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PRODUCTION OF WINTER WHEAT IN THE PHASES OF THE SOLAR ACTIVITY CYCLE

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Abstract

The impact of the phases of the solar activity cycle on winter wheat production in different physiographic zones of Ukraine: Polesie, Forest-Steppe and Steppe have been researched. Particular attention is paid to indicators of yield that have a significant impact on the development of agricultural industries. A correlation dependence between the yield of winter wheat and the phases of the cycle of solar activity was established. With a proper research of these indicators, the sectoral structures of agro-ecosystems can predict for income or prevent the growth of zonal costs in social production. The optimal periods for obtaining high and stable yields of the studied culture connected with the physical factors of nature are determined. That is why a large role is played by the scientific understanding and practical use of each individual phase of the solar activity cycle in agroecosystems, which enables a business entity to obtain a reasonable dynamic system by their periodic changes. At the same time, and is a prerequisite for control at all stages of culture production.

Key words*: *solar activity, cycles, phases, zones, winter wheat, management, economic efficiency

INTRODUCTION

Modern agricultural production for many years has been as a subject of intensive and multilateral research. This is because of the exceptional role that it plays in human economic activity. Especially actively conducted research about the influence of space factors on the production of crops in agriculture. Scientific research in this direction has a great importance for the crop industry, which has a high productivity potential with adaptability to high-precision production technologies of grain crops. In this aspect, the mastering of new management methods for the effective functioning of the agrarian sector has special significance.

It should be noted that the holistic management theory in agroecosystems, which includes space factors, should occupy a key place, which forms a sustainable and balanced development of its structural divisions. The importance of this task, which for many years was considered secondary or not at all posed on this issue, can be seen, for example, from the existing uncertainty of the impact of the phases of the solar activity cycle on the production of winter wheat. This is why, the process of finding of new approaches on the influence of the phases of the solar activity cycle is important condition to improve the efficiency of agricultural production. Especially when planning appropriate measures to stabilize the state of sown and harvesting areas and in predicting the further growth of social production.

Of course, the direction of such research has a certain specificity, since in the context of reforming agrarian relations at the state, regional and local levels, the search for new approaches to the system is of paramount importance to increase the productivity of agroecosystems based on the use of physical factors of nature. However, the economic practice of recent years has not fully ensured the implementation of all natural factors, which is mainly due to the socio-economic conditions of the transition period in the process of reforming agricultural production systems [14].

Joining as an integral natural factor in human economic activity, solar activity, as a physical factor, influences on the plant growing industry and its further development. Therefore, particular importance is the study of production indicators of winter wheat yields in the period of phases of the solar activity cycle.

Actually a phenomena of the cyclical nature of solar activity were researched by foreign and domestic scientists, in particular Jung, 1930; Chizhevsky, 1938; Kondratiev, 1965; Vitinsky, 1983; Maximov, 1970; Yakovets, 1999; Melnik, 2016 and others [1, 5, 15, 17]. But despite on a significant amount of theoretical developments, today there is a need to expand theoretical and methodological research on the impact of the phases of the solar activity cycle on the production of winter wheat in the zonal section of Ukraine.

The main purpose of this research was to explore the influence of the phases of the solar activity cycle on the yield of winter wheat in agricultural enterprises.

To resolve this issue, 25 regions of Ukraine were selected with different spatial-temporal measurements and climatic conditions. In the structure of sown areas of cereal crops, winter wheat takes the leading place. Therefore, the issue of yield, as an indicator obtained from a unit area, is one of the most important in these studies. In addition, the yield is a relative effective economic indicator showing the state and development of the crop industry.

In order to research the impact of the phases of the solar activity cycle on the winter wheat yield, the physical-geographical zones of Ukraine were taken: Polesye, Forest-Steppe and Steppe. Natural conditions of zones are heterogeneous in geomorphological, climatic and hydrological aspects, which have different effects on crop yields.

As a known, all areas of crop production are under the influence on individual phases of the solar activity cycle. In particular, we are talking about the functioning of the abiotic component, which has an ability to influence on the crop industry. From this point of view, the complex studies by P. Melnik [5] confirmed the impact of the phases of the solar activity cycle on the yield of winter wheat. This research presented data that reflect the functioning of the properties of the phases, especially, which continuously and unevenly affect the change in the yields of this crop in a space-time dimension. This especially concerns the continuous production of winter wheat as the main food crop.

Changes in the yield of winter wheat in various zones of Ukraine was carried out for the period from 1955-2018. In assessing statistical data, the focus was on ranking indicators characterizing the pronounced effect of individual phases of the solar activity cycle on its productivity. To study the dynamics of changes in crop yields of winter wheat in the zonal section of agroecosystems, zones of Polesia, Forest-Steppe, Steppe were taken, and four phases of the solar activity cycle (growth, maximum, decline and minimum) were determined based on Wolf numbers by year.

MATERIALS AND METHODS

Theoretical and methodological basis of research is the general theoretical methods of scientific knowledge, the fundamental provisions of the theory of management and principles of the economy of nature management, scientific works of domestic and foreign scientists on the issues of nature use in agroecosystems. To accomplish this tasks, the following research methods were used: dialectical, abstract-logical, scientific generalization - in the study of theoretical, methodological and methodological principles of the phases of the cycle of solar activity; analysis and synthesis - to establish the essence of abiotic factors in agroecosystems; monographic - in the reasearch of the specificity of nature in the phases of the cycle of solar activity; settlement-analytical and economic-statistical - for conducting quantitative and qualitative analyzes of the state of production of agro-industrial products depending on the cyclic action of abiotic factors; system approach - in determining methodical approaches to assessing the state of winter wheat production in different phases of solar activity.

RESULTS AND DISCUSSIONS

The global agroecosystem environment is under the powerful influence of the phases of solar activity. Their impact is manifested in the unique physical processes taking place on the Sun, which are inevitable, continuous and cyclically repeating. During this period, it becomes necessary to take into account the regular effects of physical factors of nature on the yield of winter wheat, the indicators of which may vary in magnitude. From these data, it is possible to determine the clearly hidden effect of phases of the solar activity cycle on the efficiency of the plant industry in the zonal section of agro and ecosystems.

If during the process of studying the phases of the solar activity cycle, negative results are obtained, they are systematized with subsequent research. Based on the analysis, the possible yield losses, lost profit are determined and measures are being taken to stabilize the financial condition of the business entity in social production.

The most important in the research is the study of winter wheat yields in the zonal section of agroecosystems and the determination of the phases of the solar activity cycle for the period 1955–2018. It is here that comprehensive studies are carried out to improve conceptual approaches in the system of managing crop production, as well as to solve the problems of the global action of physical processes on agroecosystems. And also, it should be noted that the research of the phases, especially the variability of their magnitude in the dynamics, should be carried out taking into account the production indicators of winter wheat received per unit of harvesting area.

Earlier, the study of the dynamics of the development of the phases of the solar activity cycle of researchers interest has changed in the direction of their adverse effects on the yields of this crop. However, this most deserves the attention of a theoretical approach than it finds in practice. The reasons are clear - the production of winter wheat depends on the physical factors of nature, where signs of anthropogenic destabilization are manifested.

The most important features of the manifestation of these signs are in the functional criteria of indicators of destabilization of ecosystems, such as [11]:

-violation of ecological relations in all their diversity (material, energy, information);

-violation of the cybernetic mechanisms of ecosystem self-regulation, namely: low effectiveness of feedbacks that cannot fully perform a regular function, compensating for negative external impacts;

-reducing the degree of assimilation of energy subsidies (solar energy)

-reducing the wealth and availability of life-supporting components of the environment;

-low efficiency of use of resource components of the environment;

-imbalance of functional groups (producers, consumers of different levels, decomposers)

-weakening the environment of the conversion function of biotic components;

-violation of the trophic structure of groups;

-intensification of intraspecific and interspecific competition;

-restructuring a balanced configuration of ecological niches;

-going beyond the ecological tolerance of the main types of biotic grouping;

-reduction of biotic potential;

-an increase in the sensitivity of biotic components to the action of secondary factors;

-accumulation of toxicants in the body and habitat.

Despite the above, the research of the impact of the phases of the solar activity cycle on the yield of winter wheat in the zonal section of agroecosystems of Ukraine has been finished.

Growth phase

The research of the growth phase of the solar activity cycle is determined by the collection of indicators of W numbers (Wolff) and the yield of winter wheat. It is these indicators that are increasingly becoming important components of the socio-economic development of agroecosystem industries. The variation of the indicators of the number W makes it possible to establish the changes that occur in the growth phase and the duration of its development period. Obviously, the changes that occur in this phase are no less important than the statistical indicators of the yield of winter wheat per unit of harvested area.

This phase of the solar activity cycle contributes to increase in the yield of winter wheat in social production. During the analyzing the data obtained, it can be said that the indices of the number W in the phases of growth of the solar activity cycle for the period 1955–2008. fluctuate within 15.1–141 W, while winter wheat yield in the Polesia zone is 0.92–3.73 t / ha, Forest-steppe zones - 0.94–4.23 and Steppe zones - 1.22–3.44 t / ha. Also, each phase of growth over the study period has its own indicators of the number of W. This is due to the formation of various amounts of sunspots, which are formed as a result of an increase in the activity of the magnetic field and their total area.

The duration of the development phase of growth in the cycle of solar activity is two to three years. All this suggests that the period of its development depends on the occurring physical processes on the Sun. Therefore, to impart high specificity phases influence on the yield in the test culture period is determined and the number average value for the number W.

Long-term researchs for the period 1955–2008 showed a variation in the indicators of winter wheat yields in the zonal section of agroecosystems. The cyclical dynamics of the uneven distribution of the weighted average yield data of this crop in the spatial dimension are displayed in (Table 1).

Table 1. Dynamics of winter wheat yield in zonal section for the period 1955-2018

Spatial dimension	Phases of the solar cycle							
	growth		maximum		recession		minimum	
	q / ha	GJ / ha	q / ha	GJ / ha	q / ha	GJ / ha	q / ha	GJ / ha
Polesie	24.8	46.56	21.7	40.82	23.7	44.54	26.9	50.62
Forest-steppe	30.1	56.62	26.5	49.88	27.6	51.87	30.3	56.97
Steppe	25.9	48.71	25.9	48.76	24.2	45.22	24.3	45.74

Source: [5].

The data presented in Table 1 indicate favorable and unfavorable periods of the growth phase of winter wheat production in the zonal section of the solar activity cycle. Thus, the forest-steppe zone is characterized by a stable resultant yield indicator, which amounts to 30.3 q / ha. It should be noted that the steppe zone, where the winter wheat yield is less than the forest-steppe by 4.4 q / ha and is 24.3 q / ha, remain sensitive in the growth phase, and the Polesie zone, by 3.4 q / ha and 26.9 q / ha This is based on the different intensity of the impact of physical processes on the zonality of winter wheat production. The most negative impact is observed precisely in the Polesia zone.

Considerable theoretical and practical interest is the question of a study on the spatial influence of the phases of the solar activity cycle on the yield of winter wheat. For the study there were taken annual international sunspot number W and the number of statistical indicators of this crop yields over the period 1955 – 2018 years.

The study of this issue was carried out in a single phase in the areas of agroecosystems of Ukraine: the Polesie, Forest-Steppe zones and Steppe zones. As a result of the studied parameters, we obtained models that have the following form:

Phase of solar cycle maximum

Growth phase of solar activity cycle

growth phase of the Polesye zone

$y = -0.5557x^2 + 65.935x - 192.8$

$R^2 = 0.8959$; ....(1)

growth phase of the Forest-steppe zone

$y = 0.9369x^2 + 111.85x - 3,298.8$

$R^2 = 0.9816$; ....(2)

growth phase of the Steppe zone

$y = 0.0083x^2 - 1,889x + 68.001$

$R^2 = 0.8831$ ....(3)

Phase of solar cycle maximum

growth phase of the Polesye zone
$y = -0.0057x^2 + 1.6114x - 88.578$
$R^2 = 0.7753$; ....(4)

growth phase of the Forest-steppe zone
$y = -0.0075x^2 + 2.1616x - 122.99$
$R^2 = 0.8527$; ....(5)

growth phase of the Steppe zone
$y = 0.0066x^2 + 1.9141x - 108.55$
$R^2 = 0.8482$ ....(6)

Phase decline of the solar cycle

the decline phase of the Polesye zone
$y = 182.58x^{-0.518}$
$R^2 = 0.7384$; ....(7)

decline phase of the Forest-steppe zone
$y = 0.1567x^{-0.44}$
$R^2 = 0.7453$; ....(8)

the decline phase of the Steppe zone
$y = 76.128x^{-0.289}$
$R^2 = 0.6706$ ....(9)

Solar cycle phase of minimum

the minimum of the Polesia zone
$y = -0.0396x^2 - 0.503x + 39.386$
$R^2 = 0.9276$; ....(10)

the minimum of the Forest-steppe zone
$y = -0.0832x^2 + 0.1848x + 42.119$
$R^2 = 0.853$; ....(11)
the minimum of the Steppe zone
$y = -0.0513x^2 + 0.513x + 30.893$
$R^2 = 0.8326$ ....(12)

So, as a result of the described data, under certain conditions in a zonal section of agroecosystems, regression models of winter wheat yield are obtained.
Comparison of the values of winter wheat yields with phases of the solar activity cycle showed that there are a rather high relationship between indicated by the parameters (Table. 2).

Table 2. Summary results of the analysis of the coefficients of determination in regression models of the phases of the solar activity cycle, 1955-2018

Spatial dimension	Phases of the solar cycle			
	growth	maximum	recession	minimum
Polesie	0.8959	0.7753	0.7384	0.9276
Forest-steppe	0.9816	0.8527	0.7453	0.853
Steppes	0.8831	0.8482	0.6707	0.8326

Source: [2].

Phase maximum

The second phase - the maximum phase is characterized by the maximum number W, which depends on the spot-building activity on the sun. The duration of the phase is from one till two years. During the period under study, the phase of the solar disturbance maximum is repeated 5 times, with the value of indicators 104.0–190.2 of W numbers by graduation Yu. Vitinsky [15]. In the maximum, the coefficient of determination was within 0.7753–0.8527, solar activity 104–190.2 W numbers and winter wheat yield in the Polesie zone – 11.6–36.1 q / ha, Forest-steppe zones – 15.5–42.8 and Steppe zones – 16.7–39.8 q / ha.
The presented data of the developed regression in models of the phase of the maximum of the solar activity cycle show a significant influence of the phases of the solar activity cycle on the production of winter wheat. The obtained coefficients of determination of regression models of the phase of the maximum cycle of solar activity has been reflected in Table 2, and confirmed the close relationship of yield with the maximum value of indicators of the number W. However, a zonal variation in yield is observed. Thus, the winter wheat yield in the Polesia zone is higher compared to the growth phase by 3.1 q/ ha, in Forest-Steppe - decreased by 3.6 q / ha and in the Steppe zone increased by 1.3 q / ha. The results of our research show that the maximum phase of the solar activity cycle is not always favorable for

the production of high yields of winter wheat in the Forest Steppe zone, but results in its increase in the zones of Polesia and the Steppe of Ukraine.

Recession phase

The phase of the decline of the solar activity cycle in the space-time dimension is also clearly distinguished. For the study period 1955–2018 . the duration of the phase is three to four years, with a repeatability of five times and a value of indicators 15.2–159.0 W. The coefficient of determination in models is calculated and ranges from 0.6707–0.7453 (Table 2). The winter wheat yield over the study period in the dynamics of the years is in the Polesia zone – 13.1–46.0 q/ha, Forest-steppe – 16.3–47.3 and the Steppe zone – 9.3 – 34.2 q/ ha.

As can be seen from Table 2, the coefficients of determination in the regression equations are 0.6707–0.7453, which is evidenced by the close connection between the yield of winter wheat and the decline phase of the solar activity cycle . Also admitted a variegation of winter wheat in a spatially-hour measuring table 1, of which varies by zones. Thus, the average yield in the Polesia zone is 23.7 q/ha, Forest-steppe – 27.6 and in the Steppe zone – 24.2 q/ha. These calculations showed that the winter wheat yield in the decline phase of the Polesia zone, compared with the maximum phase, is 1.1 q/ha higher, the Forest-steppe – 2.5 q/ha and decreased in the Steppe zone by 1.9 q/ha.

Phase minimum

It is characterized by the minimum value of solar activity . The duration of the phase is from two till three years with a repeatability in the study period five times and a score of 2.9–27.9 Wolf numbers. The coefficient of determination in regression models is 0.8326 (Table 2). The winter wheat yield in the phase at least for the period studied in the years section is in the Polesia zone – 13.7–47.0 q / ha, Forest-steppe – 14.0–46.9 and the Steppe zone – 12.3–34.7 q/ ha.

In addition, it should be noted that the coefficients of determination in regression models indicate a high degree of connection between the winter wheat yield and the minimum phase of the solar activity cycle . There is a change in the average wheat yield winter in the zonal hourly measurement table.1. So, in the Polesia zone, it is 25.4 q/ha, Forest-steppe – 30.0 and in the Steppe zone - 24.3 q/ha.The results of the analysis show that the winter wheat yield in the minimum phase of the Polesia zone is higher than the decline phase by 3/2 q / ha, the Forest-steppe – 2.7 q/ha and decreased in the Steppe zone by 0.1 q/ha.

A significant difference in the yield of winter wheat is observed in the minimum phase between the zones of Ukraine. Comparative characteristics of indicators of wheat yield in the winter zone of the Forest-steppe showed that it is significantly higher compared to the Polesia zone by 3.4 q/ha and Steppe zone by 6.0 q/ha. The yield of the Polesia zone compared to the Steppe zone is higher in 6 q / ha (Table 1).

From a global perspective on the production of winter wheat in the zonal space-time dimension impact phase of the cycle of solar activity, which should not be overlooked in all management decisions. Not taking them into account now and in the long run will lead to significant fluctuations in the yield of this crop. This is shown in Fig. 1.

An important aspect of understanding the nature and direction of the processes of phases solar cycle is the consideration of such exposure parameters as frequency (constant, unpredictable effects) and intensity. To a certain limit, the influence of destabilizing factors of the phases of the solar activity cycle can be neutralized by the action of evolutionarily developed mechanisms of natural self-regulation. However, in some cases (when the negative influence of the phases of the solar activity cycle is excessive in duration, scale or intensity) the functional potential of these mechanisms is insufficient . In the case of the primary natural system, which is an important structural and functional components agroehkosistem legally quantitative conversion into qualitative changes, enters one of the destabilizedvariant s status as individual components and system [1, 3, 5, 7, 10, 11].

It should be noted that when performing research, quantitative and qualitative indicators of the cycle phase are formed. solar activity that are able to interact with other factors [6, 12, 13].

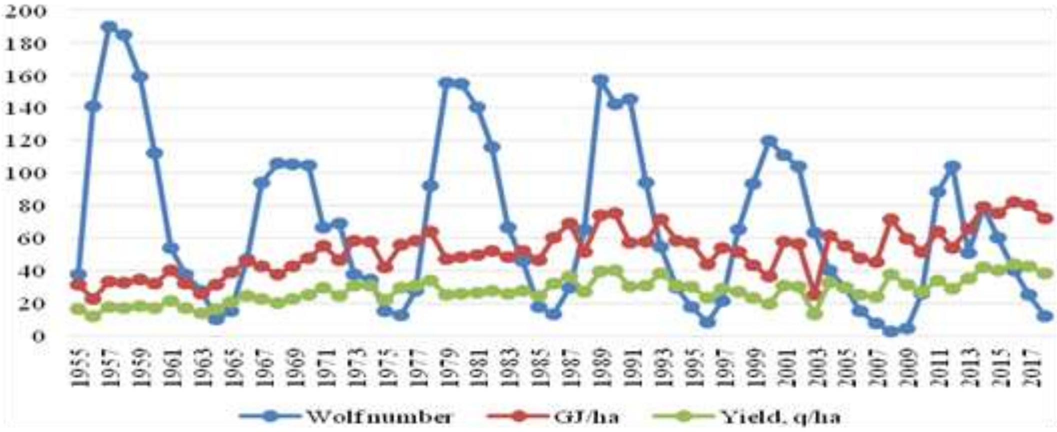

Fig. 1. Dynamics of productivity of winter wheat for the period 1955–2018 of Ukraine
Source: [5].

Therefore, define indicators in space-time dimension. By analyzing this data, you can determine to what extent it affects the efficiency of production of winter wheat, including the timely implementation of thosehnologicheskih operations, saving material and technical resource and others.

It is important to study the manifestations of "negative" effects that create side effects for sectors of agriculture. The data obtained during this period must be taken into account when planning the production of agricultural products.

Ecological and economic assessment of the influence of solar activity phases on the production of winter wheat in an agroecosystem

At each stage of its development, agricultural production presented science with fundamentally new approaches to solving problems. Now an important and far unresolved issue is the problem of the impact of the phases of the solar activity cycle on agroecosystems, which should be taken into account in crop production. This is one of the important components of the system of environmental-economic management, complex in structure and in the space-time dimension. Most of the decisions made by the management system regarding the influence of the phases of the solar activity cycle on the economy of agricultural production were ignored.

As noted V. Volodin [16] Numerous attempts to improve farming have failed, in our opinion, due to the lack of criteria for evaluating this improvement from the point of view of fully taking into account the objective laws of the development of society and nature, above all the law of compliance with environmental safety and environmental expediency. Therefore, from this point, the exclusive attention of researchers should be directed. It is precisely in the course of the operation of the management system that it creates immediate step-by-step transformation risks in the development of material,technical, environmental, economic, financial and other means in the production sectors. .

Now, the problem of the influence of the phases of the solar activity cycle on agroecosystems remains little studied in the areas of production economics . This problem is extremely complex and covers many different aspects . Especially in making management decisions on the effective use material and natural resources . Acting in a comprehensive manner, they reflect the productive activities of agro-ecosystem industries by type of production. At the same time, they have inherent individual characteristics that characterize an objective knowledge of the interaction of human social production with nature.At the same time, natural makrofizich EQF s factor of the solar activity cycle phases may adversely affect the level of harmony that creates a variety of productive indicators of economic efficiency of agro-ecosystems.

F. Ken, A. Marshal [2] noted that the source for human wealth is not only and not so much the additional cost according to Karl Marx, as the result of the Sun, whose energy quanta through plants, soil and microorganisms turn into food. F. Kene proposed distribution of the resulting product for the year in the community according to his calculations 2/5 of this product should be returned to the earth is, in order to maintain her fertility, 1/5 to the needs of farmers, 1/5 on the processing industry (in modern parlance -. in food th industry) and 1/5 for the needs of the state.

The economic efficiency of industries in the production of agricultural products is an integral part of agroecosystems as a whole. This is achieved by the rational use, reproduction and conservation of natural resources, as an important factor in obtaining high profits in production. However, the performance indicators of economic entities depend not only on the use of material and technical resources, but also on the effective action of natural geophysical factors, which are adjusted in accordance with the phases of solar activity cycles, despite the fact that the system of environmental and economic management of human activity controlled by.

No modern technology is able to contain the negative influence of the phases of the solar activity cycle. An example is the depletion of large areas of agricultural land, prolonged droughts and you fall intensive rainfall and others. Currently, the management system still does not take into account natural factors, especially space factors, in the space-time dimension of production. In particular, affecting the effective indicators of economic efficiency in the process of production of winter wheat grain.

According to the results of our research (1955–2018), we have proposed a model for determining the economic effect in the process of winter wheat production, taking into account the action phases ofsolar activity cycles [5]:

$$[Y_a \cdot S \cdot P - (\Sigma T_a + \Sigma T_e)] + [\Delta Y \cdot S \cdot P - (\Sigma\Delta T + \Sigma\Delta T'_r)] \rightarrow \max, \quad \text{.............(13)}$$

where:

Y_a – the average crop yield in the phase of the solar activity cycle, q/ha;

S – is the harvesting area, ha;

P – the unit price of the crop, UAH/q;

ΣT_a – the average amount of total expenses in the phase of the solar activity cycle, UAH/ha;

ΣT_e – the sum of expenses for the reproduction of eroded land resources, UAH/ha

ΔY – additionally harvested crop, q/ha;

$\Sigma\Delta T$ – the sum of expenses for the reproduction of eroded land resources, UAH/ha;

$\Sigma\Delta T'_r$ – the sum of expenses for reproduction of eroded land resources, additionally obtained crop volume, UAH/ha;

q – quintal (= 100 kg).

The presented model is used to calculate indicators of the economic effect of winter wheat production during the phases with the highest yield levels in the agroecosystem. The duration of such a period in production depends on the nature of the physical transmission processes on the sun, where there are changes solar cycle phases.

Level of average crop yield in the phase of solar activity cycle, t / ha:

$$(Y_a \cdot S \;\; P) - \Sigma T_a \rightarrow \bar{x}, \quad \text{..................(14)}$$

The second model is used to calculate the economic effect of winter wheat production with low yields of the current year, in comparison with the previous or average yield for the last two to three years of the same phase. This applies to phases with unequal duration of years in the cycle of solar activity.

$(Y_a \cdot S \cdot P) - \Sigma T_a \rightarrow \min$ ....(15)

This model reflected the phases of the solar activity cycle with unfavorable conditions for the production of winter wheat. It was established that this period is characterized by a sharp decline in yield and unprofitability of its production. An example is the year 2003, where the average yield of winter wheat was 13.6 q/ha in Ukraine. This is why, it is important to correctly assess the damage in individual manufacturing sectors, as well as to foresee their consequences in the future.

It should be noted that it is extremely important to obtain the achieved economic effect from the production of winter wheat. Analyzing the yield in the dynamics for the study period, it should be noted that it is physically related to the phases of the solar activity cycle , which have different effects on the size of the economic effect. In essence, this is a comprehensive integrated criterion for assessing the economic effect in agroecosystems, which is a function of individual quantitative and qualitative indicators of the phases of the solar activity cycle in the production of winter wheat.

Because in the real world most of the management decision-making is based on a comparison of data related to product manufacturing income, there is a question of formation approach to the process of evaluating the cost-effectiveness of the sectors of agriculture's zyaystva [4, 17].

From economic point of view, especially on the issue being studied, indicators of economic efficiency in branches of agriculture are the amount of profit and level of profitability. From their objective assessment depends on the rhythm of the industry. However, the magnitude of these indicators is affected by a significant number of factors that are of great scientific and practical importance. From an economic point of view, the unit cost of production of agricultural production plays a big role . So, according to the method D.N. Parmacli the cost per unit of production is determined by the formula [8]

$Z = FC/q + AVC$, q/ha ....(16)

where:

FC - is conditionally fixed costs per 1 ha, UAH;

AVC - variable costs per 1 ton of products, UAH.;

q - yield, q / ha.

The next stage in determining performance indicators is profit, the value of which depends on the influence of physical phenomena of the phases of the solar activity cycle on winter wheat production processes and, as a result, a significant growth or unprofitability of the economy of the crop industry in a whole.

Due to determine the indicators of the efficiency of winter wheat production in different phases of the solar activity cycle, we have proposed an algorithm for calculating profits (P) from the sale of grain per unit area and unit of production. The definition of this indicator is carried out according to the methodology [9], followed by its improvement, by means of the formulas presented below:

$G = y(p - AVC) - FC$, UAH/ha; ....(17)

$G = p - Z = p - AVC - FC/q$, UAH/q.......(18)

Accordingly, the increase in profit per unit of the harvested area depends on the increase in yields in the phase relative to the base (average annual yield in the phase of the solar activity cycle over the study period:

$\Delta G_3 = (p - AVC) \cdot (q_b - q_n)$, UAH / ha, ...(19)

where:

q_b - base yield, q/ha;

q_n - yield phase of the cycle, q/ha

As a result of the research, changes in the yield gain of winter wheat between the phases of the solar activity cycle were found. Therefore, when establishing an additional profit or loss for the production of winter wheat per hectare between phases of the solar activity cycle , is determined by the formula:

$\Delta G = (p_n - p_b) - \Sigma B_n$, UAH/q, ...(20)

$\Delta G = [q_f \cdot S \cdot (p_n - p_b) - \Sigma B_n]$, UAH/ha, ...(21)

where:
q_f - additional yield in phase, q/ha;
p_n - new purchase price, UAH/q;
p_b - the basic purchase price, UAH/q;
ΣB_n, - total expenses in the phase of solar activity cycle, UAH / q, UAH / ha.

These approaches in research have sufficient theoretical and practical importance in agroecosystems. The proposed process of studying the interaction of the phases of the solar activity cycle and the efficiency of winter wheat production opens up more realistic possibilities for improving the management system. Now this interaction leads to continuous improvement of social production processes with the spatial and temporal action of the physical factors of nature. Therefore, the objective and the optimal test winter wheat economic efficiency of production can be obtained in dependence on the period of the vital cycle phases of solar activity.

The study of the influence of the phases of the solar activity cycle determines the search for optimal management solutions to maximize the development of the economic activities of the agricultural production sectors. Accordingly, the ability to predict a decrease in the maximum allowable level of production, its output in terms of value per hectare of land area and compare the results of activities of business entities. The criteria for economic evaluation of efficiency in the phases of solar activity are price, profit, profitability, and others.

CONCLUSIONS

The research shows that the production of winter wheat in agro-ecosystems depends on the state of the development phases of the solar activity cycle. Since each phase is individual, unique, has its own characteristic features on the impact on the yield of this crop , there is a need to improve the management system of its production in the zones of Polesia, Forest-Steppe and Steppe of Ukraine.

The theoretical and methodological concepts about the phases of the solar activity cycle showed that there are solutions to the problems in the crop industry that overlap each other, having a reciprocal resonating effect that affects the efficiency of agro-ecosystem industries of both the separately considered region and the country as a whole.

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