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ECONOMIC ASSESSMENT OF TECHNICAL MAINTENANCE IN GRAIN PRODUCTION OF UKRAINIAN AGRICULTURE

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Abstract

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This paper explores the ways of increasing Ukrainian contribution to the grain segment of the world food security system. Statistics confirmed that three main exported crops are wheat, barley and maize, which have significantly unstable yields and profitability in Ukraine. The performed econometric analyses have verified a reverse dependence of grain losses on scales of sown areas, which are restricted because of insufficient and outdated agricultural machinery. The conducted cluster modeling made possible to form regional groups of common development in grain production and define achievable purchase quantities of tractors and harvester combines to enhance effectiveness in grain segment of Ukrainian agriculture.

Key words: food security, Ukrainian grain production, economic efficiency, agricultural machinery, clusters

Introduction

A problem of food security and necessity of acceleration in the agricultural development has great importance in the global scale. According to the United Nations' estimates, conducted by Department of Economic and Social Affairs, world population would achieve almost 10 billion people in 2050, growing by 1.2% per year. The most critical item is a prognosis that the most rapid population increase will be observed in the least developed countries (The United Nations, 2015). It generates new challenges and opportunities to agrarians, who should make progress in providing additional quantities of qualitative crop and animal products.

Natural resources of Ukraine (great arable lands, fertile soils and favorable climate) together with the technical maintenance and long-term experience of effective agricultural practice suggest that Ukrainian agrarians could confirm their status of competitive agricultural producers, especially in the grain segment. Namely, wheat production in Ukraine was 26.5 million tons in 2015 (the best result for the last 20 years), though it is 14% less than 30.3 million tons in 1990. The same situation occurs in barley production: 9.1 and 8.3 million tons in 2014 and 2015 in comparison with 9.2 million tons in 1990. The most optimistic tendency has been demonstrated in maize production with the remarkable results for Ukrainian agriculture: 30.9; 29.5 and 23.2 million tons in 2013–2015 (State Statistics Service of Ukraine, 2016). Being the key producer of agricultural crops in the global system of food security, Ukraine takes leading positions in the export of wheat, maize and barley, which are characterized by a stable demand. In particular, Ukraine took the seventh, third and fourth places (with the corresponding shares 3.8%, 10.8% and 10.6%) among the world wheat, barley and corn exporters in 2015 (World's Top Exports, 2016). Further reserves for increasing yields lay in improvements of sort productivity, reductions of harvest losses because of the irrational technical maintenance and exact economic substantiation of an effective activity. The last issue is extremely important under the current crisis conditions in Ukraine. Application of mathematical methods permits to get grounded economic recommendations in the field of a sustainable development in the grain production that has become a main reason to carry out the presented research.

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Materials and Methods

For a long time researches on providing food security attract scientists' attention in diversified directions all over the world. Accelerated population growth added some recent topics on new approaches to numerical calculations of the expected results. In particular, such proposals were given by Headey et al. (2013) who presented 4 types of criteria for efficient food security measurement. Financial crisis stimulated studies of Kavallari et al. (2014) on balancing market prices, demand and supply for agricultural commodities as transparent indicators of food security. An ecological component in facilitating food security was investigated by Godfray et al. (2014) with the focus on the concept of sustainable intensification – "more food with less environmental impact" by means of biodiversity, multifunctional landscapes, animal welfare and rational human nutrition. Economic aspects of a resource- and energy-saving production for reducing agricultural expenses and, consequently, total cost of food consumer basket were considered by Norton et al. (2015). The sustainable food security by countries and agricultural branches was researched by Grafton et al. (2015) in the context of strategic ensuring the global food security. Ukrainian scientists, in particular Shubravska et al. (2014), Vasylieva et al. (2015) also obtained results and dedicated their publications to the problems listed above, defining the national and regional properties, prospects, goals, advantages, and threats in supporting food security at both internal and external levels.

Though there are not any unanimous positions on the ways of increasing agricultural productivity and quality, in particular on use of GM crops and animals, but all agricultural scientists and practitioners have achieved agreement on necessity of facilitating technological and economic food security.

As the loss of grown grain can reach up to 30%, practical machinery management of combine harvesters generates an actual scientific problem. Isaak et al. (2006) and Masek et al. (2015) targeted their researches on development of economic models of optimal operation costs (harvested net income) under minimal fuel consumption that corresponds to ecological paradigm of the modern agriculture. It should be noted that the above mentioned scientists are representatives of the USA and the Czech Republic, which took, respectively, the second and thirteenth places among the world wheat exporters in 2015. Similar studies were carried out by Sattar et al. (2015), who compared technical advantages and gave calculated recommendations on combine harvesting with minimal grain losses by quality and quantity. Practical base and importance of these results are explained by the fact that they were obtained for Pakistani agriculture, which was the ninth world wheat producer for the sixth most populous country in 2015. Apart from an effective use of agricultural machinery, other important topics of economic analyses are the global business climate at the agricultural machinery market and a problem of agrarians' solvency for a modernization of their technical parks (VDMA**,** 2015; Fuchs et al., 2015). The last issue is the critical one for Ukrainian agriculture. Namely, the foreign and national investors are not ready to be involved in high-risked but very profitable Ukrainian grain production, banks demand unjustifiably high credit interests, and state loans are unavailable at present. Thus, Ukrainian agrarians have to count only on their own restricted financial resources (Vasylieva, 2013, 2015).

Mogilova et al. (2013) studied directions of an amortization system accomplishment and formed measures to re-evaluation of machinery assets by type of agricultural holdings in order to balance disproportion in prices of agricultural products and capital goods. For solving the problem of financing technical modernization Zakharchuk (2014) explored further leasing development as the most effective measure of a state protected support for large and middle agricultural producers. Small-scale farming needs mini machinery that opens a new market segment for the national agricultural mechanical engineering. Navrotskyj (2015) researched dependencies of capital-labour ratio and power capacities on land areas and scales of production. He outlined opportunities of innovative updating of the national agricultural machinery sector by means of integration with the world branch leaders. It could give a positive synergy not only to sustainable development of crop production, but also result in recovery of degraded Ukrainian animal husbandry that essentially depends on crop production incomes (Vasylieva, 2013, 2015).

The conducted review confirms that reasonable conclusions of technical and economic agricultural analyses suppose relevant mathematical applications, which is a core thesis of our research. Its informative base contained statistic data on a provision of Ukrainian regions with tractors, grain and maize harvester combines as well as indicators of sown areas and yields of grain crops in general and of wheat, corn, barley in particular. An effective assessment of data dependencies was performed by means of econometric methods that are verified by their long-term active use (Bessler et al., 2010). Correlation and regression analyses of the state in the technical maintenance of Ukrainian grain production enable us to set links between machinery availability, sown areas, yields and to substantiate dynamics of range in agrarians' technical provision by Ukrainian regions. For their aggregation by indicators of production results it is expedient to apply a cluster approach that has been started by M. Porter (1998, 2000). The cluster method converts operative benefits into strategic advantages in the form of productivity and competitiveness increase, expenses reduction, human recourses development, collective innovative modernization, and enlargement of joint market segment. The cluster method demonstrates its effectiveness all over the world and has been successfully implemented in some areas of Ukrainian agriculture (Vasylieva, 2016). Clusters, calculated by the artificial neural network method, make possible to determine specialization and directions of further development in Ukrainian grain production regarding its technical modernization and minimization of harvest losses.

Results and Discussion

The main part of the contemporary machinery park of Ukrainian grain production is formed by tractors "Belarus" and "MTZ". The key share of grain harvester combines is presented by "Dnipro-350", "Don-1500B". The dominant model among maize harvester combines is "NivaSK-5M".

Strong links between sown areas and available machinery are characterized by the correlation coefficient that amounts 0.9 between tractors and grain crops in general, 0.82 and 0.66 between grain harvester combines and, respectively, wheat and barley, 0.64 between maize harvester combines and corn in 2015. The performed regression analyses showed straight yield dependence on sown areas in Ukrainian grain agricultural segment (Figure 1).

Namely, every 100 ha of sown areas bring additional 0.78 c/ha of grain crops, 0.37 c/ha of wheat, 1.04 c/ha of maize and 0.85 c/ha of barley. It implies that the larger the sown area, the larger the machinery park is needed. To justify the necessary urgent improvement in the technological provision of Ukrainian grain production it should be noted that among 15 world export leaders Ukrainian wheat yield (40.1 c/ha) is significantly smaller than that (over 85 c/ha) in the United Kingdom or in Germany. Similar imperfect values have corn yield (61.6 c/ha) in comparison with over 100 c/ha in France or the USA, and also barley yield (30.1 c/ha) in comparison with over 65 c/ha in France or Germany (FAO, 2016).

Missing opportunities of Ukrainian grain production are explained by the double reduction of tractors per 1000 ha of an arable land, 40% drop and even 33 times shrink of this indicator for grain and maize harvester combines for the last 20 years. Nevertheless it should be noted that new machinery became more powerful, for example, average capacity of tractor engines in Ukrainian agricultural enterprises grew by almost 45% during the previous 2 decades (State Statistics Service of Ukraine, 2016). The promising feature of a positive development in Ukrainian grain production is the current dynamics of the technical maintenance by regions, which demonstrates a stable range alignment in machinery availability per 1000 ha (Figure 2).

Previous profound investigations convince us that the cluster approach makes possible to strengthen the reassur-

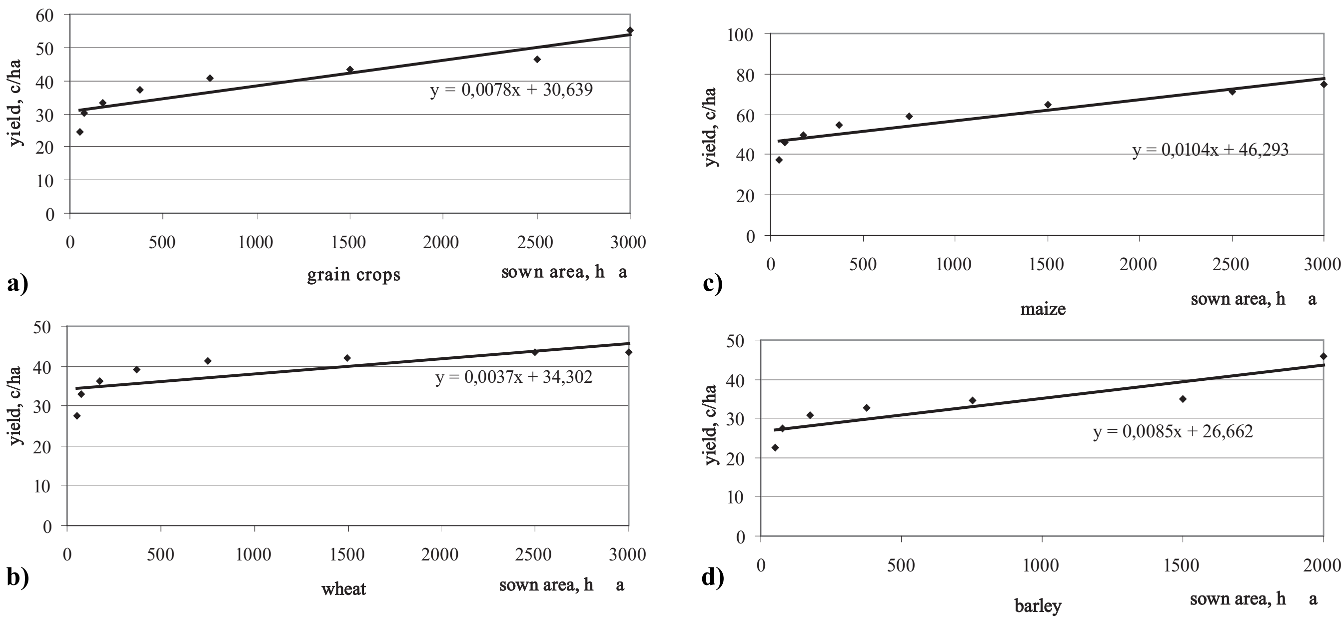

Fig. 1. Regressions of sown areas impact on yields in Ukraine, 2015

(a) – grain crops, (b) – wheat, (c) – maize, (d) – barley

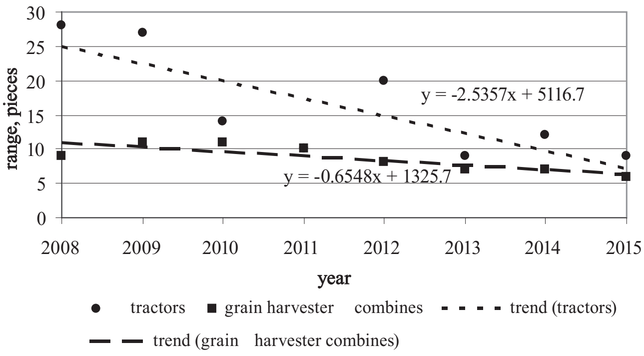

Fig. 2. Trends in the range of technical maintenance by Ukrainian regions, 2008–2015

ing tendencies and achievements of a fuller realization of Ukrainian grain potential in the world system of food security. Distribution of regional grain producers into 3 clusters, concerning the levels of involvement into the national grain segment, was set by 11 indicators: 1)–3) availability of tractors, grain and maize harvester combines; 4)–7) yields of grain crops in general as well as wheat, barley, maize in particular; 8)–11) sown areas of the listed crops. Computer calculations were made by means of NXL Clusterizer using statistics data for 2015.

The main obtained results are given below in the graphic and numerical forms (Figure 3, Table 1), describing cluster profiles in comparison with the corresponding average indicators of the whole country.

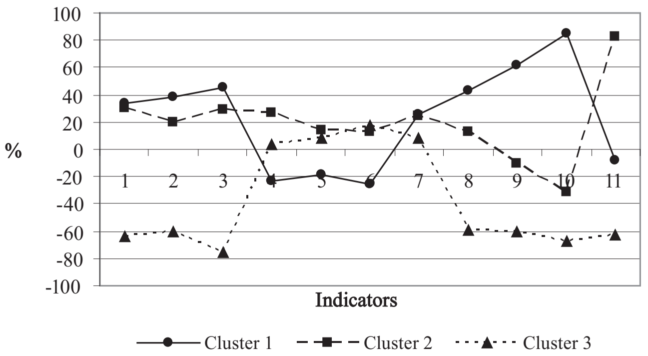

Fig. 3. Cluster profiles of Ukrainian grain production, 2015

Namely, cluster 1 included 9 regions (37.5%). Their grain producers got significant results due to the largest sown areas, except for maize, but with low yields. Machinery parks in cluster 1 have the highest indicators in comparison with the other clusters. Thus it is recommended to add more powerful tractors and harvester combines to the available ones.

Table 1
Weighted average indicators (%) of grain production clusters in Ukraine, 2015

Indicators	Clusters		
	1	2	3
1	33.6	30.3	–64.4
2	38.0	20.1	–60.3
3	45.1	29.0	–76.1
4	–23.8	26.7	3.5
5	–18.2	14.4	7.9
6	–25.3	13.0	17.1
7	25.9	24.1	8.0
8	43.1	12.9	–59.8
9	61.6	–9.9	–60.7
10	84.9	–31.9	–67.6
11	–8.7	83.0	–62.8

Cluster 2 contained 7 regions (29.2%). Their grain producers received the highest yields, but at average sown areas, except for maize that is the key regional grain culture. In order to raise revenues and reduce expenses it is recommended to modernize machinery park of cluster 2 by means of energy-saving tractors, grain harvester combines as well as to increase power capacities of the machinery applied for maize cultivating and harvesting.

Cluster 3 collected 8 (33.3%) regions. Their grain producers had the poorest machinery park used at small sown areas. But average yields in cluster 3 suppose a regular renovation of tractors and harvester combines with the advanced machinery models.

For cultivation of large arable lands, reduction of grain losses and growth of harvested yields Ukrainian agriculture undoubtedly needs the machinery modernization. This task is hardly solvable without strict economic substantiation as a share of depreciation in the grain cost structure dropped from 11.8% to 5.6% for 1990-2015. Grain production always remained profitable in Ukraine, though its level varied for the last 20 years from 1.5% in 2013 to 64.8% in 2000. The current average profitability in Ukrainian grain segment amounted 42.6% in 2015. High, but achievable yields, correlating with sufficient stable profitability, will increase agrarians' revenues without a principal cost growth that facilitate financing of an agricultural machinery substitution by their new types and models. Contemporary market of agricultural mechanical engineering proposes the powerful:

- tractors New Holland T8.300, New Holland T8.390, John Deere 8345 R, and John Deere 9420 at prices $ 238 000, $ 267 000, $ 291 000, and $ 335 000 respectively with engines' capacity over 184 kW;

- grain harvester combines John Deere T 660 and John Deere S 660 at prices $ 271 000 and $283 000 with engines' capacity 273 kW and 268 kW, fuel consumption 9.84 and 9.67 kg per ha, productivity 2.71 and 3.11 ha per hour, hoppers' capacity 9 and 11.6 m^3 respectively;
- maize harvester combine John Deere W 550 at price $ 214 000 with engine's capacity 228 kW, fuel consumption 8.33 kg per ha, productivity 2.52 ha per hour, hopper's capacity 8.1 m^3 for the agrarians in the first cluster.
- The agricultural machinery for the second cluster is presented by the middle class tractors Case IHMX255, John Deere 7310, and John Deere 7930 at prices $ 135 000, $ 155 000, and $ 189 000 respectively with engines' capacity between 110 kW and 184 kW;
- grain harvester combines DEUTS-FANR 5660 and Massey Ferguson 28 at prices $ 199 000 and $ 206 000 with engines' capacity 191 kW and 136 kW, fuel consumption 8.43 and 7.97 kg per ha, productivity 2.18 and 1.97 ha per hour, hoppers' capacity 7.3 and 5.5 m^3 respectively;
- maize harvester combine Sampo Rosenlew 2085 at price $ 177 000 with engine's capacity 136 kW, fuel consumption 7.3 kg per ha, productivity 2.0 ha per hour, hopper's capacity 5.3 m^3.

The economical machinery park of the third cluster may be updated by modern:

- tractors John Deere 6150, Massey Ferguson 6455, John Deere 6170, and John Deere 6175 at prices $ 99 000, $ 104 000, $ 107 000, and $ 110 000 respectively with engines' capacity between 59 kW and 110 kW;
- grain harvester combines Massey Ferguson 22S and Sampo Rosenlew 2045 at prices $ 104 000 and $ 110 000 with engines' capacity 74 kW and 92 kW, fuel consumption 5.5 and 6.5 kg per ha, productivity 0.94 and 1.18 ha per hour, hoppers' capacity 3.3 and 3.4 m^3 respectively;
- maize harvester combine Sampo Rosenlew 2065 at price $ 112 000 with engine's capacity 110 kW, fuel consumption 6.6 kg per ha, productivity 1.37 ha per hour, hopper's capacity 4.2 m^3.

Financing of the agricultural machinery modernization in Ukrainian grain production could be evaluated and performed on the following base. Namely, the world prices of wheat, barley, maize in 2015 were, respectively, 165, 150, 145 $/t. Losses in incomes, caused by deviations of the regional yields with regard to the clusters maximal yields in the above described model, reached in total $ 725 077 880 for cluster 1, $ 622 535 456 for cluster 2, $ 201 418 390 for cluster 3. Thus, these sums may cover purchase of over 1340 harvester combines and 1510 tractors for grain producers in cluster 1, of over 1550 harvester combines and 2140 tractors for grain producers in cluster 2, of over 910 harvester combines and 1000 tractors for grain producers in cluster 3. In other words it will result in renovation of 3.6% of tractors, as well as 13.4% of grain and maize harvester combines in the total machinery park of Ukrainian agriculture. So grain producers may attract investors to the technical renovation and confirm their own solvency with the expected excess harvest. In such a way, Ukrainian agricultural enterprises would increase effectiveness of their activity and magnify their grain contribution into the world food security system.

Conclusions

The challenges, facing the global food security system, generate additional opportunities and responsibilities for Ukrainian grain producers, which should increase effectiveness of their activity. Outdated or insufficient agricultural machinery along with climate risks and choice of low-productive sorts of crops affect harvest losses of wheat, barley and maize in Ukraine up to 60%, 25% and 50% respectively. Modern agricultural machinery market offers a large range of technical maintenance that matches contemporary requirements of energy- and recourse-saving precise cultivating and harvesting. The cluster approach enabled aggregation of regional grain producers by their scale of activity and found grounded reserves of restricted financing for purchasing necessary tractors, grain and maize harvester combines.

In spite of conducting a relatively complete research on the chosen issue, it is expedient to continue our investigation, specifying recommendations on the technical modernization of Ukrainian grain production by types of agricultural enterprises.

References

Bessler, D. A., J. H. Doefman, M. T. Holt and J. T. LaFrance, 2010. Econometric Developments in Agricultural and Resource Economics: The First 100 Years. *American Journal of Agricultural Economics,* **92** (2): 571-589.

FAO, 2016. Food and Agriculture Organization of the United Nations. Statistics Division.
http://faostat3.fao.org/download/Q/QC/E

Fuchs, C., J. Kasten and M. Urbanek, 2015. Trends and Potential of the Market for Combine Harvesters in Germany. *Machines,* **3** (4): 364-378.
http://www.mdpi.com/2075-1702/3/4/364/htm

Godfray, H. C. J. and T. Garnett, 2014. Food security and sustainable intensification. *Phil. Trans. R. Soc. B*, **369**: 20120273.

http://dx.doi.org/10.1098/rstb.2012.0273

Grafton, R. Q., C. Daugbjerg and M. E. Qureshi, 2015. Towards food security by 2050. *Food Security,* **7** (2): 179-183.

Headey, D. and O. Ecker, 2013. Rethinking the measurement of food security: from first principles to best practice. *Food Security,* **5** (3): 327-343.

Isaac, N. E., G. R. Quick, S. J. Birrell, W. M. Edwards and B. A. Coers, 2006. Combine harvester econometric model with forward speed optimization. *Applied Engineering in Agriculture,* **22** (1): 25-31.

Kavallari, A., T. Fellmann and S. H. Gay, 2014. Shocks in economic growth = shocking effects for food security? *Food Security,* **6** (4): 567-583.

Masek, J., P. Novak and T. Pavlicek, 2015. Evaluation of combine harvester fuel consumption and operation costs. In: Engineering for Rural Development 2015 (Proceedings of the 14th International Scientific Conference, Jelgava, 20–22 May, 2015), *Latvia University of Agriculture*, Jelgava, pp. 78-83.

http://tf.llu.lv/conference/proceedings2015/Papers/013_Masek.pdf

Mogiliva, M. M., Ya. K. Bilousko and H. M. Pidlisetskyj, 2013. Material and Technical Provision of Agrarian Sector. *Economics of AIC*, **2**: 61-67 (Ua).

http://eapk.org.ua/sites/default/files/eapk/13_02_10.pdf

Navrotskyj, Ya. F., 2015. Tendencies of Development of Agricultural Machinery Market. *Economics of AIC*, **8**: 56-60 (Ua).

Norton, G. W., J. Alwang and W. A. Masters, 2015. Economics of Agricultural Development: World Food Systems and Resource Use. *Routledge,* New York, 464 pp.

Porter, M. E., 1998. Clusters and the new economics of competition. *Harvard Business Review,* **76** (6): 77-90.

Porter, M. E., 2000. Location, Competition, and Economic Development: Local Clusters in Global Economy. *Economic Development Quarterly,* **14** (1): 15-34.

Sattar, M., Mueen-u-Din, Mushtaq Ali, Liaqat Ali, M. Q. Waqar, M. Anjum Ali and L. Khalid, 2015. Grain losses of wheat as affected by different harvesting and threshing techniques. *International Journal of Research in Agriculture and Forestry,* **2** (6): 20-26.

http://www.ijraf.org/pdf/v2-i6/4.pdf

Shubravska, O. V. (ed.) et al., 2014. Agri-Food Development дf Ukraine in the Context of Providing Food Security. *IEF NASU,* Kyiv, 455 pp. (Ua).

State Statistics Service of Ukraine, 2016.

http://www.ukrstat.gov.ua/

The United Nations, 2015. Department of Economic and Social Affairs, Population Division.

https://esa.un.org/unpd/wpp/

Vasylieva, N. K., 2013. Forecasting prices in the crop production sector in Ukraine and regions. *Economic Annals-XXI,* **11–12** (2): 26-29 (Ua).

Vasylieva, N. K., 2015. Economic and mathematical development models of regional meat and dairy cluster. *Actual Problems of Economics*, **165** (3): 429-435 (Ua).

Vasylieva, N. K., 2016. Cluster models of households' agrarian production development. *Economic Annals-XXI,* **3-4** (2): 13-16.

Vasylieva, N. K., I. I. Vinichenko and L. I. Katan, 2015. Economic and mathematical evaluation of Ukrainian agrarian market by branches. *Economic Annals-XXI,* **9-10**: 41-44.

VDMA, 2015. Agricultural Machinery Economic Report.

http://lt.vdma.org/documents/105903/0/VDMA%20Economic%20Report%202015%20full%20version_fin.pdf/39201773-ea76-4db2-a466-ea41dbe93ffb

World's Top Exports, 2016.

http://www.worldstopexports.com/category/products/food/fresh-food/

Zakharchuk, O. V., 2014. Problems of material and technical maintenance of Ukrainian agricultural enterprises. *Economics of AIC*, **7**: 92-99 (Ua).

http://eapk.org.ua/sites/default/files/eapk/14_07_92-99.pdf

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