	0.158
Maize for grain	0.372	0.161	0.370	0.225	0.156	-0.210	0.331	0.350
Sunflower	0.358	0.254	0.121	-0.262	0.097	-0.017	0.388	0.032
Potato	0.198	0.306	0.327	-0.037	N/d	N/d	N/d	0.214
Competitiveness subindex by the covering of production expenses with cash revenue								
Grains, total	0.507	0.378	0.410	0.018	N/d	N/d	N/d	0.430
Winter wheat grain	0.261	0.428	0.319	0.039	N/d	N/d	N/d	0.297
Maize for grain	0.403	0.140	0.172	0.065	N/d	N/d	N/d	0.313
Sunflower	-0.191	0.604	-0.186	-0.140	N/d	N/d	N/d	-0.272
Potato	0.511	0.431	0.231	0.196	N/d	N/d	N/d	0.300

Note. N/d – no data.

Source: author's calculations based on data of the State Institution «Soils Protection Institute of Ukraine» and data of the form No. 50-s.g.

The results of grouping of agricultural enterprises of the districts of Volyn region (Table 4) demonstrated that an increase of the ecological-agrochemical assessment of soil generally made a positive impact on their competitiveness at the market of grain of winter wheat, however, only the fourth group was competitive having 44 points of the average soil assessment.

Table 4

Impact of ecological-agrochemical assessment of soil on the sustainable competitiveness of agricultural enterprises of the districts of Volyn region on winter wheat grain market, 2010–2016

Groups of districts by the ecological-agrochemical assessment of soils, points		Number of districts in the group, units	Average of ecological-agroche-mical assessment of soils, points	Competitiveness subindex by:				
				yield	production cost per 1 centner	selling price per 1 centner	covering of production expenses with cash revenue	operating expenses per 1 ha
I	To 30	21	27	0.647	1.023	0.963	0.938	0.792
II	31–35	35	31	0.427	1.052	0.930	0.676	0.576
III	36–40	28	38	0.922	0.991	0.983	0.980	0.898
IV	Over 40	21	44	1.118	1.004	1.011	1.029	1.105

Source: author's calculations based on the data of the form No. 50-s.g. and data of the State Institution «Soils Protection Institute of Ukraine».

It is determined that an increase of the ecological-agrochemical assessment of soil caused an increase of the subindexes of competitiveness by the yield, sale price and production expenses per 1 ha, although with some fluctuations. In particular, according to the yield factor, the second group was the absolute outsider that was caused not only by the ecological-agrochemical assessment of soil or by the size of production expenses, which were the smallest in that group. Nevertheless, the second group reached the best level by the production costs of 1 c. However, it was an outsider by the covering of production expenses with cash revenue.

Similar tendencies are identified in formation of competitiveness of agricultural enterprises on the soil with different ecological-agrochemical assessment in the Chernihiv region (Table 5). An increase of the mentioned assessment caused the increase of the subindex of competitiveness by the yield from 0.740 in the first group to 1.130 in the fifth group under the simultaneous growth of the subindex by the expenses costs per 1 ha from 0.854 to 1.087 respectively. The subindex of competitiveness by the cost of 1 c demonstrated the overall tendency to increase, which was only violated by the enterprises of the fifth group that was also particular for the dynamics of the subindex of competitiveness by the covering of production expenses with cash revenue. Unlike the previous case, results of that grouping did not secure identification of the impact of fertility and quality of soil on formation of the sale prices of grain, because the corresponding subindex did not demonstrate clear tendencies in the dynamics.

Table 5

Impact of ecological-agrochemical assessment of soil on the sustainable competitiveness of agricultural enterprises of the districts of Chernihiv region on the grain market, 2010–2016

Groups of districts by the ecological-agrochemical assessment of soils, points		Number of districts in the group, units	Average of ecological-agroche-mical assessment of soils, points	Competitiveness subindex by:				
				yield	production cost per 1 centner	selling price per 1 centner	covering of production expenses with cash revenue	operating expenses per 1 ha
I	To 35	21	34	0.740	0.878	0.990	0.874	0.854
II	36–40	35	37	0.716	0.881	1.002	0.862	0.865
III	41–45	35	43	0.825	1.001	0.917	0.899	0.918
IV	46–50	28	49	1.089	1.033	0.957	1.005	1.072
V	Over 50	35	55	1.130	0.979	0.993	0.972	1.087

Source: author's calculations based on the data of the form No. 50-s.g. and data of the State Institution «Soils Protection Institute of Ukraine».

The dependence of the subindex of competitiveness by the yield of grains on the ecological-agrochemical assessment of soil is approximated by the equation of a straight line (Fig. 3). Referring to it, an increase of the mentioned assessment by 1 point caused the increase of the mentioned subindex by 0.022. The author identifies a notable direct correlation relation (r = 0.639), whereas variation of the dependent variable is by 40.8 % dependent on the fluctuation of the factorial index.

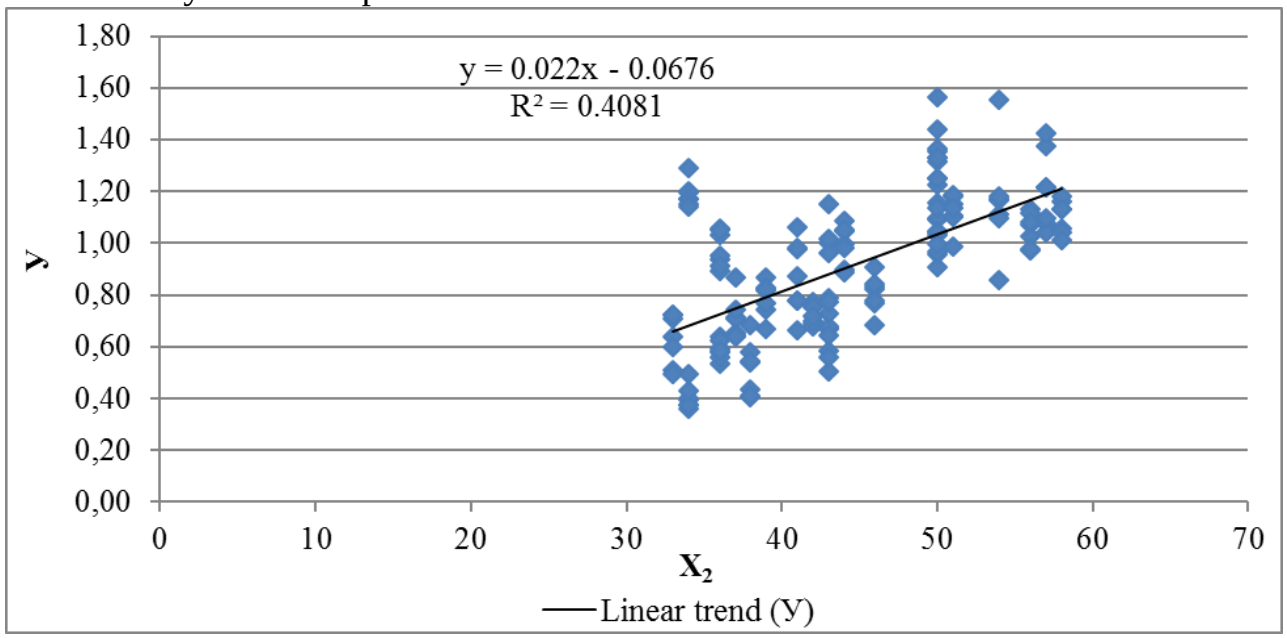


Fig. 3. Graph of dependence of the subindex of competitiveness by the grain yield (Y) on the ecological-agrochemical assessment of soil (X_2, points) in agricultural enterprises of the districts of Chernihiv region, 2010–2016

Source: built by the authors on the basis of own research according to the data of the State Institution «Soils Protection Institute of Ukraine» and data of the form No. 50-s.g.

At the second stage was studied the relationship between the ecological-agrochemical assessment of soil and financial support, on the one hand, and the sustainable competitiveness of enterprises, on the other hand. Based on the results of correlation analysis, econometric models are constructed (Fig. 4–5). The developed double-factor econometric models of linear and non-linear (quadratic) types secured quantitative estimating of the combined impact of the parameters of soil fertility and financial support of production on the competitiveness of agricultural enterprises. The mentioned models can be considered as specific production functions with some modification of the factors, i.e. operating (production) expenses per 1 ha perform as a capital (financial support), whereas parameters of soil fertility serve as a land factor.

As it was expected, in Volyn region an increase of the ecological-agrochemical assessment of soil by 1 point and financial support by 1 thsd. USD/ha caused the subindex of competitiveness by the yield of winter wheat increased on average by 0.029 and 0.689 respectively. The model calculations demonstrate that in the variant of relatively low financial support of production (300 USD/ha), the increase of the ecological-agrochemical assessment of soil (from 25 to 45 points, i.e. 1.8 times) caused comparatively greater impact on the subindex of competitiveness by the yield (it increases 2.5 times – from 0.389 to 0.961) than in the variant of relatively higher financial support (900 USD/ha), where the subindex increased 1.7 times (from 0.802 to 1.374). In the variant of relatively low fertility (25 points), the three times increase of financial support (from 300 to 900 USD/ha) caused a greater impact on the mentioned subindex (it increased 2.1 times) than in the variant of higher fertility (45 points). Both models are statistically significant (Table 5). However, some coefficients in the quadratic model are statistically unreliable. Thus, in the process of management it is recommended to give preference to the linear model, which is of the appropriate statistical quality.

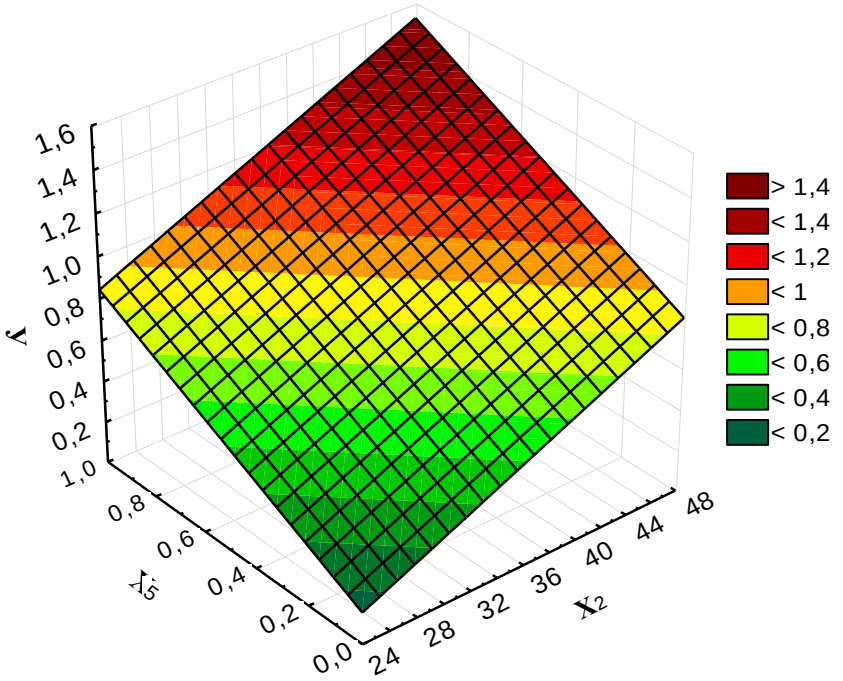
Table 5

Parameters of econometric models of dependence of the subindex of competitiveness by the yield of winter wheat grain on the ecological-agrochemical assessment of soil and financial support for its production on the example of agricultural enterprises of the districts of Volyn region, 2010–2016 *(n = 93)*

Statistical characteristics	Indicators and their meanings	
	Linear model	Quadratic model
Coefficient of multiple correlation (R)	R = 0.838 (high correlation)	R = 0.864 (high correlation)
Coefficient of multiple determination (R^2)	R^2 = 0.703 (statistically significant because significance $F < 0.05$)	R^2 = 0.746 (statistically significant because significance $F < 0.05$)
Fisher's F-criterion	F_{fact} = 106.4; F_{tabl} = 2.90 – at 95 % probability level; $F_{fact} > F_{tabl}$	F_{fact} = 51.0; F_{tabl} = 5.87 – at 95 % probability level; $F_{fact} > F_{tabl}$
Student's t-criterion	t_{fact} = 26.8; t_{tabl} = 1.98 – at 95 % probability level; $t_{fact} > t_{tabl}$	t_{fact} = 32.3; t_{tabl} = 1.98 – at 95 % probability level; $t_{fact} > t_{tabl}$
Standard error of estimation	0.171	0.161

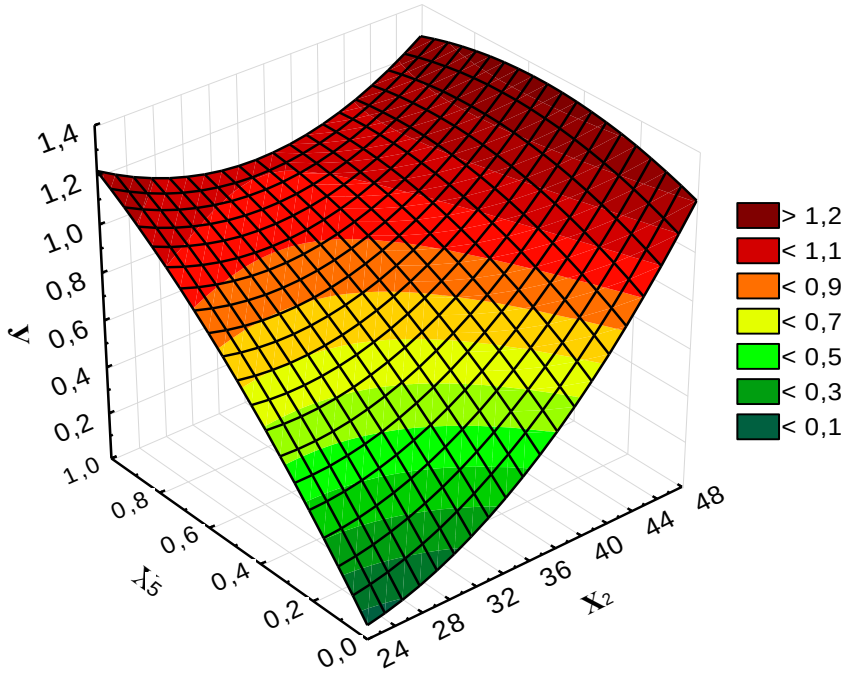
Source: author's calculations.

$У = -0,5329+0,0286x_2+0,6885x_5$



a)

$У = 0,7245-0,0653x_2+2,701x_5+0,0016x_2^2-0,0457x_2x_5-0,4468x_5^2$

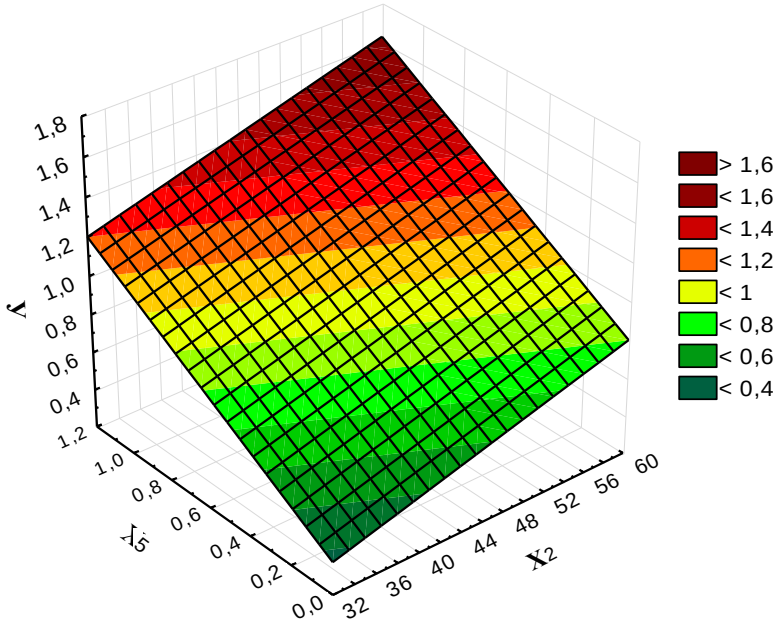


b)

Fig. 4. Linear (a) and quadratic (b) models of the dependence of the subindex of competitiveness by the yield of winter wheat grain (*Y*, coefficient) on the ecological-agrochemical assessment of soil (X_2, points) and financial support for its production (X_5, thsd. USD/ha of harvested area) on the example of agricultural enterprises of the districts of Volyn region, 2010–2016

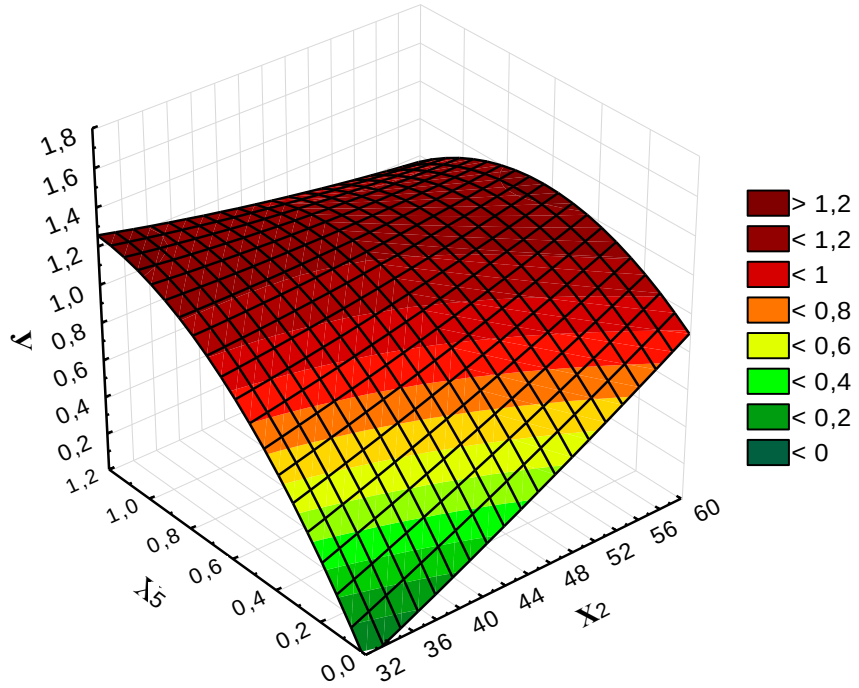
Source: built by the author on the basis of his own research according to the data of the form No. 50-s.g. and data of the State Institution «Soils Protection Institute of Ukraine».

$$У = -0,119+0,0153x_2+0,6903x_5$$



a)

$$У = -0,835+0,0205x_2+3,249x_5+0,0001x_2^2-0,0365x_2x_5-0,8348x_5^2$$



b)

Fig. 5. Linear (a) and quadratic (b) models of the dependence of the subindex of competitiveness by the yield of grain (*Y*, coefficient) on the ecological-agrochemical assessment of soil (X_2, points) and financial support for its production (X_5, thsd. USD/ha of harvested area) on the example of agricultural enterprises of the districts of Chernihiv region, 2010–2016

Source: built by the author on the basis of his own research according to the data of the form No. 50-s.g. and data of the State Institution «Soils Protection Institute of Ukraine».

The example of Chernihiv region demonstrates that the increase of the

ecological-agrochemical assessment of soil by 1 point and financial support by 100USD/ha has secured the growth of the subindex of competitiveness by the yield of grain by 0.015 and 0.069 respectively. The coefficient of a multiple determination for a linear model confirms that variation of the dependent variable is by 57.7 % caused by the variation of the included factors (Table 6).

Table 6

Parameters of econometric models of dependence of the subindex of competitiveness by the yield of grain on the ecological-agrochemical assessment of soil and financial support for its production on the example of agricultural enterprises of the districts of Chernihiv region, 2010–2016 *(n = 88)*

Statistical characteristics	Indicators and their meanings	
	Linear model	Quadratic model
Coefficient of multiple correlation (R)	R = 0.760 (high correlation)	R = 0.806 (high correlation)
Coefficient of multiple determination (R^2)	R^2 = 0.577 (statistically significant because significance $F < 0.05$)	R^2 = 0.650 (statistically significant because significance $F < 0.05$)
Fisher's F-criterion	F_{fact} = 58.0; F_{tabl} = 2.85 – at 95 % probability level; $F_{fact} > F_{tabl}$	F_{fact} = 30.5; F_{tabl} = 5.82 – at 95 % probability level; $F_{fact} > F_{tabl}$
Student's t-criterion	t_{fact} = 19.4; t_{tabl} = 2.00 – at 95 % probability level; $t_{fact} > t_{tabl}$	t_{fact} = 21.2; t_{tabl} = 2.00 – at 95 % probability level; $t_{fact} > t_{tabl}$
Standard error of estimation	0.182	0.169

Source: author's calculations.

So, both models are statistically reliable. However, in the quadratic function, some regressors are statistically unreliable. Thus, to make forecast, it is better to use a linear function, whereas for other goals both of them can be used. It is determined that an increase of the ecological-agrochemical assessment of soil by one standard deviation (in case other factors stay unchanged) causes the subindex of competitiveness increases by 0.435 of its standard deviation, whereas the increase of the volume of expenses results in its growth by 0.481 of its standard deviation.

Conclusions. This paper presents empirical evidence for the impact of the soil fertility and financial support on the formation of sustainable competitiveness of enterprises. For the first time, one- and two-factor linear and quadratic econometric models were developed, which made it possible to carry out quantitative assessment of the impact of the ecological-agrochemical assessment of soils and the financial support per hectare on the formation of the subindex of competitiveness by the yield in various soil-climatic zones of Ukraine. The provision on the formation of the subindex of competitiveness by the yield under the conditions of the economic law of diminishing returns, was further developed.

The obtained results prove the hypothesis of a positive relationship between the ecological-agrochemical assessment of soils, financial support per hectare, and the sustainable competitiveness of subjects, however, the level of impact of soil fertility differs significantly in different soil-climatic conditions. It is shown that soil fertility and financial support can sometimes act as substitutes, for example, in a zone of

insufficient moisture or low soil fertility. Increasing the financial support for agricultural production per hectare may be a strategy to increase productivity when soils are less fertile. At the same time, with a low financial support for production, it is almost impossible to achieve a zone of competitiveness even at high quality soil. The model calculations demonstrate that in the variant of relatively low financial support of production (300 USD/ha), the increase of the ecological-agrochemical assessment of soil (from 25 to 45 points, i.e. 1.8 times) caused comparatively greater impact on the subindex of competitiveness by the yield (it increases 2.5 times – from 0.389 to 0.961) than in the variant of relatively higher financial support (900 USD/ha), where the subindex increased 1.7 times (from 0.802 to 1.374). In the variant of relatively low fertility (25 points), the three times increase of financial support (from 300 to 900 USD/ha) caused a greater impact on the mentioned subindex (it increased 2.1 times) than in the variant of higher fertility (45 points).

Hence, the example of Volyn and Chernihiv region is used to develop the graphic-analytical models of the determined dependence with the appropriate trend and parameters of the obtained econometric models, which provide sufficient arguments for a close direct dependence of the subindex of competitiveness by the yield on the soil fertility and financial support. The main results of the study can be used for (i) estimation and forecasting of the level of competitiveness depending on the ecological-agrochemical assessment of soils and the financial support per hectare; (ii) determining the effect of measures to improve the soil fertility on the competitiveness; (iii) determining the impact of soil degradation on competitiveness of agribusiness entities; (iv) identification of reserves to improve competitiveness. The research should be continued and focus on the substantiation of the motivational mechanism for improving soil quality, and also on forecasting the level of sustainable competitiveness depending on soil fertility and forecast financial support for agricultural production.

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