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THE INFLUENCE OF SOIL BACKGROUND OPTIMIZATION AND FOLIAR TOP DRESSING ON PHYSIOLOGICAL AND BIOCHEMICAL PROCESSES IN PEAR TREES OF TAVRIISKA VARIETY

Представлені результати досліджень щодо впливу оптимізації ґрунтового фону і позакореневого підживлення на фізіолого-біохімічні процеси в дерев груші сорту Таврійська. Польовий дослід закладений в 2015 році за двофакторною схемою в трикратному повторенні за наявності восьми облікових дерев на кожній елементарній ділянці. Перед закладанням досліду агрохімічними аналізами ґрунту було виявлено вміст рухомих форм калію на 46 мг/кг менше від середнього показника оптимального рівня, а нітратного азоту (за нітрифікаційною здатністю ґрунту) і рухомих сполук фосфору – більше оптимальних рівнів. Для оптимізації ґрунтового фону розрахована і внесена норма K_2O – 598 кг/га і таким чином був створений оптимізований фон мінерального ґрунтового живлення груші усіма трьома основними макроелементами (NPK).

Схема дослідження включала два рівня вмісту в ґрунті доступних для рослин сполук і форм азоту (N), фосфору (P_2O_5) і калію (K_2O): не оптимізований (без ґрунтового удобрення) і оптимізований внесенням розрахованих за результатами агрохімічних аналізів ґрунту добрив тих макроелементів, яких не вистачало в кореневмісному шарі ґрунту (0-60 см) до оптимальних рівнів (фактор А) і чотири варіанти позакореневого підживлення: 1 – без підживлення (обприскування листового покриву водою), 2, 3 і 4 – обприскування розчинами удобрювальних препаратів, відповідно: Реаком плюс (сад-город) – 5 л/га, Вуксал Мікроплант – 3 л/га і Біохелат «Плодово-ягідні культури» – 3 л/га (фактор Б). Зазначені дози препаратів розчиняли в розрахунку 1000 л розчину на гектар саду.

За достатніх рівнів вмісту доступних для рослин сполук азоту та фосфору в чорноземі звичайному (значно перевищують оптимальні для яблуні) і недостатнього живлення калієм (нижче оптимального вмісту його обмінних форм на 46 мг/кг ґрунту) внесенням розрахованої норми K_2O 598 кг/га створився достатній рівень живлення дерев груші цим елементом і загальний оптимізований фон їх мінерального живлення головними макроелементами (NPK), який підтримувався протягом усього трирічного періоду досліджень.

На оптимізованому фоні ґрунтового живлення досліджуваних дерев головними макроелементами (NPK) встановлено, що фізіологічний стан і стійкість до несприятливих погодних умов у дерев груші покращилися. Істотно великим накопиченням хлорофілу в листі відрізнялися дерева на оптимізованому ґрунтовому фоні, оброблені препаратом Вуксал Мікроплант – 9,87 мг/100 г. Більше накопичення суми цукрів відбувалося у дерев, що знаходяться на оптимізованому ґрунтовому фоні і позакоренево підживлені препаратом Вуксал Мікроплант – 4,0 мг/г.

Ключові слова: груша, сорт Таврійська, удобрення, позакореневе підживлення, оптимальний рівень, хлорофіл, вуглеводи, суха речовина.

Introduction. Pear, despite its extremely high flavor and consumer qualities, is spreading too slowly in gardening. One of the reasons for this is the existence of a problem in the study of fertilizer application systems in horticulture, which was previously most often used in apple plantations. The recommendations for their fertilizing apple orchards were given together for pears, as the closest to the biological and technological features of the culture. However, the pear is still markedly different in the needs of mineral elements, in particular with the growing masses of vegetative organs and the formation of fruit crops, as well as the relation to external environmental conditions, which must be taken into account for the production of fertilizers with optimal parameters for its nutrition. But even at the optimal levels of soil nutrition, there can be a lack of individual mineral elements for their intensive assimilation during certain periods of growth and development of fruit trees, which negatively affects the physiological and biochemical processes in the plant. Therefore, it is important to study the possibilities of enhancement of these processes by foliar application in addition to the main soil fertilizer, which creates optimal backgrounds of mineral nutrition of trees through root systems.

Analysis of research and publications. Pear is one of the most common fruit crops, in which, in selecting varieties that are most suitable for cultivation in specific soil-climatic conditions, it is necessary to take into account not only high productivity but also the ability to adapt quickly and effectively during stress [1-4].

The promise of introduced plants is determined by their resistance to unfavorable environmental factors. In this regard, when introducing fruits and berries, it is very important to identify varieties that

can tolerate atmospheric and soil drought. The criteria for drought tolerance of plants is watering and water-retaining ability of leaves of plants [5].

Important for normal growth and development, and hence for high plant productivity, is providing them with essential elements of mineral nutrition. Lack of nutrients in the soil cause a violation of the physiological and biochemical processes in the tissues, as a result of which pathological phenomena develop, the signs of which are inhibition of growth, changes in coloration of leaves, formation of necrosis, deformations, depletion of leaves and fruits. All this leads to a decrease in the yield, deterioration of its quality, and often - to the death of plants [6-8].

In plant organisms, the normal course of all processes of life is due to the presence of sufficient quantities of water in cells and tissues. The water-retaining ability of cells depends on the conditions of growing plants. The study of water management of pear trees and their regulation is an actual and important problem, especially in the south of Ukraine, where the growing season is almost annually dry, and the limiting factor during growing of plants is insufficient amount of natural moisture. In this case, an in-depth study of the physiological mechanisms of adaptation of the pear to drought is also important in order to increase the resistance of plants to the lack of moisture in the soil. Insufficient moisture, causing changes in physiological and biochemical processes, also affects anatomical characteristics [9].

Symptoms of mild water stress often cause accumulation of betaine in a leaf of young pears. Betaine, caused by water stress in mature leaves, is maintained for about two weeks after re-irrigation and gradually decreases after the abstinence of water stress, and a month later, its content is reduced to normal levels. The exogenously applied on the leaves of betaine slightly improves the growth of the shoots and the ability of the leaves to resist dehydration, reduces the leaves' wicking under the influence of stress and promotes the restoration of leaves after wilting for re-irrigation. These data show that accumulation of betaine is caused by water stress and is associated with tolerance to the drought of pear trees [10].

An important indicator characterizing the work of the photosynthetic apparatus of plants is the content of chlorophylls "a" and "in" and their correlation. The study of the accumulation of pigments (chlorophyll a and b and carotenoids) in plant leaves is of great importance, since their content affects the intensity of photosynthesis, the synthesis of spare organic substances (carbohydrates and proteins) and the enhancement of adaptive properties of photosynthetic structures under adverse environmental conditions [11-12]. Chlorophyll metabolism is probably the most prominent manifestation of life. It is estimated that the annual chlorophyll turnover is more than 1000 million tons [13-16]. An important means of regulating the accumulation of pigments in plants, including pears, is the use of physiologically active drugs and trace elements that can stabilize or increase the amount of pigments in the leaves of plants [17-18].

Frost resistance is not clearly restricted in its manifestation. The crucial role in preserving the plant plays not the maximum possible value of the negative temperature, but to a greater extent the period of influence and the state of the organism of the plant that is exposed to the negative temperature [19-20]. The level of cold weather is determined by the content of carbohydrates in its wood. Carbohydrates are the main nutrients of a plant organism, which are characterized by high reactivity. They take part in many chemical reactions of metabolism. High regenerative capacity of the grafted material depends on the content of the plastic substances in the tissues of the trees and, first of all, carbohydrates. It is established that the more carbohydrates are contained in the tissues of the shoots, the better is the process of fusion of grafted components and rooting of seedlings. Growth of shoots, deposition in the supply of plastic substances and the overall viability of fruit plants is determined by the carbohydrate metabolism, which, in turn, significantly depends on the conditions of cultivation [21-22].

Mobilization of starch and carbohydrates flow to the kidneys is compounded when there are low winter temperatures. This conclusion was made after Japanese scientists study comparing total soluble sugars and reducing sugars concentration, acid invertase cell wall and sucrose-phosphate synthase in the wood chipper Japanese pear trees and corresponding cooling conditions during the rest period [23-26].

The literature is almost no information on the impact of exogenous optimizing soil mineral nutrition background macro key (NRK) and top dressing fertilizer complex drugs with different composition of macro- and micronutrients in chelated form of power on the accumulation of chlorophylls and carotenoids in leaves. In this regard, we studied the effect of their actions on the accumulation of photosynthetic pigments leaves pear trees in the western region of the Southern Barrens.

The purpose of the research is to investigate the effect of optimizing the soil background of mineral nutrition with main macroelements (NPK) and foliar nutrition with complex fertilizer

preparations with different composition of macronutrients and micronutrients of nutrition in chelate form on the physiological and biochemical parameters of the puffer apparatus and the annual growth of Tavriiska pear trees on chernozem common in the western region of the Southern Ukrainian steppe.

Research methodology. Investigation of the effect of optimization of mineral nutrition on basic macroelements (NPK) by soil fertilization and foliar application of complex microfertilizers on Tavriiska varieties of pear trees was conducted starting from 2015. According to the conducted soil analyzes, in the soil in the balls 0-60 cm found: N – 40,0, P_2O_5 – 78 and K_2O – 379 mg/kg. When comparing the data given with the pears for determining the levels of mineral nutrition, the main macroelements (NPK) show that the content of nitrate nitrogen exceeds 5 mg/kg of the upper limit of the optimal level, which is 34–35 mg/kg, the content of mobile phosphates is close to the upper limit of the optimal level - 60-80 mg/kg, and exchangeable forms of potassium is lower by 46 mg/kg from the average (425 mg/kg) of the optimal level – 400–450 mg/kg of soil. Therefore, when laying the experiment to create an optimized background of nutrition of pears with nitrogen, phosphorus and potassium, only the norm of potassium fertilizer (598 kg/ha K_2O) was calculated, which was supposed to maintain the optimal level of content in the soil of exchangeable forms of potassium during a three-year period. The results of agrochemical analyzes in the years of research (2015–2017) indicate that the content of fruit trees available for nutrition of nitrogen and phosphorus compounds at the beginning of the experiment and in the research years was not less than optimal levels. The fertilizer produced by the K_2O level was also within the optimal level of 402 mg/kg.

The scheme of the two factor studies envisaged the study of two levels of the content of the compounds available for plants and nitrogen (N), phosphorus (P_2O_5) and potassium (K_2O) available to plants: 1) not optimized (without soil fertilization), and 2) optimized by the application of agrochemical soil analysis of fertilizers with those macroelements, which lacked in the roots of the soil layer (0-60 cm) to the optimal levels (factor A). As well as four variants of foliar fertilization: 1 – without feeding (spraying the sheet with water), 2, 3 and 4 – spraying with fertilizer solutions, respectively: Reakom plus (garden) – 5 l/ha, Wuxal Microplant – 3 l/ha and Biochelat «Fruit and berry crops» – 3 l/ha (factor B). These doses of drugs were dissolved in water at a rate of 1000 liters of solution per hectare of garden.

The repetition of the experiment is threefold, the lilies are systematically placed. In each plot, eight accounting trees planted in 2010 under the scheme of 4 x 2.5 m. The soil in the experimental garden was kept by the steam system, the water regime in it was maintained thanks to drip irrigation at a humidity level of 60%.

The content of green pigments (chlorophylls «a», «b», carotenoids and their sum) in the leaves was determined by acetone method of Godnev [27]. 85% acetone was used for the extraction of pigments. The optical density of the solutions was measured on the Spekol spectrophotocolorimeter. The calculation of the content of pigments was carried out on the cheese mass by the equations of Rebbelen. Free and bound water in the leaves were determined by the refractomometric method [28]. The content of sugars in shoots was determined by the Bertrand method in the modification of L. V. Milovany [29]. Shoots for analysis were selected after vegetation. The amount of starch is a volumetric method by Kh. M. Pochinok [30]. Photocolorimetry of solutions was carried out at the Spekol SP at a wavelength of 500 nm.

Research results. During the vegetation season in 2016, when the soil background was optimized and the use of various preparations for foliar feeding, there was a change in the state of water in the pear leaf.

It was established that in the beginning and at the end of vegetation in the leaf of pears of the Tavriiska variety (Table 1), the content of the cooled water was higher than that available in all studied variants. In particular, it was the highest in leaf of trees with foliar applications Biochelat "Fruit and berry crops" and Wuxal Microplant, the ratio between the content of coherent and free water was 3.4.

It was established that in the background of optimized mineral nutrition of plants, created due to soil fertilization, the physiological state and resistance to adverse weather conditions in pear trees are better. This conclusion is based on the data of Table 1, which tends to increase the content of free and bound water in the leaves of trees, in variants with optimization of the soil background.

Significant changes in growth associated with the intensification of biosynthesis processes in leaves and shoots. Therefore, it is advisable to detect the effect of the investigational drugs on the basic physiological parameters in the tissues of the leaves of the pear. Accumulation of chlorophyll in the leaves is a determining factor for the intense passage of photosynthesis. The content and ratio of

chlorophyll is an integral indicator of metabolism and the formation of organic substances in plants, which affects their growth and productivity.

Table 1 – **Effect of fertilization and foliar nutrition on the state (fractional composition) of water in the leaf of Tavriiska pear tree,** %, 2016

Backgrounds of soil nutrition of trees (factor A)	Options for Foliar Feeding (Factor B)	Free water			Connected water		
		VI*	VIII	X	VI	VIII	X
Unoptimized	Without feeding (control)	13,1	11,0	10,3	50,3	43,7	40,9
	Reakom plus (garden)	13,3	11,2	10,5	50,4	43,9	41,3
	Wuxal Microplant	13,7	11,5	10,8	50,6	44,2	41,5
	Bio-chelat «Fruit and berry crops»	13,5	11,6	10,7	50,5	44,5	41,7
Optimized	Without feeding	13,6	11,7	10,5	50,9	44,0	41,1
	Reakom plus (garden)	13,9	11,8	10,8	51,2	44,2	41,4
	Wuxal Microplant	14,7	12,5	11,1	51,8	45,1	41,8
	Bio-chelat «Fruit and berry crops»	14,5	11,9	11,0	51,5	44,8	42,0
NIR_{05}	Factor A	1,0	0,7	0,6	0,7	1,2	0,8
	Factor B	1,1	0,8	0,4	1,2	0,9	0,4

Note. * Timing of sampling (months).

Various options for fertilization and fertilization have different effects on the content of pigments in the leaves of pears. The content of pigments in the leaves of the trees of the pears of the Tavriiska variety was significantly influenced by the optimization of the soil background and fertilization with the drugs Wuxal Microplant and Biochelat «Fruit and berry crops». The leaves of the treated trees had a more intense color than the control plants. This fact has allowed us to assume that under the influence of optimization of the soil background and for the foliar application of the drugs there was a shift in the chain of biosynthesis of pigments. The results of laboratory studies of the content of pigments - chlorophyll (a + b) in the leaves of pear trees confirmed this our assumption (Fig. 1).

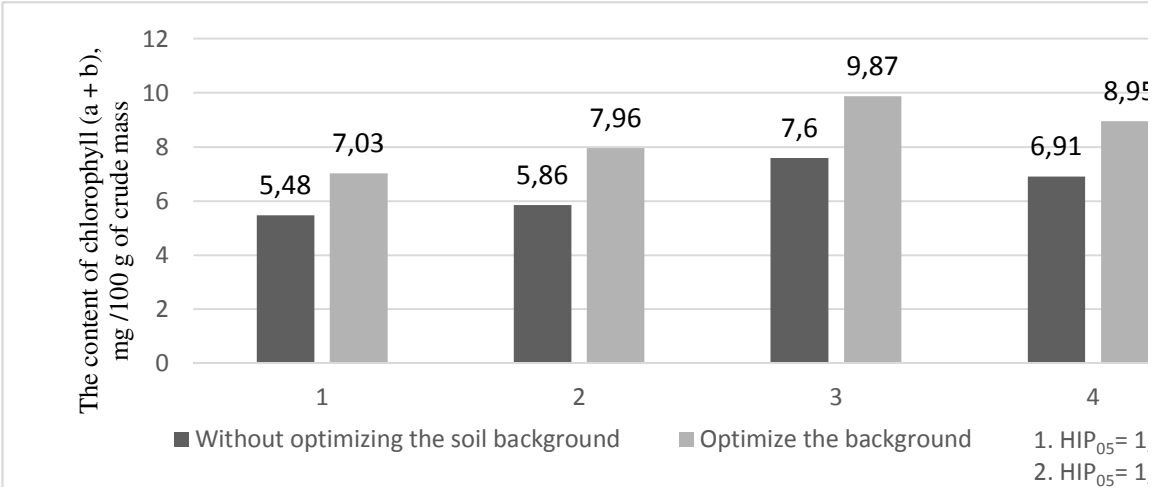

Fig. 1. **The content of chlorophylls (a + b) in the Pear Tavriiska leaf depending on from foliar fertilization and optimized fertilization** (2016): 1 – without feeding; 2 – Reakom plus (garden); 3 – Wuxal Microplant; 4 – Biochelat «Fruit and berry crops».

The analysis of the content of chlorophylls in the variant without optimization of the soil background (black columns) and in variants with fertilization showed significantly more accumulation of chlorophyll in the leaves of the trees on the optimized soil background (gray columns) treated with the drug Wuxal Microplant – 9.87 mg/100 g. The number of chlorophylls (a + b) in the leaf of the studied variants of the soil backgrounds and the nutrition increased in variants, where the K_2O was introduced into the soil and used for nutrition. Significantly increased the content of chlorophyll to optimize the soil background in all variants – an increase of 1.55–4.39 mg/100 g with NIR_{05} factor A – 1.2 mg/100 g. Increasing the content of chlorophyll in the leaves was significant in the case of root growth of Wuxal Microplant – 2,12 mg/100 g in the non-optimized background, and optimization – by 2.84 mg/100 g, and Biochelat «Fruit and berry crops» – at 1.92 mg/100 g, with NIR_{05} factor B – 1.5 mg/100 g.

Carbohydrates are the main nutrients of the plant organism. They are characterized by high reactivity and take an active part in many chemical reactions of metabolism. The effect of optimization of the soil background and preparations for foliar feeding on the content of carbohydrates (mono, dactyl and starch) in ripe shoots of vegetative trees was studied. It was found that the total number of carbohydrates in experimental variants increased with respect to control. The highest starch values were found in the variants where the soil background was optimized and the extra-root nutrition was carried out with the preparations Biochelat "Fruit and berry crops" and Wuxal Microplant (Table 2). As the dispersion analysis showed, this increase was significant. Consequently, these trees have more energy material, their shoots have grown better and they are more resistant to adverse weather conditions.

Table 2 **– Content of carbohydrates in the shoots of Tavriiska pear tree trees depending on fertilization and foliar nutrition**, mg/g, 2016

Backgrounds of soil nutrition of trees (factor A)	Options for Foliar Feeding (Factor B)	Starch	Sugar			Sum of carbohydrates
			Montsucar	Ditsuhar	Sugar Sum	
Unoptimized	Without feeding (control)	3,60	0,95	1,90	2,85	6,45
	Reakom plus (garden)	4,50	1,45	1,80	3,25	7,75
	Wuxal Microplant	4,95	1,65	2,55	4,20	9,15
	Bio-chelat «Fruit and berry crops»	4,55	1,80	1,90	3,70	8,25
Optimized	Without feeding	3,75	1,15	1,81	2,96	6,71
	Reakom plus (garden)	4,65	1,55	1,80	3,35	8,00
	Wuxal Microplant	5,05	1,75	2,65	4,40	9,45
	Bio-chelat «Fruit and berry crops»	5,15	1,90	1,95	3,85	9,00
NIR_{05}	Factor A	1,5	0,9	0,9	1,5	2,0
	Factor B	0,7	0,3	0,1	0,2	0,4

Significant increase in the accumulation of sugar was observed in trees treated with the Wuxal Microplant with optimized soil background – 4.0 mg/g and without it – 4.20 mg/g. It is known that low molecular weight carbohydrates are able to bind free radicals that cause destructive oxidative processes, usually enhanced by the action of cells damaging physical factors. In addition, monosacrides and sucrose perform signal function, take direct part in the regulation of cell division, growth and differentiation. These processes play a decisive role in the initial stages of plant development, namely at the beginning of the vegetation.

Accumulation of low molecular weight carbohydrates is considered as an adaptation to unfavorable environmental conditions. This property of carbohydrates is very important for qualitative passage of vegetation stages by a tree in conditions of drought and high temperatures of the Southern Steppe of Ukraine. The introduction of fertilizers and the use of nourishment contributed not only to the more intensive accumulation in the tissues of shoots of pears of sugar trees, but also starch.

Conclusions. 1. It has been established that in the background of optimized mineral nutrition of plants created due to soil fertilization, the physiological state and resistance to adverse weather conditions in the pear trees are better.

2. Significantly higher accumulation of chlorophyll in the leaves differed trees on optimized soil background treated with the drug Wuxal Microplant – 9.87 mg/100 g. The increase was significant.

3. The highest starch values were found in the variants, where the soil background was optimized and the foliar nutrition of the Biochelat «Fruit and berry crops» and Wuxal Microplant – 5,15 and 5,05 mg/g, respectively, were carried out. The best amount of sugar was accumulated in trees treated with Wuxal Microplant with optimized soil background – 4.0 mg/g and without it – 4.20 mg/g.

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Влияние оптимизации почвенного фона и внекорневой подкормки на физиолого-биохимические процессы в деревьях груши сорта Таврическая

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Представлены результаты исследований влияния оптимизации почвенного фона и внекорневой подкормки на физиолого-биохимические процессы у деревьев груши сорта Таврическая. Полевой опыт заложен в 2015 году по двухфакторной схеме в трехкратном повторении при наличии восьми учётных деревьев на каждой элементарной делянке. Перед закладкой опыта агрохимическими анализами почвы было выявлено содержание подвижных форм калия на 46 мг/кг меньше от среднего показателя оптимального уровня, а нитратного азота (по нитрификационной способности почвы) и подвижных соединений фосфора – больше оптимальных уровней. Для оптимизации почвенного фона рассчитана и внесена норма K_2O – 598 кг/га и таким образом был создан оптимизированный фон минерального почвенного питания груши всеми тремя основными макроэлементами (NPK).

Схема исследования включала два уровня содержания в почве доступных для растений соединений и форм азота (N), фосфора (P_2O_5) и калия (K_2O): не оптимизированный (без почвенного удобрения) и оптимизированный внесением рассчитанных по результатам агрохимических анализов почвы удобрений с теми макроэлементами, которых не хватало в корнеобитаемом слое почвы (0-60 см) до оптимальных уровней (фактор А) и четыре варианта внекорневой подкормки: 1 – без

подкормки (опрыскивание листового покрова водой), 2, 3 и 4 – опрыскивание растворами удобряющих препаратов, соответственно: Реаком плюс (сад-огород) – 5 л/га, Вуксал Микроплант – 3 л/га и Биохелат «Плодово-ягодные культуры» – 3 л/га (фактор Б). Указанные дозы препаратов растворяли в расчёте 1000 л раствора на гектар сада.

При достаточных уровнях содержания доступных для растений соединений азота и фосфора в чернозёме обыкновенном (значительно превышающих оптимальные для яблони) и недостаточного питания калием (ниже оптимального содержания его обменных форм на 46 мг/кг почвы) внесением рассчитанной нормы K_2O 598 кг/га создался достаточный уровень питания деревьев груши этим элементом и общий оптимизированный фон их минерального питания главными макроэлементами (NPK), который поддерживался на протяжении всего трёхгодичного периода исследований.

На оптимизированном фоне почвенного питания исследуемых деревьев главными макроэлементами (NPK) установлено, что физиологическое состояние и устойчивость к неблагоприятным погодным условиям у деревьев груши улучшились. Существенно большим накоплением хлорофилла в листьях отличались деревья на оптимизированном почвенном фоне, обработаные препаратом Вуксал Микроплант – 9,87 мг/100 г. Большее накопление суммы сахаров происходило у деревьев, находящихся на оптимизированном почвенном фоне и получившие внекорневую подкормку препаратом Вуксал Микроплант – 4,0 мг/г.

Ключевые слова: груша, сорт Таврическая, удобрения, внекорневые подкормки, оптимальный уровень, хлорофилл, углеводы, сухие вещества.

The influence of soil background optimization and foliar top dressing on physiological and biochemical processes in pear trees of Tavriiska variety

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The results of the research conducted in the field experiment, laid out in 2015 under the two-factor scheme in triple repetition with the presence of eight accounting trees on each elementary site, are presented. Before laying the experiment agrochemical analysis of the soil revealed the content of mobile forms of potassium by 46 mg/kg less than the average index of optimal level, and nitrate nitrogen (on nitrification ability of the soil) and mobile phosphorus compounds – more than optimal levels. To optimize the soil background, the K2O rate of 598 kg/ha was calculated and introduced, and thus an optimized background of mineral soil nutrition of pears was created with all three major macrocells (NARs).

The scheme of the study included two levels of the content of the compounds available for plants and nitrogen (N), phosphorus (P_2O_5) and potassium (K_2O) available to plants: not optimized (without soil fertilization) and optimized by applying agrochemical analysis of soil fertilizers calculated on the basis of the results of those macroalgae There were not enough roots in the soil layer (0-60 cm) to the optimum levels (factor A) and four variants of foliar application: 1 – without feeding (spraying the sheet with water), 2, 3 and 4 – spraying with solutions of fertilizers, respectively: P akom plus (Garden Town) – 5 l/ha Wuxal Mikroplant – 3 l/ha and Biohelat "Fruit Culture" – 3 l/ha (factor B). These doses of drugs were dissolved in the calculation of 1000 liters of solution per hectare of the garden.

At sufficient levels of the available plants for plants nitrogen and phosphorus in chernozem common (significantly exceeding the optimal for apple) and inadequate potassium supply (below the optimal content of its exchange forms by 46 mg/kg of soil), an adequate level was created by applying the calculated norm of K_2O at 598 kg/ha the feeding of the pear trees with this element and the overall optimized background of their mineral nutrition by main macroelements (NPK), which was maintained throughout the three-year study period.

On the optimized background of soil nutrition of the investigated trees, the main macroelements (NPK) found that the physiological state and resistance to adverse weather conditions in pear trees improved. Significantly high accumulation of chlorophyll in the leaf differed in the trees on an optimized soil background, treated with the drug Wuxal Microplant – 9.87 mg/100 g. More accumulation of sugar content occurred in trees that are on optimized soil background and topically nourishing the drug Wuxal Microplant – 4.0 mg/g.

Key words: pear, Tavriiska, fertilization, foliar nutrition, optimal level, chlorophyll, carbohydrates, dry matter.

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ЕВОЛЮЦІЯ ТЕОРЕТИЧНИХ І ПРАКТИЧНИХ ОСНОВ ПЕРЕХОДУ ВІД ПОЛИЦЕВОГО ДО БЕЗПОЛИЦЕВОГО І ПОВЕРХНЕВОГО ОБРОБІТКУ ГРУНТУ В УКРАЇНІ ДО СЕРЕДИНИ ПЕРШОЇ ПОЛОВИНИ 20 ст.

Викладений історичний шлях розвитку і становлення системи основного обробітку грунту. Акцентовано увагу на історичних передумовах мінімізації механічного обробітку ґрунту. Висвітлена роль вітчизняних вчених в розробці теоретичних і практичних основ мінімізації обробітку. Доведено, що до початку 20 ст. глибина зяблевого обробітку зростала, а з