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REPRODUCTION MANAGEMENT OF SOIL FERTILITY FOR INNOVATIVE APPROACH IN AGROMELIORATION OF UKRAINE

The object of research is managing reproduction of soil fertility using innovations in the field of agromelioration. One of the most problematic places is actualization the role and impact of innovations in agromelioration to ensure their effective management for the reproduction of soil fertility, increase land productivity and the sustainability of their use. Issues that raise in research are essential for the agricultural economy, but not always achieve goals for this reason, including natural and climatic factors. The set of such causes is not always possible to predict and to consider it especially at macro level.

In the course of the study, the modeling approaches of the economic processes in land agromelioration on the basis of widespread use of random numbers (Monte Carlo), according to the received series production studies of changes in crop yields by crop rotation. Separately were used methods the Economic and Statistical – with the determination of the processes of validization and evaluation of the obtained results, Balance – when calculating the indicators of aggregated states, Planned and Calculated according to the development of targets and measurement of economic and ecological effects, etc.

The results of the studies allow general condition of land resources in which there is a need for agromelioration measures due to disturbance of the soil environment and deviation of the pH value from the permissible level. It's noted that in Ukraine due to the existing unbalanced land use there is a further acidification of soils, at the same time there are significant areas of land that need desalination and/or desalinization. We carried out an in-depth analysis and substantiation of the transition to innovations in land agromelioration technologies, which are not inferior to the best world standards and are modern resource-saving due to the use of land agromelioration. The ecological and economic efficiency of the use of calcium-iron sludge (CIS) in relation to the desalination action in comparison with other agromelioration measures is revealed. We proposed to improve scientific and methodological approaches to estimation the effectiveness of management the reproduction of soil fertility by randomness (uncertainty) conditions the based on production approbation, using a variety of agromeliorative techniques (variances).

Keywords: *Monte Carlo method, managing the reproduction of soil fertility, innovation in the branch of agromelioration, ecological and economic effect.*

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1. Introduction

It should be evaluate any agrotechnical and agromeliorative measures from the position of organizational and production activity of the economic entity. One of these ways to determine the expediency of investing in projects and measures aimed at improving the fertile state of soils, and in general land resources is in the field of economic approach to their scientific substantiation. So on, the key criterion is economic efficiency.

Today dynamic systems of economic relation between economic entities and state organizations are in close linking with a market mechanism, which is a determining factor in the formation and transmission of signals to participants in market relations regarding their ability to effectively distribute production resources. Including the importance for the agro-industrial production – the land, as a factor of production, possible firmness to speak about one of the priority places that the correction it occupies among all other types. At the same time, its role and importance increases due to its specific property, namely the presence of the limited fertile soils. Therefore, careful (rational) using land contributes to the multiplication of profitability to both its owner and the user.

In Ukraine the area of saline and salinization soils have the huge size, their improvement requires one of the priority measures. Such design decisions should be attributed to the scientifically substantiated and widespread use of various reclamation and agromeliorative techniques, but the final word, with their balanced and ecological safety use, which will contribute not only to rational use productivity and cost-effectiveness. The materiality of this problem is due to the fact that modern land use must be taken into account market principles.

Modern agriculture requires a variety of scientific and practical approaches to the rational, environmentally friendly and efficient use of land resources. One of these techniques is direct land agromelioration, which involves a set of works that include organizational, economic and technical measures aimed at radical and rapid cultivation of unproductive soils. Also it insures protection from degradation caused by excessive (unacceptable) anthropogenic load and non-compliance of scientifically recommendations by modes of economic turnover.

2. The object of research and its technological audit

The object of research is managing reproduction of soil fertility using innovations in the field of agromelioration. The reproduction of soil fertility is the prerogative of many studies in matters of land use. This problem isn't characteristic only of Ukraine, but is of international importance, and is adopted in the relevant regulatory documents that guide the UN in its decisions.

Therefore, one of the most problematic places is actualization the role and impact of innovations in agromelioration to ensure their effective management for the reproduction of soil fertility, increase land productivity and the sustainability of their use. Issues that raise in research are essential for the agricultural economy, but not always achieve goals for this reason, including natural and climatic factors. The set of such causes is not always possible to predict and to consider it especially at macro level.

3. The aim and objectives of research

The aim of research is scientific substantiation of innovative approaches for agromelioration to improve the management reproduction of soil fertility and increase sustainability of soil resources. According to the aim of research, the following objectives are set in the work:

1. The formation of elements of ecological audit on the occurrence and spread of saline and salinized soils in Ukraine and management processes their reproduction fertility and sustainable use.
2. To establish innovative agromelioration projects for reproduction soil fertility base on the elements to improve a mechanism validity obtained production results pass to simulation, generating random values and including estimation their statistical significance.
3. An improvement scientific and methodical approach for evaluation ecological and economic efficiency the agromelioration measures by innovative and traditional content including different set of meliorants primarily for desalination and desalinization soils.

4. Research of existing solutions to the problem

What would not be perfect organizational, economic and institutional mechanisms for the use of water resources in the economic complex, the most important factor in water use is the water supply of the country, which is an objective natural resource factor of socio-economic development. And the level of water supply is the starting point for consideration of various forms, methods and approaches by attracting water resources in the reproductive process. Meanwhile, there is a significant territorial differentiation in Ukraine on water resources and water consumption [1].

Ensuring compliance with the best, and sometimes optimal regimes of water consumption of agricultural plants is one of the significant factors for the implementation of sustainable land management. It's obvious that the water-soil regime will eventually depend on the achievement of the sustainability of crops and crop rotation productivity. In considering source [2], deviation of soil moisture from optimal standards by 10 % causes a decrease in the yield of some crops to 20–25 %. However, yield on re-salted soils (for use an irrigation of water by poor quality and violation the evidence-bases irrigation modes and agrotechnical measures) more reduce, respectively for cereals – 1.5–2 times; tilled crops – 3–4; vegetables – almost 5 times.

Thus, not only moisture deficiency in the soil adversely affects the plant, but also the soils themselves, depending on the degree of salinization and quality of irrigation water, are also marked by feedback from crop yields. Concerning research [3], where showed the results of the point assessment of the capacity of providing ecosystemic services of land from the use of irrigation water, there proposed three classes of its suitability for irrigation of different soil groups according to their buffering are distinguished: suitable, limited and unsuitable. At the same time, for suitable water for irrigation for the provision of ecosystem services is estimated at 10 points, with limited suitability – 5 points and unsuitable – didn't score any points.

Particularly threatening in terms of food supply and economically accessibility of the population to food resources seems to be due to climate change and increased dryness of territories, even in the Forest-Steppe zone of Ukraine. That is, unstable agriculture dynamically expands the new territories of cultivation of land in the recent natural and climatic zones. All this leads to agriculture in conditions of increased risk and resistance of land use. The considering research to [4], we are preserving trends of temperature growth in the warm period and in the future can create huge issues for growing crops.

According to the UN, by 2050, it's projected to grow global demand by 55 %, mainly due to increasing production needs, generation of thermal electricity and household use [5]. Obviously, given the significant tariffs for the use of irrigation water on irrigated lands in the future, the costs will increase and, in particular, due to increased demand for water resources in agriculture. Therefore, changing existing irrigation schemes through the control of the plastic water stress regime is able to save 27 % of irrigation water [6].

Among the various melioration measures aimed at improving the quality of agricultural land, chemical land reclamation occupies one of the leading positions in the system of intensive agriculture [7]. Thus, chemical ameliorants include various substances or their mixtures of natural or man-made origin such as gypsum, phosphogypsum, chalk, defecation mud and rocks containing more than 10 % of calcium compounds, including calcium-iron-containing sludge (CIS), which is a waste of steel-wire production.

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Agromelioration measures in Ukraine have a certain territorial distribution, as acidic soil solution prevails in Polissya and Forest-Steppe, and alkaline one – in Steppe. Therefore, it affects the development and carrying out of agromeliorative measures, organizational, technological and project bases for its implementation.

According to the X round (2011–2015) of the agrochemical survey of agricultural lands, the area of lands in Ukraine with acidic soil solution is 3621 thousand hectares or 19.1 % of the total area. As for the alkaline soil medium, the total land area is 4462.3 thousand hectares or 23.9 % of all lands [8].

Evaluation of the effectiveness of innovations of agromeliorative measures is a multidimensional vector of improving the use of land resources and it is not possible to study it only from the standpoint of one or more indicators. For this priority in our study let's follow the principles of methodology for determining the economic effectiveness of the innovation that is the direct basis for operating with specific indicators of its evaluation. In general, these indicators in the field of protection and rational use of soil resources are classified according to the method of calculation, the degree of synthesis, content and source data [9]. However, this study organically combines not only the issue of economic evaluation of innovations in land reclamation, but the emphasis is mainly shifted to the ecological efficiency of their implementation on irrigated lands, on lands where there is a high risk of salinization.

In Ukraine, more than 80 % of land areas (over 24 million hectares) are characterized by such types of water regime of arable soils, which form the dominance of scarce (or periodically scarce) moisture. At the same time, irrigation can improve the efficiency of land use, but at the same time can cause unnecessary costs and, moreover, environmental damage. For example, low hydro-buffering under conditions of high infiltration capacity of soil-subsoil leads not only to unreasonably high losses of water masses of precipitation, but also to leaching of biogenic elements from the soil root-containing nutrient medium. Therefore, scientists suggest for irrigated agriculture to adhere to such a limit that the soil moisture is constantly maintained in the range closer to the lower limit of its availability than to the upper one [10].

In general, the negative (dangerous) consequences of agromeliorative measures can be obtained on any soil with a disturbed pH balance. Thus, studies of thermodynamics of soil processes show that continuous and excessive liming of acid soils often leads to the development of dangerous phenomena in modern soil formation, which can significantly worsen the ecological state not only of the soil but also the environment medium. It is characteristic that the intensification of negative effects on the ecological state of the soil environment occurs on low-buffer acid-base balance soils. At the same time it is noted the prolonging effect of influence of ameliorant on an agroecological state, in particular aftereffect of the phenomenon (effect) of overliming of acid soils can last till 2–3 and more years [11].

Therefore, in order to achieve a sustainable ecological balance together with the economic efficiency of land use, it is necessary to move to innovative agromeliorative measures, although it is not deny the possibility of using traditional or similar technologies, which usually provide higher rates of chemical melioration. It depends on many factors and conditions, when specific decisions are made in this matter, but any of them must meet both the urgent need and compliance with scientifically sound requirements for their implementation, and the last one must be under mandatory supervision [12].

On the basis of the National Scientific Center «Institute for Soil Science and Agrochemistry Research named after O. N. Sokolovsky» (Kharkiv, Ukraine) scientists developed and tested innovative soil reclamation technology in humid natural and climatic zones. As author of paper [13] notes, this technology is based on local soil reclamation in which reclamation is achieved not of the entire arable mass of soil (about 3000 t/ha), but only a small part of it (190–200 t/ha), as a result of which it allows saving money on soil cultivation and fertilization with ameliorants. No less important is the fact that with this reclamation technology the yield of crop products remains at the level of the traditional method of applying ameliorants. A special place in innovative technology is given to the preparation of organo-mineral fertilizers.

Insufficient consideration of technologies, minimization of organic and suboptimal application of mineral fertilizers simultaneously with increasing anthropogenic load negatively affects the environmental safety of land use, causing, in particular, significant distortion of the capacity of soluble bases, variables and mobilization of nutrients in soils in Ukraine. The authors have shown [14], the processes of acidification of the soil cover are observed in 15 regions and are manifested even in the agro-landscapes of the Steppe, and the intensity in increasing area of acid soils ranges from 1 % to 14 %.

In this context, the development of a mechanism for effective management of land degradation neutrality is relevant, the ability to ultimately achieve sustainable use of soil resources, in particular, due to the reasons for the violation of their acid-base balance. This is one of the key components of successful land management, as it requires solving one of the key challenges for the restoration and renaturalization of degraded and unproductive lands [15].

Let's suggest that the implementation of these targets is possible with the further development of innovative technologies for land melioration. It's provide further widely application not only improved technical methods use of land and cultivation, but also the spread develop of various scientific and practical approaches to innovation in producing agrochemically valuable organo-mineral fertilizers on special recipes and kind of «know-how». They can use include the variability combination as both traditional fertilizers as lot of types waste from mining and metallurgical complex and chemical industry.

In addition, for high-quality preparation of fertilizers with reclamation effect, it is necessary to use beneficial microorganisms on which innovative EM-technology (effective microorganisms) is based, which gave a significant impetus to further development of organic production and positively affects the reproduction of fertility of soils, which are naturally unproductive. The use of phytomelioration is no less important in regulating the reaction of the soil medium [16, 17].

Given the ability of the soil to provide ecosystem services, they are better depending on the initial state and the natural supply with moisture, while irrigation impairs their importance. As a result of scientific research conducted by author of paper [18], it was determined that non-irrigated ordinary chernozems with good ecological and ameliorative state are characterized by a high level of ecosystem services, and irrigated ones with satisfactory and unsatisfactory state – medium and low. Given that in the context of climate change and its subsequent aridization, the need for irrigated land will increase, and given the effects of irrigation and local water quality – the risk of deterioration of soil ecosystem services is high.

According to [19], the potential for obtaining income from changes in crop yields (wheat, corn, rice, etc.) reaches on irrigated lands up to 80 %, but they simultaneously emphasize that it is quite difficult to identify. Therefore, methods related to simulation and/or generation of random values in different approaches are of great importance [20–22]. The main principles to application of simulation processes for random variables are given by the author in the source [23]. The evaluation of the economic efficiency of the projects for irrigation lands showed their high statistical reliability and significant of the results [24, 25].

5. Method of research

In the course of the study, the modeling approaches of the economic processes in land agromelioration on the basis of widespread use of random numbers (Monte Carlo method), according to the received series production studies of changes in crop yields by crop rotation. Additionally for realize aims studies were used methods:

– Economic and Statistical – with the determination of the processes of validization and evaluation of the obtained results;
– Balance – when calculating the indicators of aggregated states;
– Planned and Calculated for develop targets and measurement of economic and ecological effects;
– Graphical – in the visualization of quantitative values;
– Project and Analysis – to justification of the final parameters of models for variants of experiments and their comparisons by project management.

6. Research results

To improve the situation with the salinizing effect of irrigated water, it is necessary to apply ameliorants, but the application of phosphogypsum and raw gypsum have a number of disadvantages. Thus, even if they are used with the norms calculated taking into account the actual degree of salinity of the soil and at the same time the water quality, they did not completely eliminate the chemical and agrochemical degradation of soils [18]. Therefore, the study in the Northern Steppe was conducted with the analysis of options of agromeliorative measures on change of the content of carbonates, which is shown in Fig. 1.

Indicator probability (*P*-level), standard deviation (*Z*), measurement error (ε, %) and minimum number of random data generated in Table 1.

If probability equal 0.95 than should be generate 384 unites which provide an error of 5 %, and if the data is increase to 500 units with the same probability, the error decreases to 4.4 %. Hence, if probability equal 0.99, the amount of random data or to satisfy the error of 5.8 %, necessary increase the same number of cases. Therefore, in this study it's sufficient to limit itself to the value of the error less than 5 % with a probability at 0.95.

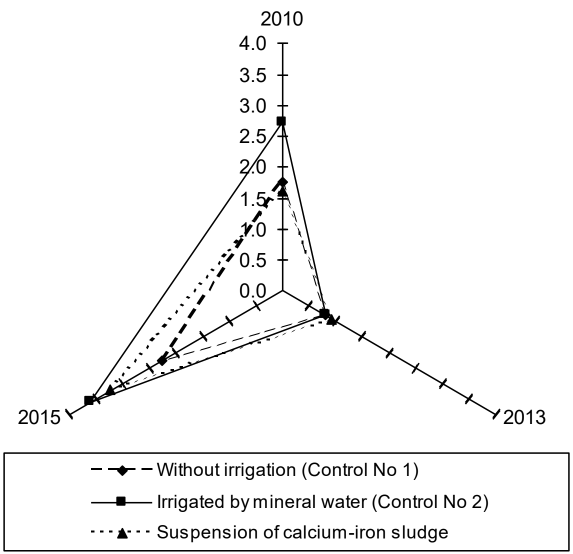

Fig. 1. The average content of carbonates in the soil layer (up to 25 cm) according to the variants of experiments from agromeliorative measures during 2010–2015, %

Table 1

Statistical evaluation of normal distribution values

P-level (probability)	±*z* score/sigma value	Error (ε), %	N_{min}
setting error			
0.950	1.96	5.0	384
0.954	2.00	5.0	400
0.990	2.58	5.0	666
0.997	3.00	5.0	900
error from setting numerical minimum (N_{min})			
0.950	1.96	4.4	500
0.954	2.00	4.5	500
0.990	2.58	5.8	500
0.997	3.00	6.7	500

Imitation of the values of the average crop yield on crop rotation proves the presence of their significant fluctuations (deviations), Fig. 2.

It should be noted that during the formation of design variants let's calculate the value of tariffs for irrigation, depending on the needs of the annual load on the sprinklers in the conditions of the northern steppe. At the same time, it didn't take into account the payment for water, but calculated our own water (sampling) of water, according to the methodological approach proposed by author of paper [26].

In 2010, the initial content of carbonates in the soil layer to a depth of 25 cm with the variant of irrigation with mineralized water (control No. 2) significantly outweighed the value compared to control No. 1 (without irrigation) and the application of calcium-iron sludge. However, in the future, as shown by soil sampling, the content of carbonates between the variants changed in favor of calcium-iron sludge, although in 2015 for the latter compared to control No. 2 their content lagged slightly, but differed sharply compared to control No. 1 (without irrigation). Therefore, it is obvious that the implementation of agromeliorative measures positively affected the dynamics of carbonate content in the soil, and the largest increase in the effect is observed with the application of calcium-iron sludge (CIS).

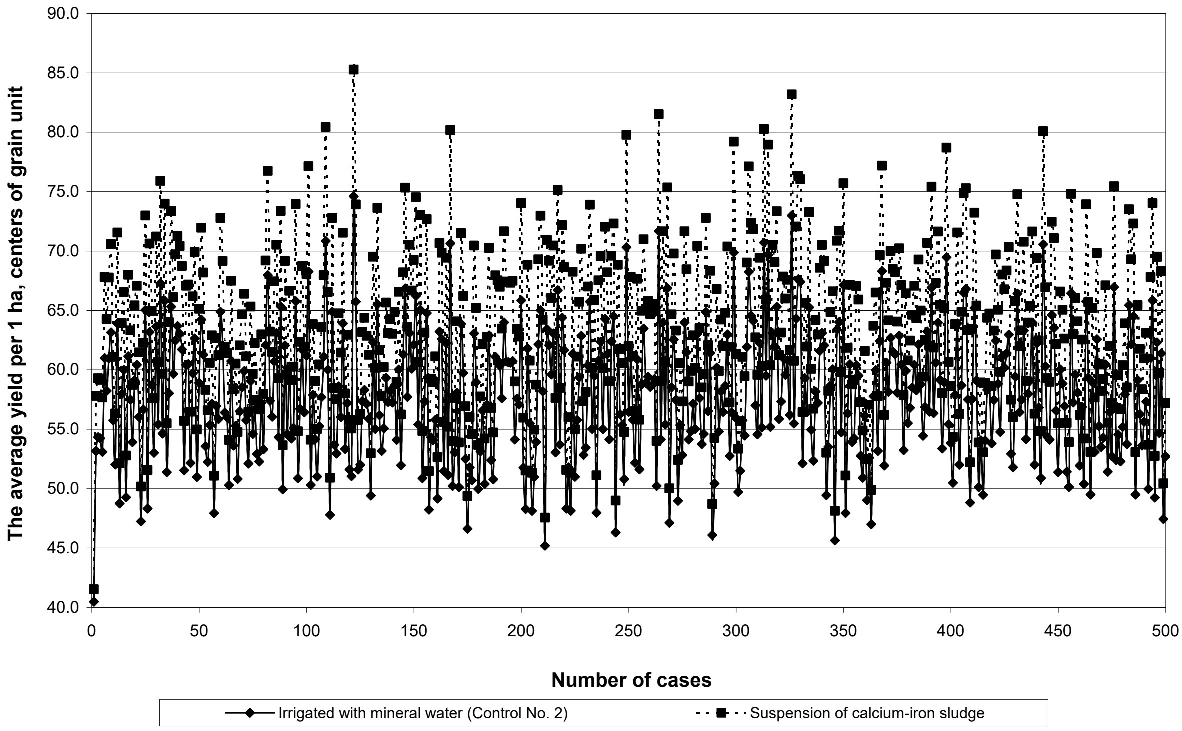

Fig. 2. Imitation of crop yields by crop rotation for 2009–2017 years, centers of grain unit per 1 ha

Therefore, source [27] reveals an alternative to known for reducing salinity and soil pollution – ameliorants, is the use of local raw materials – calcium and iron-calcium sulfuric acid industrial waste.

The calculated conditional effect from soil desalination (to a depth of up to 25 cm) by types of ameliorants is given in Table 2.

The conditional effect was assessed on the basis of normative values of calcium content in terms of ameliorants, as well as in determining the absolute increase in carbonate mass in the soil by agromeliorative measures in comparison with the control variant No. 1 (without irrigation) during the entire crop rotation. Conditional effect, which is essentially ecological, as it improves the equilibrium reaction of the soil solution, the quality of its absorption complex due to the displacement of sodium and magnesium cations, while determining the value of this effect is based on both relative carbonate content in ameliorants and their market price with the cost of delivery and application.

In general, the application of CIS proves that the conditional effect from this agricultural measure significantly exceeds the variant on irrigation with mineralized water and its value is in a wide range depending on the assessed ameliorant. The assessment of CIS shows that the conditional effect of soil desalination is higher both by irrigation with mineralized water – 24.5 t/ha, and by the application of calcium-iron sludge, which is 67.5 t/ha. It is clearly seen that the assessment of the conditional effect in the physical mass of the ameliorant for CIS is close to phosphogypsum and chalk, and most deviates from gypsum. And given the cost of these ameliorants, the difference between calcium-iron sludge and other ameliorants becomes even more significant.

Table 2

Conditional effect (income/expenses) of the change of carbonate content in the soil layer (up to 25 cm) according to the assessment of ameliorants of desalination action in 9-multicourse crop rotation depending on the variant of the experiment per 1 ha

Variant of experience	Ameliorant	Conditional effect on the volume of ameliorant (physical mass), t/ha	Conditional effect (income/expenses) at the cost of purchasing additional ameliorants, USD/ha	Conditional effect (income/expenses) on the purchase price and costs of applying ameliorants, USD/ha
Irrigated with mineral water (Control No. 2)	Phosphogypsum	24.2	361	410
	Calcium-iron sludge	24.5	229	352
	Chalk	15.3	344	374
	Gypsum	22.3	2881	2925
Suspension of calcium-iron sludge	Phosphogypsum	66.6	996	1128
	Calcium-iron sludge	67.5	634	974
	Chalk	42.1	947	1031
	Gypsum	61.4	7930	8048

However, it should be noted that at physical weight – the conditional effect was greater than with two agromeliorative measures for calcium-iron sludge, where after valuation the same effect became the opposite, and now CIS has the lowest value, which indicates more moderate economic costs compared to other types of ameliorants in case of their possible use for desalination of soil in the studied conditions. That is, the lower value of the conditional effect on calcium-iron sludge is considered not only as the revenue side, but mainly indicates the saved reclamation resource for the implementation of these two agronomic techniques in relation to the control value according to experiment No. 1 (without irrigation). Thus, the data in Table 2 show that the saved costs (income) on irrigation with mineralized water (control No. 2) compared with control No. 1 (without irrigation) with ameliorant – CIS, is 352 USD/ha, when for gypsum – 2925 USD/ha, and in the experiment with the application of calcium-iron sludge increase to 974 and 8048 USD/ha, respectively. Therefore, the conditional effect from desalination of the soil is in a wide cost range, estimated by the cost method to restore the carbonate content specifically at soil depth up to 25 cm, depending on the choice of ameliorant.

Innovations require not only agromeliorative measures in agricultural production, but equally important are scientific and methodological techniques (approaches) that allow a more objective analysis to identify these changes, to give a fuller description of them. Therefore, let's calculate the proportion of the conditional effect from improving the reclamation of soils with impaired alkaline reaction, taking into account the modeling of the probability of changes in crop yields and overall crop productivity by the Monte Carlo method, which is covered in detail in the scientific publication [25]. Including such effects related to land amelioration causes them to be evaluated by other approaches [28].

To determine the yield of crops according to the obtained moments of their distribution in time and space dynamics, as a similar experiment had four repetitions during 9 years, the entire crop rotation. According to the results of simulation modeling, the most probable scenario was identified, which corresponds to the subsequently calculated and adopted for the economic justification of agromeliorative measures the value of the average yield of crops that entered the crop rotation. This is confirmed by the statistical significance of fluctuations in the random value of yield according to the distribution quantile and the significance of the statistical estimate of the normal distribution in 95 % of cases.

Only after confirming the normal distribution of the analyzed yield and the ability to achieve the most probable value, let's calculate the difference between the conditional effect from land melioration in terms of its share to the overall environmental and economic effect. The ecological effect continued to include the results according to the survey of the soil to a depth of 25 cm (Fig. 3).

As shown in Fig. 3, the most specific weight of the conditional effect from soil desalination (up to 25 cm deep) is characteristic of the assessment of gypsum, and the least of CIS. Given the positive changes in the ecological condition of soils based on irrigation with mineralized water (control No. 2) compared to the experiment without irrigation (control No. 1), however, the application of CIS adds a better nature of growth, as its share continues to increase, which indicates not only the quantitative but also the structural shift in the overall effect of the application of this agromeliorative measure. An additional increase in specific weight of the conditional effect in the overall environmental and economic effect between the application of calcium-iron sludge and control No. 2 for all ameliorants is about 7 %. And the approximation is caused not so much by the physical parameters of ameliorants as their cost component due to differences in the cost of their use.

Thus, the conditional amelioration effect according to experiment No. 2 (irrigation with mineralized water) reaches the saved costs (income) estimated by CIS in 21.9 %, and by gypsum – 69.9 %, according to the experiment with calcium-iron sludge this value is respectively 28.9 and 77 %. Evaluation by other ameliorants shows insignificant differences compared to CIS in terms of the studied agromeliorative measures.

The results of profitability (unprofitableness) of agromeliorative measures in comparison with the control No. 1 (without irrigation), which are evaluated by different types of ameliorants of desalination action are shown in Fig. 4.

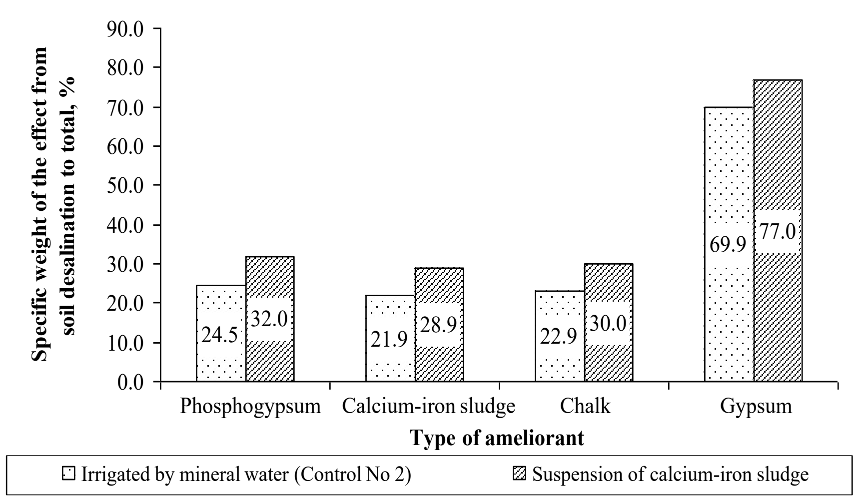

Fig. 3. Specific weight of the conditional effect from soil desalination to a depth of 25 cm estimated by different ameliorants to the total value of the ecological and economic effect compared to the control No. 1 (without irrigation) with a high probability of crop yield

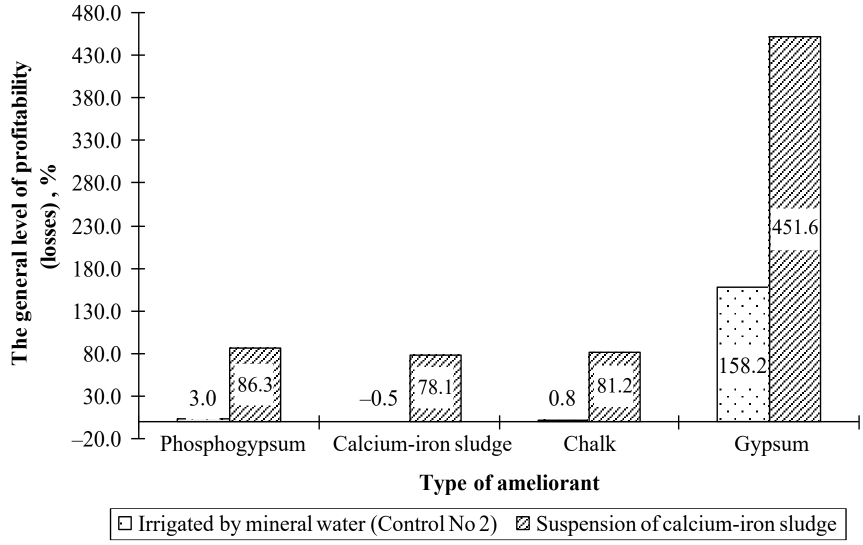

Fig. 4. The level of profitability (unprofitableness) of agromeliorative measures assessed by the obtained ecological and economic effect compared to the control No. 1 (without irrigation) in terms of types of ameliorants with a high probability of crop yield, %

Calculations show that irrigation with mineralized water is quite expensive, and therefore, depending on the assessment of the ameliorant, its profitability is low for phosphogypsum 3 %, and for chalk is 0.8 %. In addition, according to calcium-iron sludge, this agricultural measure is worse than in the control No. 1, and the value of the indicator is –0.5 %. The high level of this agromeliorative measure is achieved only by assessing the reclamation effect of gypsum, but forms an overly optimistic scenario, as there is a significant alternative choice of different ameliorants, and therefore cannot indicate extremely high profitability of the measure, as the economic component remains unchanged. In the case of using calcium-iron sludge, the level of profitability is achieved by all evaluation variants of ameliorants and is significant compared to the control No. 2, and also differs positively from the control No. 1. In general, the level of profitability of the use of calcium-iron sludge is 78.1 % compared to control No. 1 (without irrigation), while at control No. 2 the value is negative (–0.5 %). The use in the assessment of other ameliorants proves a similar environmental and economic effect, except for the variant with gypsum. For the latter, the large share is shifted to the conditional effect of desalination and/or salinization, which is caused mainly by the high cost of the ameliorant and the cost of its application, rather than significant savings due to calcium-containing compounds in its composition.

7. SWOT analysis of research results

Strengths. The use of methods of simulation of random variables contributed to the transformation of data into a valid form with a statistical error of less than 5 %. Thus, the horizon of the accuracy of data, which is more sensitive to the influence of various factors, including natural and climatic conditions is achieved. Along with this, a multivariate evaluation of the agromeliorative effect on the reproduction of soil fertility by various types of amelioration, which allow to choose a more deficit resource was used.

Weaknesses. The analysis requires taking into account such conditions for meliorants on the calculation of desalinization, which can be manifest differently in the same cases, since the gross content does not always proportionally affect the active fraction of the substances ameliorants. It's difficult to assess the ecological effect of changing the reaction of soil (pH) or the reliability of calculating carbonate content in the soil, and therefore requires more adequacy laboratory tests.

Opportunities. It should be note that in the further process of taking into account the ecological and economic effect in the development of a project from soil amelioration requires not only arable horizon up to 20–25 cm, but also deeper. In addition, this approach will allow to combine other methods of market assessments in the management reproduction of soil fertility, in particular normative monetary, which is already concerning with land circulation.

Threats. Among the significant threats, there is a negative effect on projected results, depending on the choice of ameliorant, which is able to overestimate (optimistic data too much) expectation payback parameters, especially in ecological effect. In addition, an ecological effect has one of the kinds when there may be other equally significant changes for soils that are subject to innovation in agromelioration.

8. Conclusions

1. The paper shows that among causes of the ecological audit should be attribute the significant scale of violations the water regimes lands, which due to need for their improve state of quality and suitability for production in Ukraine. Also, in country more than 80 % of land areas or over 24 million hectares are characterized by such types of water regime of arable soils, which form the dominance of scarce (or periodically scarce) moisture. At the same time, problems with the ensure of water resources would only intensify, because according to forecast the UN to 2050, the global demand for water will increase by 55 %. So, give the deviation of soil moisture by 10 %, it leads to decrease in the yield of some crops near 20–25 %. In Ukraine needs to melioration measures can be different for soils with an alkaline solution, them square are

setting 4462.3 thousand ha or 23.9 % from agricultural land area. Thus, it causes to spread huge areas of saline and salinized soils and requires improvement of mechanism a compliance ecological condition for them priority moistening and other agromalioration measures (plantage plowing, apply various ameliorants, in particular calcium-iron sludge (CIS), phytomelioration, etc.).

2. In general, the management of soil fertility reproduction on agromelioration is a complex process that requires detail of the project, improving the methods of evaluating the ecological and economic efficiency of agromelioration measures, assessing the contribution of innovations and the accuracy of production results. The widespread use of random values (Monte Carlo method) contributes to the objectification of the obtained indicators for the evaluation of reclamation measures and the efficiency of soil resource management.

The projects were established to the obtained production data for condition Northern Steppe of Ukraine, which included options without irrigation, irrigated with mineralized water (control No. 2) and introduction of CIS. Where for the solutions a statistical error of 4.4 % with a probability of 0.95 was applied, the experience data strictly have increased the reliability. The quantity of generated random variables was 500 units for each agromelioration measures.

3. According to the results of research, innovations in land melioration are very important for managing their sustainability of reproduction, increasing productivity and economic value. It was found that irrigation with mineralized water is an environmentally effective reclamation measure, but its economic efficiency is insufficient, as it was influenced by the quality of irrigated water. The estimation of agromelioration measures on the base improved scientific and methodical approach of determining the ecological and economic efficiency for desalination and desalinization soils was done, when use such ameliorants as phosphogypsum, CIS, chalk and gypsum. However, it is revealed that the ecological and economic efficiency of the application of CIS is not only the highest in comparison with lands without irrigation, but also significantly differs from the experiment of irrigation with mineralized water. This approach makes possible to use ameliorants for more resource-saving type an amelioration land. Thus, saved costs (income) on irrigation with mineralized water (control No. 2) compared with control No. 1 (without irrigation) with ameliorant – CIS, is 352 USD/ha, when for gypsum – 2925 USD/ha, and in the experiment with the application of calcium-iron sludge increase to 974 and 8048 USD/ha, respectively. The conditional ecological effect (carbonate content at the depth to 25 cm) soil desalination and desalinization depends for choose an ameliorant, because has a wide range influence at estimation an agromeliorative measure. In addition, the application of CIS showed a high level of ecological and economic efficiency and feasibility project realization among scenarios (variances) on salinity soils, which will allow to their effective managing for reproduction of fertility soils and sustainability use land.

Conflict of interests

The author declares that there is no conflict of interest regarding this research, including financial, personal nature, authorship or other nature that could affect the research and its results presented in this article.

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