Increasing the technological and economic efficiency of nursery production based on processes biologization*

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Abstract. The necessity of reformatting the structural organization of processes, which determines the priority of using the ways, forms and methods of the sixth technological structure, in particular, biotechnologies is actualized. The main definitions are given: nursery, biologization, greening, resource saving, promising technology. The analysis of the efficiency of sapling fruit production, the structural organization of specific processes for the production of planting material and sapling is presented. The main elements of the agrocenosis, which are most susceptible to chemical and technogenic effects, have been determined. The analysis of soil fertility and the state of soil biota is carried out, the problem of microbiological processes branch in all agrocenosis elements is actualized. It was found that the increased chemical load on the agrocenosis of the fruit nursery led to the destruction of microflora useful species. The nature of plant organs infection has changed, and negative changes have occurred in the plants immune status. The priority role of biologization in ensuring the stability of the fruit nursery agrocenosis has been substantiated.

The worldwide practice of scientific and technological progress is implemented in the spatio-temporal framework of a particular technological structure***, which is characterized by modern features and strategic type of machines, technologies, of organization forms, etc. In turn, the technological structures are consistent with the waves (short, medium, long) of scientific and technological development of social and economic formations.

The wave-like dynamics of social and economic development, the change in the forms and methods of transforming the subject of labor impose the special requirements to the organization format of a particular system, to the need its constant improvement –

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*** The technological structure is characterized by the level of sectoral production, the structure and content of objects of labor.

development, that is, the structural organization, forms, ways and methods should be transformed adequately to changes in the social and economic environment and technological structures [1].

As a retrospective analysis of domestic scientific and technical achievements in technological structure shows, the fruit growing industry produces the products of the fourth technological structure (the period of dominance until 1980) with individual elements of the fifth technological structure (the period of dominance 1980-2030) and the sixth technological structure (the beginning of distribution 2005). This is due to the state of the productive forces.

The change in technological structures make actual the need to reform the structural organization of processes, adjust their tasks, the key positions of which should be the development of scientific and technical production ensured the technological development by the ways, forms and methods of mainly the sixth technological structures: bioinformatics; biotechnologies based on molecular biology and biochemistry and genetic engineering; the artificial intellect systems.

There are the strongly pronounced specificity of fruit growing: the fruit agrocenosis is quite static during exploitation period and in location. Physiological, biochemical and other processes in the agrocenosis are in constant development depending on its design, age characteristics, climatic manifestations, etc., which makes it necessary their constant study to develop the preventive measures to maintain the agrocenosis in a high-yielding state and prevent epiphytoties, etc. [2-4].

In fruit growing, a significant change in the parameters of the agrocenosis design elements (change in the technological structure) occurs at the age of 25-30. By this time, it should be the accumulation of necessary and sufficient knowledge.

The existing technological structure determines a set of conditions for achieving and maintaining the competitiveness of production by improving the technologies focused on exceeding their previous counterparts in terms of quantitative and qualitative result indicators.

The developed promising technologies[*] in the format of emerging technological shifts actualize the solution of problems with new methods and ways, such as *greening*[**], *biologization*[***] and *resource saving*[****] of the whole technological processes. This, in turn, forms a list of necessary properties and signs that the plant and variety will have to possess:
– high environmental plasticity-adaptive potential, a large range of immune resistance to abiotic and biotic stress factors, reproductive potential that is realized at a high level under various stressors, as well as a number of specific features due to the further technologies development [5].

The signs of a promising technology are indicators of technological and economic efficiency as a reflection of the effects formed in a specific functional area.

Technological and economic efficiency – a set of technological and economic effects in relation to natural (natural and economic) and financial and material costs.

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[*] ***Promising technologies*** – technologies capable of ensuring the competitiveness of production for a certain extrapolated period.

[**] ***Ecologization*** **–** the process of restoring the reproductive capabilities of ecosystems, increasing their sustainability.

[***] ***Biologization*** **–** is the most complete involvement in the reproduction processes of natural biological resources and increasing the biological potential of plants themselves through modern methods, including selection.

[****] ***Resource saving*** **–** is a set of methods, methods, and means of relative optimization of resource costs for production, as well as the release of resources involved in the production or replacement of one resource with another (non-renewable) in order to increase economic and environmental efficiency.

In nursery keeping, the technological efficiency evaluates the production obtained in relation to the normatively established quantitative and qualitative indicators of the fruit nursery, and economic efficiency gives a volume-cost estimate of the products produced in relation to the costs of its obtaining.

Nursery keeping – the basic subsystem of fruit growing, providing getting the certified planting material (laying, cuttings, seedlings, root suckers, seeds, rootstocks, winter grafting, saplings obtained by means of vegetative or seed propagation) and the production of grafted fruit saplings crops, berry plants of the highest quality categories, meeting the phytosanitary requirements and quantitative and qualitative characteristics of national standards.

Analyzing the production efficiency of fruit saplings, it should be noted its significant decrease. So, for the period 2008-2019 the saplings production cost increased from 21 rubles / piece up to 116 rubles / piece or by 5,5 times, the selling price for the same period increased from 62 rubles / piece up to 180 rubles / piece or by 2,9 times. The coefficient of outstripping the cost price growth is 1,9 times higher than the increase in the selling price, as a result of which the production profitability decreased from 194 % in 2008 to 55 % in 2019.

The decline in production efficiency is due to the outstripping dynamics of growth in production costs than the growth in sale price, and a decrease in the purchasing ruble power.

Along with a decrease in production efficiency due to macroeconomic processes, an increase in the chemical and technogenic load on agrocenoses in nursery should be noted: – an increase in the volume of mechanized work by 12,2 % (from 65,6 machine-hour / ha in 2010 up to 73,6 machine-hour / ha in 2019) and pesticide load by 9,8 % (from 27,4 kg / ha in 2010 to 30,1 kg / ha in 2019).

The nursery, as main point, is a set of elements organized by specific agro-technological processes aimed at the production of planting material and fruit saplings of higher quality categories: the selection of initial breeding material, the identification of varietal identity; testing plants phytosanitary state, improvement of initial material, cultivation of plants of origin category; creation and cultivation of the uterine stick garden, uterine seed garden, plantations for growing the vegetative propagated rootstocks, schools of seedlings, plots (fields) for growing; plant protection against diseases and vermin's; varietal testing of rootstocks and saplings of fruit crops in the nursery, certification of planting material and saplings [6, 7].

A significant change in the agrocenoses structural elements, associated with the intensification of production processes, causes both positive and negative aspects of reproduction.

The most significant negative manifestations of anthropogenic intensification against the background of changing abiotic and biotic factors are: violation of the nature management rationality in agrocenoses and the ecological balance[*****] of agroecosystems [8, 9].

In nursery, as well as in fruit growing in general, the main elements of the agrocenosis are most susceptible to anthropogenic impacts – soil and soil microbiota, microbio-, acaro- and entomosystems of ground part, cultivated and propagated fruit plants.

Prolonged cultivation of perennial plantations on different soils types has revealed the general regularities of agrocenoses state: a decrease in the content of organic matter and total humus in the soil, a decrease in the thickness of humus horizons; the predominance of mineralization of organic matter over humification processes; decrease in the content of basic nutrients; soil pollution with pesticides; deterioration of the agrophysical soil properties; violation of microbiological processes and increased soil toxicity [10].

[*****] ***Ecological balance*** – the balance of natural or human-modified environmental components and natural processes that lead to a long (conditionally infinite) existence of this ecosystem

In addition, the toxic chemicals inhibit the microorganisms and the vital activity of soil mesofauna, reduce the activity of adaptive enzymes in the soil biochemical processes, which negatively affects its restorative and cleansing properties. The migration of soil toxicants in the ecosystem of agrocenoses reduces the resistance of plants to damage by harmful objects, which leads to an increase in the chemical and technogenic load (Vorob'eva, 2018).

A decrease in the humus content in chernozems ordinary to three or less percent, which is unusual for them, refers them to low-humus soils, and the soil deprivation of the labile humus significant part, provided the plant with nutrients and physiologically active substances, not only reduces the nitrogen supply to the soil and accelerates its mineralization process, but also significant impact the productivity and growth processes.

In the samples analyzed annually, the content of pesticide residues is found in more than 50 % of soil samples, where the hygienic standards were exceeded by 1,3-5,1 times.

The increase in the volume of the soil mass (compaction) in the upper 20 cm layer is 1,42 g / cm^3 in the row-spacing and 1,6 g / cm^3 in the rut row-spacing.

Chemical and technogenic impacts have been led to a sharp deterioration of soil agrophysical properties – loss of structure, formation of lumps during processing, drenching and a decrease in the water resistance of aggregates under the influence of moisture, and a decrease in soil biogenicity.

Violation of microbiological processes reduces the number of primary destructors of organic matter and saprophilic fungi, and increases in the amount of actinomycents produced the phytotoxic substances which increase in soil toxicity and soil fatigue.

Modern and promising technologies aim, first of all, to create the conditions for a plant to realize its properties and characteristics in terms of the functionality of physiological manifestations, that is the fundamental basis for the plant interaction with other agrocenosis elements (Egorov, 2013).

The state of the agrocenosis, the level of the plant's reproductive potential and chemical-technogenic effects, which are interrelated, make actual the need to intensify processes mainly by biological methods.

Greening is the process of restoring the ecosystems reproductive capabilities, and *biologization* is the ways of achieving environmental and economic efficiency.

As a result of significant technogenic impacts the natural mechanisms in the field of biosystems ecology, the problem of reducing the activity and biogenicity of the soil arose. For the preservation and restoration of soil fertility, the methods are being carried out to stimulate the development of rhizosphere symbiotic and associative microorganisms.

The interaction of plants with beneficial microorganisms has an important meaning, since specific relationships develop between them and productive relationships with great number of functional manifestations are determined [11-13].

The modern biological preparations, created with the effective strains of beneficial microorganisms, are used to ensure the vital activity of various and, first of all, the main components of agrocenoses, to increase the efficiency of reproductive processes.

Rhizosphere microorganisms increase in soil fertility, normalize plant viable, neutralize the phytotoxins, reduce soil fatigue, maintain the biodiversity of useful soil microflora of agrocenoses, transforming root fall into humic substances, maintain balance and reproductive capacity of the soil.

Soil bacteria produce the substances with fungicidal or fungistatic properties against phytopathogenic fungi and other plant diseases, protecting them from phytopathogenic microflora and vermin’s.

The use of a significant amount of chemical agents in plant protection and crop protection systems, of the regulations violation for their use, has made the problems: the depletion of agrocenoses due to the destruction of useful microflora species, which has led to stability violation of microbioacaro and entomosystems, a change in the nature of plant organs

infection; negative changes in the immune status of cultivated and propagated plants, as well as the appearance of more resistant strains of phytopathogens and vermin's species [14].

Climate changes also cause the changes in the series of processes occurring in the biosphere – the formation of life forms adapted to new abiotic conditions, the harmful organisms acquire the new features, create a different cycle of interaction, providing not only a way to survive in the changed conditions, but also adverse effect the environment.

In nurseries, there is an increase in the species composition of vermin's, primarily due to uncontrolled import of planting material from abroad, with objects of external and internal quarantine; the import of previously harmful vermin's and aggressive races of vermin's known in Russia. Recently, almost the whole imported planting material contains pathogens that cause the death or oppression of plants when the planting material is cultivated in the nursery, as well as infect the plants and soil in the nursery. This is especially concern to specialized pathogens, root rot pathogens. The most pathogens can be present in the purchased planting material in a hidden (latent) form and manifest only a few months after planting in the nursery, which makes it difficult to diagnose them early. There are: common European cancer, which can be introduced with grafting cuttings for oculation, it affects the organs of the aboveground system of the plant; root cancer; from vermin's – *Helicoverpa armigera* Hubner, *Geometridae* Leach, *Tortricidae* Latr., *Acrolepiidae* Hein. (Podgornaya, 2020).

The lack of spatial isolation in the nursery for horticultural and ornamental crops leads to an increase in the number of stem vermin's on saplings of fruit crops, the same picture is observed when a nursery is laying near forests [15].

Currently in nurseries there is an increase in the invasion of new species: – *Metcalfa pruinosa* (Say), *Anarsia lineatella* L., *Ricania japonica Melichar*, *Halyomorpha halys* Stål, etc.

As a result of phytosanitary monitoring of some nurseries, it was revealed that when growing the pear saplings, the *Psylla pyri* L. are the main problem (imago, larvaes and egg-laying were noted on whole saplings). On stone fruit crops (sweet cherry, cherry, peach) – *Clasterosporium carpohilum* Lev. and *Prunus necrotic ring spot ilarvirus*. On apple saplings – *Podosphaera leucotricha* Salm. (from 1 to 3 points); *Aphis pomi* De Geer and *Dysaphis mali* Ferr. (settler and beginning of larval hatching). Aphids are dangerous because they carry viruses to healthy saplings and seedlings.

Changes in the temperature regime and moisture supply, as well as the use of mainly chemical means of protection against vermin's are the main factors of increase in the harmfulness of phytophages and damage to the plants.

The manifestations of chemical pollution of the environment are: adaptation of phytophages to changes in abiotic factors; changes in the life cycle of dominant vermin's and a decrease in their sensitivity to insectoacaricides; the beginning of the greatest harmfulness period of species number and an increase in their harmfulness; the appearance of new species; changes in the species composition of harmful insects and mites.

The analysis presented above states that further production intensification and rationality of nature management should be achieved by means of biologization – the gradual substitution of chemical pesticides applied for biological preparations, microbiological agents, preservation and creation of a large number of mechanisms and structures of self-regulation, control of the dynamics of harmful and useful objects, as well as their adaptive reactions.

The use of a biologized system of planting protection forms a number of technological, environmental, economic effects, manifested in the growth of environmental and economic efficiency.

This, in its turn, requires the identification and study of the pathogens adaptations, the features of the spatio-temporal development of mycopathocenosis components and

connections during the formation of fungal populations in agrocenoses ecosystems, the study of the ecosystem's resistance to the stress effects of xenobiotics, knowledge of the translocation processes and metabolism of pesticides in biological systems and other objects of external environment.

The solution of the related scientific and practical problems should be based on knowledge obtaining about the evolution of the species composition of agrocenoses entomo-, acaro-, pathosystems, trends and regularities of their formation; the mechanisms of the plants immune-genetic system activity in relation to pathogens and the integration of oligogens that control the specific plant resistance to various physiological races of pathogens; transcription analysis of the gene regulation in the pathogenic microorganisms; disclosure of self-regulation mechanisms of biosystems in agrocenoses, biotransformation of pesticides and metabolites translocation in the plants.

It is necessary to find and use the new unconventional fungicides and microbiological agents, work out the regulations for the alternation of fungicides with different mechanisms of the pathogen effect, the use of microbiological preparations and their combinations.

The sharp continental climate of the last decade has led to an imbalance in biological cycles of plant development, their weakening, and increasing in meteostress damage. The increasing volume of the use of preparations of chemical origin and their accumulation in trophic connectons led to a violation of the biological balance in the agrocenoses ecosystems, became an additional damaging factor to plants, created the prerequisites for a decrease in their immune status and made the obstacles in the realization of their production potential.

In some nurseries of fruit crops, the excessive foliar treatment of saplings with fertilizers and growth regulators is often observed. As a result, undeveloped root systems are formed in the saplings, which leads to subsequent problems in their survival and growth, and to the massive development of parasitic fungi and bacteria in the crown (against the background of excess nutrition), that requires an increase in the number of pesticide treatments. The negative consequences are formed: – washout of non-assimilated fertilizers into the soil and the subsequent growth of unusual flora (blue-green algae), which significantly make worse the quality of the soil and further pesticide pollution of the environment (Kuznetsova, 2020; Buntsevich, 2018).

Negative manifestations of a technogenic nature in agroecosystems actualize not only the ecologization aspects, but also focus on the possession of a plant (variety) of a group of specific traits that allow the plant to be not only resistant or tolerant to stress factors, but also to ensure through the agro-technological regulations, a decrease in the level of technogenic impacts the agrocenoses.

Immunity is the quality of living organisms to prevent the penetration of alien molecules into the cells of organisms, to recognize them, destroy and remove them from the body; an integral system designed to protect the organism from any harmful factors and influences (Arcehovskay, 1963); the ability to maintain its integrity and biological individuality, to maintain the stability of the relationship between phytophages and their host plants (Shapiro, Vilkova, 1986).

The main direction the problem solving of reducing plant immunity, as well as reducing the chemical pressure of agroecosystems, is the creation (breeding) of varieties with a high level of specific resistance.

The method of immunity induction is used to reduce the stress toxic effect of chemicals and increase in plant resistance to phytopathogens damage (Nenko, 2015).

For ensuring the sustainability of agrocenoses, reducing the level of chemical and technogenic impacts the agroecosystems, leveling the negative manifestations caused by these effects, the priority role is given to *biologization*, as the «main expression of ecologization» (Kiryushin, 2012), as well as the use of living organisms, their systems and their products in solving the technological problems, that is, the most complete involvement

in the reproductive processes of natural biological resources and an increase in the biological potential of the plants themselves through the modern methods, including breeding, primarily by biotechnological forms, ways and methods based on molecular biology and biochemistry, genetic engineering; the introduction and large use of modern biological agents alternative chemical pesticides; the use of bioagents in order to preserve and develop the structures and mechanisms of self-regulation; the use of new biologically active preparations to improve an efficiency in controlling the genotype expressiveness, expanding the boundaries of plant tolerance and their stress resistance; ecological regulation, increasing the soil fertility and biogenicity by stimulation of rhizosphere microorganisms development and returning organic matter to the soil; biosynthesis of fungistatic substances in the plants.

In the modern view, the *biotechnology* is the industrial use of biological processes and agents based on the production of highly efficient forms of microorganisms, cell cultures and plant tissues with desired qualities.

A biological process is a process in which genes and their products are involved, and it is completed through one or many ordered of reactions series and carried out using the biotechnological instruments – genetic engineering methods, at every level of organization of living nature, including the formed agrocenosis of a fruit nursery: – molecular (biochemistry), cellular (cytology), organismic (physiology), population (ecology).

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