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AGROPHYSICAL AND BIOTIC FACTORS OF REGULATION OF BIOLOGICAL ACTIVITY OF SOIL IN CROP ROTATION

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On the basis of field stationary experiments the dynamics of the total biological activity of the soil, depending on the biomass of plant residues of crop rotation crops, methods of basic soil cultivation and hydrothermal factors, was studied. It has been established that the release of carbon dioxide from the soil with greater intensity was observed on the background of deep plowing, where better conditions for aeration were and the distribution of plant residues in the profile of the arable layer was more quantitative. Minimal methods of soil cultivation, through consolidation of the soil, led to a decrease in the parameters of the zone of biotic activity and growth processes of crop rotation crops. It also inhibited total biological soil activity and reduced the amount of carbon dioxide released.

Among the crops of crop rotation, the largest mass of organic matter left behind corn (4,34 tons/ha), and the minimum sunflower (2,24 tons/ha), which determined the potential of biological soil activity. Reducing the depth of the basic soil cultivation is accompanied by an increase of soil hardness and deterioration of its water absorption, which enhances conservative processes and inhibits the decomposition of organic matter. Biological activity of the soil on the background of plowing exceeds the direct sowing by 15–20 %.

Key words: *crop rotation, soil cultivation, biological activity, organic mass, hardness of soil, crops.*

The question of the differentiation of the arable layer at different methods of basic cultivation in crop rotation on fertility and biological activity, the dynamics of these indicators, depending on the intensity of mechanical impacts on the soil and the circulation of organic substances, is extremely important for the theoretical ground of the innovative soil protection technology of growing crops.

Numerous studies on the study of the nutritional regime of the soil during the transition to non-plough methods of its cultivating in different zones has established the fact of greater concentration of basic nutrients (phosphorus and potassium) in the upper layer, reducing the nutrient and effective fertility of the lower layers with its long-term their application [1–4].

Herewith, in some cases, the localization of the elements of fertility is considered as a satisfactory fact, because near the underdeveloped root system of plants in the beginning of the vegetation there is an increased content of nutrients [5–8], in others as a negative one, because in the conditions of drought the nutritional elements in the upper layer become positionally and physiologically inaccessible to plants [9–12].

It is also established that the increased

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amount of plant residues (mulch) leads to a decrease in the digestibility of nitrogen by plants. By the decomposition of plant residues, which have a wide ratio of carbon to nitrogen, there is a biological absorption of the last ones by soil microorganisms for their own intensive development.

The purpose of research was to set the patterns of distribution of the general biological activity of the soil depending on the mass of organic matter and moisture content of the arable layer of black currant, the type of agricultural crop in the rotation and methods of basic soil cultivation. Optimize the complex of agrotechnological measures to restore soil fertility.

Materials and methods of research. The complex influence of crop rotation crops, soil cultivation and mineral fertilizers on the biological activity of the soil was studied in the stationary field experiment located on the fields of SE "Research station "Dnipro" of Institute of Grain Crops of NAAS of Ukraine in 1991.

During 2015–2017, in the experiments, records and identification of controlled factors such as the biological mass of plant residues, moisture and hardness of the soil, volumes of CO_2 released from the soil by the key phases of development of agricultural crops and the activity of microbiological activity were carried out.

The analysis of agrophysical and biotic indices was carried out in all fields of crop rotation: peas – winter wheat – sunflower – spring barley – corn for grain. On the background of crop rotation, the following methods of basic soil cultivation were studied: deep plowing by PO-3-35, chisel cultivation on 20–22 cm by Consertill Plow, shallow disk cultivation on 10–12 cm by BDV-6,3, No-till by Great Plains and va-riants without fertilizer and with application $N_{45}P_{45}K_{30}$.

In the period of crop care, the system of weed control was built on the basis of complex chemical and agronomic measures. By this, the application of soil and insurance herbicides, as well as mechanical techniques, was carried out according to the same scheme and in accordance with the permitted regulations, both on the background of deep plowing and chisel cultivation. On crops of winter wheat and spring barley in the shrub phase before going into the tube, the herbicide of the vegetative action agritox in dose of 0.8 l/ha was applicated. As a soil herbicide for application in pre-sowing cultivation for corn for grain and sunflower the avatar was used in a dose of 2,5 l/ha and 2,0 l/ha, respectively.

Weather conditions in the years of research were quite favorable, but had certain characteristics. In the spring of 2016, precipitation was 153 % to the norm, which had a beneficial effect on the weak winter crops, and in 2017, at 97 mm precipitation in April, moderate temperatures played a positive role. The completion of vegetation of late crops (August) took place at high temperatures 32–34 ºC.

Research results. As our studies have shown, minimizing of soil cultivation along with agrophysical deformations causes significant changes in differentiation of layer 0–30 cm relative to the positional location of nutrients, the concentration of potential humus substances in the aerobic zone and the intensification of microbiological activity, as it evidenced by the volumes of carbon dioxide released.

The decomposition of the plant residues took place due to their mechanical mixing with the soil and as a result of the decomposition by microorganisms.

As can be seen (Table 1), in crop rotation corn for grain left the largest organic mass, and sunflower left the minimum one. Radical redistribution of the project coating on the surface and in profile of the arable layer of soil was caused by methods of basic cultivation. So, after harvesting corn and plowing for the next culture on the surface of the field remained 0,61 t/ha of plant residues, and on the background of shallow disc cultivation 3,12 t/ha and in case of preparation for direct sowing, respectively, 4,34 t/ha.

One of the reasons influencing biotic activity in the soil is the degree of compaction of the rhizosphere zone, depending on the methods of basic cultivation.

The agrophysical monitoring of the soil condition showed that when cultivating different crops in the crop rotation, the arable layer was non-uniform in terms of hardness in a vertical cut.

On all crops of crop rotation, a zone of separation between the upper less solid layer 10–15 kg/cm^2 and the deeper one with mechanical resistance to plants of 25–30 kg/cm^2 appeared. The essence of this phenomenon lies in the fact that the line of sharp differentiation lies at different depths and clearly characterizes the agrophysical significance of the methods of soil cultivation.

This methods makes it possible to obtain extremely accurate experimental data and exceeds other methods for controlling the agrophysical condition of soil in any period of field work. Particularly important is that this method not only fixes the agrophysical condition of the soil, but allows it to be linked to the dynamics of growth and development of crops, that is, it reveals all biophysical mechanisms in agrocenosis.

1. Dynamics of the biomass of the mulched surface of the field for different methods of soil cultivation, t/ha (2015–2017)

Cultures	Term of determination	Soil cultivation		
		plowing	shallow disc	No-till
Peas	autumn	0,30	2,10	3,21
	spring	0,11	1,62	2,41
Winter wheat	autumn	0,39	2,48	3,91
	spring	0,23	2,01	3,36
Sunflower	autumn	0,28	1,87	2,24
	spring	0,21	1,42	2,03
Spring barley	autumn	0,24	1,96	2,60
	spring	0,10	1,58	1,85
Corn	autumn	0,61	3,12	4,34
	spring	0,35	2,88	4,05

As shown by the research (Table 2), the depth of bedding of a solid layer of soil connected clouthely to the methods of basic cultivation and biological peculiarities of crop rotation crops.

As of June 1, the thickness of the less compacted layer 0–24 cm was observed on the background of deep plowing in sunflower and corn crops, and the most thin (0–8 cm) he was found in crops of peas, spring barley and winter wheat on the background of direct sowing.

In general, the minimization of soil cultivation was accompanied by compaction the arable layer by limiting the loose soil volume to 8–12 cm,while on the background of plowing more favorable conditions were observed for the growth of the root system in a layer up to 14–24 cm.

With restriction of the favorable agrophysical volume of the soil because of decrease the intensity of the basic cultivation, all crop rotation crops braked their linear growth. So, winter wheat reduced the height of the plants on the background of No-till to 87 cm compared to the plowing 94 cm, and corn in the phase of 6–7 leaves – up to 43 cm from 61 cm in the plowing.

A proof of the agrophysical differentiation of the arable layer of soil for long-term use in the crop rotation the soil cultivation tools of the

2. Depth of bedding of a solid layer of soil in different methods of soil cultivation in crop rotation (upper – 10–15 kg / cm^2, bottom – 25–30 kg/cm^2) (2015–2017)

Cultures	Development phasa	Moisture of soil in 0–30 cm layer, %	Soil cultivation		
			plowing	shallow disc	No-till
Peas	milky-wax stiffness	15,3	14 / 66	9 / 60	8 / 55
Winter wheat	milk condition	13,4	14 / 94	10 / 90	8 / 87
Sunflower	4 pair of leaves	19,4	24 / 42	14 / 38	12 / 32
Spring barley	forming of leaves	13,5	14 / 73	10 / 67	8 / 62
Corn	6–7 leaves	20,3	24 / 61	12 / 50	9 / 43

Numerator: depth of bedding of a solid layer of soil, cm. Denominator: growth of plants, cm same type is the reaction of chernozem to moisture due to rain falls. So, after intensive rain (45 mm) at 30 July, 2017 after harvesting of early grain crops and during the milky-wax state of crop grain, the favorable rooting zone of the arable layer of soil has considerably expanded. The depth of border between the solid and loose layer after harvesting peas moved to a depth of 16–23 cm, and under sunflower crops up to 21–27 cm, which is 3–9 cm deeper than before the rain falls. However, even after significant soil moisturing, the advantage of plowing over the minimum coil cultivation was preserved by the ability to spill over as a result of a better picking function of the soil.

By the analogous parameters, after different methods of basic cultivation, a projective cover was created for each crop rotation crop.

During the winter conservative period, the plant residues also undergone degradation and decomposition, although at the time, the mechanical impact of the soil cultivation tools was absent. Thus, on the background of shallow disking be-fore the beginning of spring field operations, the reduction of biomass of various crop rotations was 0,24–0,48 t/ha, and in direct sowing 0,21–0,80 t/ha.

That is, for a year in all fields of crop rotation, which consists of 5 fields, it is necessary to utilize and convert into humus 16,3 t/ha plant residues. This is a great technological and environ-mental task of modern agriculture.

The dynamics of the projective coverage of the field surface with plant residues showed that the methods of basic soil cultivation significantly differed in the nature of antierosion efficiency and processes of microbiological destructtion of straw under the influence of moisture, temperature and mechanical action. At the same time, the methods of minimal soil cultivation contributed to strengthening the anti-erosion resistance of czernozem under the influence of rain drops, a more favorable regime for the mineralization of organic residues instead of the necessary humification.

The intensity of decomposition of organic matter in the soil is a heterogeneous process, which depends primarily on the determining factors such as moisture, temperature and aeration level of the treated layer of chernozem. Objectivity of the processes of breathing of the biotic component of the soil by physical parameters makes it possible to estimate the total biological activity of the soil, which is based on the amount of carbon dioxide released at different exposures per unit area of the surface of the field. As our studies have shown, the biological activity of the soil depended on the phases of corn development, and in this sence there was a rather wide amplitude of oscillation. Thus, on the example of the plowing, it can be seen that the maximum intensity of soil respiration (475 mg/m^2) was 30 days after corn sowing, when the optimal combination of temperature and soil moisture was noted. Insufficient warming of the soil under normal moisture at the time of sowing the corn caused a decrease in biological activity to 331 mg/m^2 (Table 3).

Analogical regularities conserning to the dependence of CO_2 released from the soil during the individual phases of corn development, the indicators obtained in shallow disc cultivation and direct sowing were subordinated. During all periods of determination of the general biolo-

3. Effect of crop rotation and methods of soil cultivation on the total biological activity, mg/m^2 CO_2 in 2 hours (2015–2017)

Cultures	Terms of determination, number, month	Soil cultivation		
		ploughing	shallow disc	No-till
Peas	May, 1	371	347	320
	June, 1	503	463	405
Winter wheat	May, 1	317	302	289
	June, 1	409	380	351
Sunflower	May, 1	350	347	295
	June, 1	492	439	420
Spring barley	May, 1	328	313	296
	June, 1	433	397	360
Corn	May, 1	331	314	282
	June, 1	475	458	411

gical activity of the soil there was a steady tendency towards the influence of certain types of soil cultivation on microbiological activity.

So, at the stage of the maximum and minimum amplitude of the activity of the processes of respiration, the indices of the total biological activity of the soil were higher on the background of plowing and yielded to the rest of the methods of mechanical action on chernozem during direct sowing. If for 30 days after sowing corn in the plowing and chisel cultivation biological activity was 475–458 mg/m^2, then on the background of direct sowing it was 411 mg/m^2.

The reason for such a distribution of indicators of biological activity of the soil, depending on the methods of basic soil cultivation, was the different profiled disposition of biomass of spring barley. Availability of oxygen, the presence of moisture and organic material in the upper layer of soil in shallow disc cultivation created the most favourable environment for microorganisms.

At the same time, in direct sowing a significant proportion of plant residues was located on the surface of the soil and was isolated from the zone of active activity of the soil biota. The plowing due to the displacement of biomass into the deep layers of the soil with limited access to oxygen also to some extent inhibited the intensity of the CO_2 release.

Conclusions

Thus, the biological activity of the soil is a derivative index that depends in different degree on the specific features of the technology of cultivating crop rotation crops, the presence of organic matter of plant residues in the chernozem, the level of compaction of the arable layer and the methods of basic soil cultivation. The use of deep plowing due to the creation of favourable conditions for the spreading of the root system of crops, sufficient aeration and moisture properties ensured maximum biological activity in all crops of crop rotation.

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Шевченко М. С. [1]***, Швець Н. В.*** [1]***, Шевченко С. М.*** [2] ***Агрофізичні і біотичні фактори регулювання біологічної активності ґрунту в сівозміні.*** *Зернові культури*. 2018. Т 2. № 1. С. 109–115.

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Вивчено динаміку загальної біологічної активності ґрунту залежно від кількості рослинних решток культур сівозміни, способів основного обробітку та гідротермічних факторів. Встановлено, що більш інтенсивне виділення вуглекислого газу з ґрунту було на фоні глибокої оранки, де умови аерації кращі, а розподіл поживних решток по профілю орного шару більш якісний. Мінімальні способи обробітку, через ущільнення ґрунту, призводили до зменшення параметрів зони активної біотичної діяльності і послаблення ростових процесів у культур сівозміни. При цьому також гальмувалась загальна біологічна активність грунту і зменшувалась кількість виділеного вуглекислого газу.

Серед культур сівозміни найбільшу кількість органічної речовини залишила після себе кукурудза (4,34 т/га), а мінімальну – соняшник (2,24 т/га), що і визначало потенціал біологічної активності. Зменшення глибини основного обробітку грунту супроводжується збільшенням його твердості і погіршенням водовбирної здатності, в зв'язку з цим посилюються консервативні процеси і гальмується розкладання органічної речовини. Інтенсивність біологічної активності грунту на фоні оранки більш висока, ніж на ділянках з прямою сівбою – на 15–20 %.

Ключові слова: *сівозміна, обробіток ґрунту, біологічна активність, органічна маса, твердість, культури.*

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Шевченко М. С.[1]***, Швец Н. В.***[1]***, Шевченко С. М.***[2] ***Агрофизические и биотические факторы регулирования биологической активности почвы в севооборотах.***
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На основании полевых стационарных опытов изучена динамика общей биологической активности почвы в зависимости от количества растительных остатков культур севооборота, способов основной обработки почвы и гидротермических факторов. Установлено, что более интенсивное выделение углекислого газа из почвы наблюдается на фоне глубокой вспашки, где условия аэрации лучше, а распределение пожнивных остатков по профилю пахотного слоя более качественное. Минимальные способы обработки, в связи с уплотнением почвы, вызывали уменьшение параметров зоны активности биотической деятельности и ослабление ростовых процессов у растений культур севооборота. При этом также замедлялась общая биологическая активность почвы и уменьшалось количество выделенного углекислого газа.

Среди культур севооборота наибольшее количество органического вещества оставляла после себя кукуруза (4,34 т/га), а минимальное – подсолнечник (2,24 т/га), что и определяло потенциал биологической активности. Уменьшение глубины основной обработки сопровождается повышением твердости почвы и ухудшением её водоудерживающей способности, что приводит к усилению консервативных процессов и замедлению разложения органического вещества. Биологическая активность почвы на фоне вспашки более высокая, чем на участках с прямым посевом – на 15–20 %.

Ключевые слова: *севооборот, обработка почвы, биологическая активность, органическая масса, твердость, культуры.*