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Directions for improving of agricultural land use in Ukraine in conditions of global warming and consequences of the Russian's military aggression

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Abstract. The article is devoted to the problematic aspects of agricultural land use in Ukraine. Analyzed influence on the use of agricultural land such factors as systems of farming, global warming, uneven precipitation distribution by months, deficit of humus in the soil and consequences of the impact on the soil of Russia's military aggression. Considered such systems of farming as traditional, organic, No-Till and made conclusion about a harmfulness of traditional farming system on ecology. The main directions of organizational restructuring in crop production in the post-war period are studied. The following main directions have been identified: increasing the level of specialization of production in accordance with farm conditions by choosing crops that are best suited to the climate, soils and assets of the enterprise, as well as increasing the productivity of the use of these assets through the introduction of modern innovative technologies for the production of agricultural products, in particular, soil cultivation technologies. It was concluded that economic and ecological expediency will be the main factors that will determine the directions of organizational restructuring in the plant production of agricultural enterprises of Ukraine in the post-war period and will ensure the recovery and development of the domestic agricultural industry.

1. Introduction

Agricultural land is a main resource for farming and providing food for the population and raw materials for processing. Condition of agricultural land depends on from its use and the measures of its preservation and increasing of soil fertility. Contents of humus in the soil is a key indicator of its fertility. The trend of soil degradation has been observed in Ukrainian agriculture in recent decades. There are several reasons for it. The main of them are the following: intensive growing of monocultures such as corn, sunflower, rapeseed on large areas without a crop rotation; significant reduction of organic fertilizer application; soil erosion. As a result, having the most natural soil fertility, so-called "chernozems" (black soil), Ukraine is not on the first place in terms of agricultural land productivity among European countries.

The complex soil ecosystem is most destroyed by erosion. For the present time the share of arable land in Ukraine is 81 % of total agricultural land, that is twice more in comparison with most European countries, annual increase of eroded land is about 70-80 thousands ha with total area of eroded land 123,1 millions ha. The same time, humus content in soil is decreasing from 3,5 to 3,2 %. Ecological-economy losses from soil erosion are more than 9 billion UHR [6]. In the near future, if such trends continue, Ukrainian agricultural land can have a humus famine which will mean serious

ecological catastrophe and no agritechnical, environmental, organizational measures will be able to renovate the soil potential.

In the result of land reform 27,5 millions ha of agricultural land is privatized. Most of this land is used as leased land. In the process of land lease, there was some disproportion between economic interest of lessors and lessees. If lessors want to receive a maximum income from their land and at the same time to save the soil fertility, then lessees strive to get a maximum profit and the soil fertility is not their first priority. It is why there is a need to introduce certain agrochemical control of soil fertility in the framework of ecological strategy of agricultural land use.

Russian military aggression has a significant impact on the condition of agricultural land, resulting in the contamination of large areas of agricultural land due to the explosion of mines and shells, the deployment of military equipment, the storage of ammunition, etc. Economic and ecological expediency will be the main factors that will determine the directions of organizational restructuring in the crop production of agricultural enterprises of Ukraine in the post-war period and will ensure the recovery and development of the domestic agricultural industry.

2. Materials and methods

The information base of research consists of the scientific works of domestic and foreign scientists in the field of economics of nature use and environmental protection. In addition to the specified sources, this includes legislative and normative acts of the Verkhovna Rada of Ukraine, Cabinet of Ministers of Ukraine, data of the State Statistics Committee of Ukraine, the State Committee of Ukraine on Land Resources, the Regional State Design and Technology Center for the Protection of Soil Fertility and Product Quality "Oblderzhrodyuchyst".

The survey was carried out in the period 1970-2020, covering questions regarding the dynamic of average daily air temperature and precipitation in the Chernihiv region of Ukraine. Among the many indicators that determine the level of fertility of arable land, the most important are the content of humus and nutrients and the reaction of the soil solution. The agrochemical condition of the soils of the region is constantly deteriorating because the removal of nutrients from the soil is not compensated for by the introduction of appropriate doses of organic and mineral fertilizers. The balance of nutrients in agriculture until 1993 was positive in terms of all nutrients (NPK), which explains the accumulation of residual amounts of phosphates, exchangeable potassium in the soil and fully compensated for nitrogen consumption. Since 1993, the balance has become negative for all macroelements, which indicates the depletion of soils, a decrease in their nutrient reserves [4].

The average ecological and agrochemical score of soil fertility in the region is 47 points, which makes it possible to ensure, due to natural fertility, the yield of grain crops - 19.3 t/ha, corn for grain - 24 t/ha, sugar beet - 132 t/ha, potatoes - 85 t/ha The eco-agrochemical fertility score in the region varies from 35 to 61 points among districts of the region [1, 4].

Humus reserves per 1 ha of arable land are determined by the following formula:

$$Hr = (3600 \times H) / 100 \quad (1)$$

where Hr – humus reserves per 1 ha of arable land, t;
3600 – the total weight of the soil in the 0–30 centimeters layer, t;
H% – humus content in the soil, %.
One hectare of reference soil contains 6.2% humus, or 223,200 kg/ha.

The supply of power elements for 1 ha of arable land is determined by the following formula:

$$Se = (3600 \times Sp) / 1000 \quad (2)$$

where: Se - the supply of power elements for 1 ha of arable land, t;
Sp is the provision of soil nutrients, mg/kg.

The reference soil contains 225 mg/kg (81 kg/ha) of easily hydrolyzable nitrogen, 250 mg/kg (900 kg/ha) of mobile phosphorus, 200 mg/kg (720 kg/ha) of exchangeable potassium.

3. Results and discussion

3.1. Farming system

One of the directions for development of ecological strategy agricultural land use can be an appropriate farming system. Farming system is a complex of interconnected agrotechnology, irrigation and organizational measures regarding agricultural land use and renovation of soil fertility. As for present time there are three main farming systems that are used by Ukrainian farms: traditional, organic and No-Till. Referring to many researchers we can make the conclusion that traditional farming system can not provide an ecological balance and security, and are dangerous for the environment by destruction of the soil structure and sequestration of a carbon in air [6, 8, 10, 13].

In contrast to traditional farming system, organic farming system is able to improve the state of the ecosystem, in particular biological variability, biological cycles and biological soil activity. It is possible by using cultural, biological and mechanical methods when cultivating the land in opposite to synthetic materials. Organic farming is not only a system of agricultural production, but also is a complex approach for supporting the sustainable development of agriculture. The advantage of organic farming is a possibility for adaptation to many climate zones and local conditions. Due to the fact that organic farming uses only organic materials like fertility, plants protecting tools, and packaging, this system contributes to an increase of organic substances in the soil. As a result, under the influence of natural factors, organic farming provides much more moisture in the soil in comparison with traditional farming. It is very important in conditions of global warming. In addition to it organic farming provides a lower cost of farming and decreases the risk of receiving big losses in conditions of climate instability and low yield [5].

One more of positive elements for organic farming is a sailing of certificated products that provides almost twice higher prices in comparison with products of traditional farming. It creates the possibilities to decrease of production cost and increase of farm income and profit. In other words organic farming can be a part of strategy for adaptation of farms to globally changing of climate and can be used for improving of living conditions of rural population not only in arid areas of south part of Ukraine, but also for all countryside.

Another farming system that can be attributed to the ecological strategy of agricultural land use is No-Till farming. No-Till farming is a technology of agricultural production that excludes from production cycle such technological operations as a plowing, disking, cultivation. Herewith, a sowing is carried out on crop residues of predecessor cultures. It should be mentioned that such technology was introduced and used in Poltava oblast of Ukraine in 1970-1980 years and demonstrated its high productivity and economic efficiency. Such examples of successful many years experience of No-Till farming there are in many countries around the world and one of the main effect of such farming is a preservation of a moisture in the soil, improving a water availability, decreasing of soil erosion. The reasons for such improvement of water accumulation is better water infiltration and decreasing of water evaporation due to a presence on the soil surface of plant residues. Usually for tradition farming the coefficient of relationship between daily level of precipitation and amount of absorption of moisture has a trend to decreasing with increasing of precipitation intensity, but for No-Till farming such decreasing is much slower [10,11].

Such type of moisture accumulation by using No-Till farming provides an increase in crop yield. For example in the Step zone of Ukraine such increasing of moisture in the soil increases of corn yield on about 1,5 t per ha [3, 9]. In additional to accumulation of moisture No-Till farming contribute to the reduction of an evaporation of moisture from the soil, and as a result, prevents of soil erosion. All of the above-mentioned is very important in the conditions of global warming, not stable precipitation and occurrence of droughts, which are becoming a typical phenomenon for almost all aria of Ukraine.

3.2. Global warming

In the tables 1 and 2 the dynamic of average daily air temperature and precipitation on the example of Chernihiv oblast of Ukraine for the last 50 years are presented [3, 11, 12, 14]. The tables show the clear trends for increasing air temperature and instability of precipitation for all four seasons for the mentioned period of time. In particular, there is an increase in the temperature and decreasing of precipitation in winter months and as a result decreasing of a snow cover of 15 centimeters [11, 12]. The same time distribution of precipitation within a separate oblast is heterogeneous. For example, if average precipitation in May 2018 in Chernihiv oblast was 18.4 millimeters, in Snovskyi district of this oblast it was only 5 millimeters. The same time the average precipitation in Vinnyts'ka oblast was 20 millimeters, but for some districts only 2 millimeters, [3, 15]. Such a situation is typical for all oblasts of Central and North Ukraine. It is a strong argument for implementation of irrigation not only for the South part, but for all aria of Ukraine. Also, it should be mentioned increasing of a heavy rainfall and wind that causing the droughts during summer and spring time and increase a risk for soil deflation.

Table 1. The dynamic of average daily air temperature in Chernihiv oblast, C^0

Month	Average daily air temperature								
	1970-2014	2015	2016	2017	2018	2019	2020	2015-2020	2015-2020 +,- to 1970-2014
January	-7,3	-2,7	-7,5	-5,9	1,4	-4,5	0,8	-3,1	4,2
February	-5,9	-1,4	-0,5	-3,3	-5,4	0,6	2,5	-1,3	4,7
March	-1,2	4,3	2,5	4,6	-2,9	5,1	6,5	3,4	4,6
April	7,6	8,5	10	8,1	11	7,6	6,6	8,6	1,0
May	14,1	15	15,4	13,4	18,4	17	25	17,4	3,3
June	17,8	19,1	19,3	17,7	19,2	22	24	20,2	2,4
July	18,9	19,8	21,2	18,3	20,3	19	20	19,8	0,9
August	17,9	20,5	19,7	20,3	20,9	20	15	19,4	1,5
September	12,9	16,4	14	14,8	16,5	16	14	15,3	2,4
October	6,7	5,3	5,3	6,8	9,5	7,1	9,8	7,3	0,6
November	1,1	3,6	0,1	2,6	-0,3	4,2	3,8	2,3	1,2
December	-3,3	1,2	-2,1	0,8	-1,4	2,7	-0,6	0,1	3,4
Average	6,6	9,1	8,1	8,2	8,9	9,7	10,6	9,1	2,5

The table 1 shows that average temperature of air in Chernihiv oblast in 2015-2020 increased in comparison with 1970-2014 period on 2,5° per year, but for January, February and March this increasing was 4,2 - 4,7°. It is dramatic increasing. It should be mentioned that different crops have not the same reaction on temperature increasing, depending on from climate zone. All crops can be divided on two groups regarding their reaction on temperature increasing. First group includes such crops like wheat, barley, sunflower seeds, soybean, rise. For example, increasing of air temperature contributes of yield increasing for grain and legumes on 46% for Forest-step zone (Central part of Ukraine) and on 61 % for Polissya (North-West part of Ukraine) in comparison with 1990 [15]. Second group includes such crops as corn, sorghum, sugar beets, millet and increasing of air temperature causes decreasing of their yield. It should be mentioned that increasing of temperature also is accompanied by significant spread of pests that has negative influence on crop yield.

The table 2 shows that decreasing of precipitation for the period of 2015-2020 in comparison with 1970-2014 is significant and is 128,4 millimeters, but for such month as August this decreasing is 34,2 millimeters.

Table 2. The dynamic of precipitation in Chernihiv oblast, millimetres

Month	Precipitation								
	1970-2014	2015	2016	2017	2018	2019	2020	2015-2020	2015-2020+, 1970-2014
January	37	10	33	27	31	33	31	27,5	-9,5
February	35	18	45	28	47	20	36	32,3	-2,7
March	37	47	36	25	58	35	14	35,8	-1,2
April	42	8,2	53	17	19	31	37	27,5	-14,5
May	50	88	63	28	20	63	63	54,2	4,2
June	67	45	46	44	77	30	63	50,8	-16,2
July	76	75	55	4	167	37	41	63,2	-12,8
August	65	5	74	58	26	6	16	30,8	-34,2
September	44	39	18	29	38	23	16	27,2	-16,8
October	42	27	71	77	5,4	10	33	37,2	-4,8
November	52	60	43	40	13	20	26	33,7	-18,3
December	44	53	35	59	54	24	29	42,3	-1,7
Per year	591	475,2	572	436	555,4	332	405	462,6	-128,4

Figure 1 shows the dynamics of average annual precipitation and daily air temperature in the Chernihiv region for the period 1970-2020.

The above-mentioned example of Chernihiv oblast where type of soil is sod-podzolic and sandy can be made a conclusion about the advisability of implementation of irrigation that was not typical for the previous period of time for this area. Irrigation provides not only water supply, but also creates the possibilities for application of fertilizers for plants in the necessary periods. Such a way of application of fertilizers together with irrigation is called fertigation or fertilizing irrigation. It has many advantages like decreasing energy-intensive technological operations that decreases the cost of fuel, fertilizers and plants protection tools. The same time the efficiency of fertilizer application increases several times by using fertilizer in small doses during vegetation period without mechanical and chemical damaging of the plants. Such type of irrigation is one of the main factors increasing plant yield under conditions of climate change and can provide up to 75 % of crop yields increase[3, 13, 15].

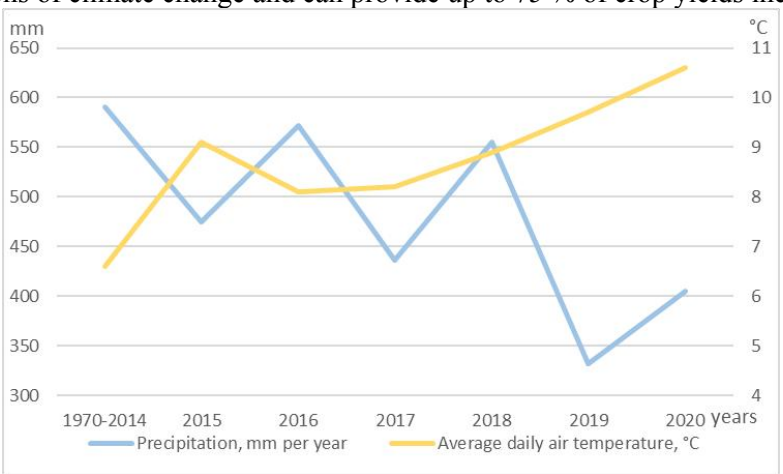

Fig. 1. Dynamics of changes in average annual precipitation and daily air temperature in the Chernihiv region for the period 1970-2020

3.3. Humus

As was mentioned above the humus content in the soil is a key indicator of soil fertility. Calculation of the balance of the humus indicates that deficit-free balance of humus guarantees the yield of winter wheat 46, barley 56, corn 80, potato 185, annual herbs 146 centers per ha. Unfortunately, on large areas of agricultural land in Ukraine there is a negative balance of humus and the rate of humus mineralization exceeds the humus replenishment rate. It is why increasing soil fertility by increasing humus content should be one of the most important measures of ecological strategy of land use in Ukraine.

In table 3 the calculation of the humus balance in the soil on an example of agricultural enterprises of Chernihiv oblast is presented [1, 2, 4]. The calculation shows the negative humus balance for all crops. It means that mineralization or using humus by crops for one production cycle exceeds humus receipts from humification of crop-root residues and applied organic fertilizers. Unfortunately, such a situation is typical not only for agricultural enterprises of Chernihiv oblast, but almost for all farms in Ukraine. Only some of them have a positive humus balance.

Table 3. The humus balance in agricultural enterprises of Chernihiv oblast, 2015

Crop	Humus mineralization for one production cycle, thousands tons	Humus receipts from humification of crop-root residues, thousands tons	Humus receipts from applied organic fertilizers, thousands tons	The balance of humus, thousands tons
1	2	3	4	5=3+4-2
Wheat	221,13	167,18	5,7154	-48,23
Rey	137,67	74,93	5,3374	-57,40
Barely	89,25	69,26	3,0345	-16,96
Oat	88,265	44,48	3,2109	-40,57
Millet	3,9	1,66	0,1802	-2,06
Buckwheat	22,848	5,49	1,1138	-16,24
Corn	199,44	262,85	7,6784	71,09
Legumes	32,816	15,58	1,4767	-15,76
Other grains	0,11	0,06		-0,05
Total	795,429	641,48	27,75	-126,20

In the Chernihiv region, about 80% of the arable land is a leased land. As practice shows, the tenants are not always good faithfully to the use of leased land. In an effort to obtain maximum profits, they are engaged in growing monocultures such as corn grain, sunflower, rape, soy, do not adhere to crop rotation, do not use organic fertilizers. That is, they are not too concerned with preservation and increase in soil fertility when landowners are interested in increasing of the soil fertility after the termination of the lease. Under these circumstances, measures are required for agrochemical control of land with the conclusion of land lease agreements and after completing them. If a decrease in land fertility is fixed, the tenant must compensate the landowner his loss.

Also, the following measures of the ecological strategy of agricultural land use in Ukraine can be mentioned:

- ✓ Development of contour, reclamation and other progressive systems and forms of organization of the territory that provide the rational land use;
- ✓ Compliance of environmentally friendly agricultural production;
- ✓ Implementation of agricultural land conservation;
- ✓ Cleaning of agricultural land from shrubs, small forests, stones and improving of cultural status of land;

- ✓ Removal, use and saving of fertile layer of soil during the works connected with violation of land;
- ✓ Providing of liming, plastering, agrotechnical, phytomeliorative and hydraulic anti-erosion measures;Conductive of measures aimed at fighting with water, wind erosion, sat downs, flooding, water logging, drying, compacted, waste pollution of production, chemical and radioactive substances.

3.4. The main directions of overcoming the consequences of the impact on the soil

We will consider two main directions: increasing the level of specialization of production in accordance with the conditions of the economy; increasing the productivity of the use of the company's assets through the introduction of modern innovative technologies for the production of agricultural products.

*3.4.1. Increasing the level of specialization of production according to the conditions of the farm involves specialization in crops that are best suited to the climate, soils and assets of the farm.*It is advisable to reduce the number of crops grown by the enterprise. This will make it possible to create an effective system of cultures that will best meet the conditions of a specific farm. The principle of self-sufficiency, which was used even under the planned system, when the enterprise sought to have the entire set of crops for the purpose of self-sufficiency and diversification of production, will not make economic sense in the post-war period, because it will not allow enterprises to significantly increase economic efficiency.

At the same time, it is important to use such crop rotation, which will ensure a combination of crops that have a beneficial effect on each other, will require the use of the same agricultural machines and equipment, will make it possible to improve the quality of the land, protect it from erosion, and will be equally profitable. Examples of such crops can be soy and corn, sunflower and rapeseed. So, crop rotation with a ratio of 75% winter wheat and 25% sunflower and canola can be optimal, which reduces the risk of sunflower diseases. In this way, it is possible to ensure an eight-year rotation of sunflower and rapeseed. Such an organizational system will make it possible to make the best use of the advantages of crop rotation - to reduce the amount of use of fertilizers, chemicals and fuel, to ensure environmental benefits and increase economic efficiency. In addition, it is important to increase the level of environmental safety, which is of particular importance in the conditions of climate change, the deterioration of the general ecological condition of the soil after military operations, which resulted in the contamination of large areas of agricultural land due to the explosion of mines and shells, the deployment of military equipment, the storage of ammunition, etc. Also, the environmental disaster that occurred as a result of Russians blowing up the Kakhovka hydroelectric plant and the disappearance of the Kakhovka reservoir with an area of more than 2000 km2 has a significant impact on the use of agricultural resources in the southern part of Ukraine. This reservoir provided irrigation for 326,000 hectares of agricultural land.

3.4.2. Increasing the productivity of the use of enterprise assets through the introduction of modern innovative technologies for the production of agricultural products is directly related to the previous direction, because the specialization of production creates conditions not only for the growth of labor productivity, but also for the introduction of highly specialized innovative technologies. Thus, there is a trend in agriculture around the world to minimize tillage operations, provided that the greatest economic benefit is obtained from a particular crop. This greatest economic benefit is achieved when the marginal cost of cultivating a hectare of crops is approximately equal to the marginal value of the output obtained from that hectare. As the analysis shows, in the agricultural enterprises of Ukraine, the volume of work on soil treatment is much greater than it should be to obtain the greatest economic benefit. Such excess leads to significant overspending of fuel and premature wear and tear of equipment, reducing the profitability of production. In addition, there is compaction, destruction of the

soil structure and loss of valuable soil moisture, which is unacceptable in the conditions of post-war land reclamation. Annual plowing of wheat stubble is not necessary or advisable in most cases. Such a situation with soil cultivation in agricultural enterprises of Ukraine is dictated by traditions rather than economic expediency and the need to save resources.

Different crops adapt differently to minimizing tillage. In particular, wheat, corn, and soybeans produce good yields with minimal tillage, while sunflowers and sugar beets require more intensive tillage to achieve high results. After the final formation of crops and crop rotation, an optimal land cultivation program can be developed.

In accordance with this program, the necessary equipment and agricultural machines are determined, which can be ordered from well-known manufacturers from European countries, the USA, Canada, etc.

An example of minimum tillage for the southern region of the country, which was significantly affected by the war, could be the cultivation of winter wheat and winter rapeseed. These cultures are well adapted to minimal cultivation and can even give a good result in its complete absence. As for equipment, for this you will need a combine harvester, a large tractor, a disc harrow, a sprayer and a special seeder. Herbicides are mandatory for any system, but their cost will be offset by fuel savings. This technology will improve the quality of the soil by increasing the content of organic substances in it and reducing erosion. Depending on the condition of the soil, plowing may be required once every three or four years, which would mean processing 25-30% of the farm's acreage per year.

In this case, the list of necessary equipment will need to be supplemented with a plow or a loosener. Thus, economic and ecological expediency will be the main factors that will determine the directions of organizational restructuring in the crop production of agricultural enterprises of Ukraine in the post-war period and will ensure the recovery and development of the domestic agricultural industry.

4. Conclusions

It can be argued that in recent decades Ukraine has observed degradation of agricultural land, decreasing of its fertility by reducing the use of organic fertilizers, starting to cultivation of monocultures, and reducing the amount of land under irrigation. The negative influence on reducing agricultural land fertility has also caused global warming due to increasing average annual temperature of air, uneven precipitation by months, occurrence of droughts, wind erosion, pest spread and plant diseases. Also the main directions of overcoming the consequences of the impact on the soil of the Russian military aggression can be increasing the level of specialization of production and the productivity of the use of the company's assets through the introduction of modern innovative technologies for the production of agricultural products. Such a situation requires development and implementation of ecological strategy of agricultural land use which provides use of organic and No-Till farming systems, increasing application of organic fertilizers, implementation of irrigation and other measures for rational use of agricultural land and increasing of its fertility

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