УДК 633.152(470.630)

4.1.1. Общее земледелие и растениеводство (биологические науки, сельскохозяйственные науки)

ДИНАМИКА ФОРМИРОВАНИЯ АГРОФИЗИЧЕСКИХ ПОКАЗАТЕЛЕЙ ЧЕРНОЗЕМА ВЫЩЕЛОЧЕННОГО В ЗАВИСИМОСТИ ОТ ОСНОВНОЙ ОБРАБОТКИ ПОЧВЫ ПО ПРЕДШЕСТВЕННИКУ КУКУРУЗА

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Статья посвящена изучению динамики формирования агрофизических показателей чернозема выщелоченного в зависимости от основной обработки почвы по предшественнику кукуруза в технологии возделывания озимой пшеницы сорта Безостаяя 100 Место проведения исследований – опытное поле УОХ «Кубань» КубГАУ. Первое отделение Учхоз Кубань КубГАУ находится на второй террасе правого берега реки Кубани, в 5 км от города Краснодара. Объект исследований влияние минимизации основной обработки почвы на агрофизические показатели чернозема выщелоченного. Исследованиями установлено, что вспашка почвы на глубину 20-22 см обеспечила лучшие начальные агрофизические показатели для роста пшеницы, по сравнению с мелкой обработкой (дисковым лущением). Плотность почвы после вспашки (1,13 г/см³) в момент всходов была оптимальной для развития корневой системы, в то время как после мелкой обработки она была выше (1,25 г/см³). Наблюдался постепенный рост плотности почвы на обоих вариантах обработки в течение вегетационного периода. Однако, вспашка сохраняла более благоприятные условия: плотность к концу сезона составила 1,21 г/см³, в то время как после дискования она достигла 1,29 г/см³. Вспашка также показала лучшие показатели твердости (9,9 кг/см² в фазе всходов против 15,3 кг/см² при дисковании), которые также постепенно увеличивались, но оставались ниже при вспашке. Наиболее значительным преимуществом вспашки оказалось обеспечение лучшей влагообеспеченности: запасы

UDC 633.152(470.630)

4.1.1. General agriculture and crop production (biological sciences, agricultural sciences)

DYNAMICS OF FORMATION OF AGROPHYSICAL INDICATORS OF LEACHED CHERNOZEM DEPENDING ON THE BASIC SOIL CULTIVATION BY THE PREDECESSOR CORN

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The article is dedicated to study of the dynamics of formation of agrophysical indicators of leached chernozem depending on the primary tillage by the predecessor corn in the technology of cultivation of winter wheat of the Bezostaya 100 variety. The research location is the experimental field of the KubSAU. The first department of the Kuban educational farm of KubSAU is located on the second terrace of the right bank of the Kuban River, 5 km from the city of Krasnodar. The object of research is the effect of minimizing primary tillage on the agrophysical indicators of leached chernozem. Research has shown that plowing the soil to a depth of 20-22 cm ensured better initial agrophysical indicators for wheat growth compared to shallow cultivation (disc stubble cultivation). The soil density after plowing (1.13 g/cm³) at the time of emergence was optimal for root system development, while after shallow cultivation it was higher (1.25 g/cm³). A gradual increase in soil density was observed for both cultivation options during the growing season. However, plowing maintained more favorable conditions: the density by the end of the season was 1.21 g/cm³, while after disking it reached 1.29 g/cm³. Plowing also showed better hardness indicators (9.9 kg/cm² in the emergence phase versus 15.3 kg/cm² during disking), which also gradually increased, but remained lower during plowing. The most significant advantage of plowing was the provision of better moisture supply: the reserves of productive moisture in the meter-thick soil layer were 19 mm (at the beginning) and 7 mm (at the end of the growing season) greater than with disc stubble cultivation.

продуктивной влаги в метровом слое почвы были на 19 мм (начало) и 7 мм (конец вегетации) больше, чем при дисковом лущении. Таким образом, вспашка на 20-22 см улучшает структуру почвы, на 17,1 % в начале и на 10,1 % в конце вегетационного периода, создавая более благоприятные условия для роста озимой пшеницы

Thus, plowing to 20-22 cm improves the soil structure by 17.1% at the beginning and by 10.1% at the end of the growing season, creating more favorable conditions for the growth of winter wheat

Ключевые слова: ЧЕРНОЗЕМ ВЫЩЕЛОЧЕННЫЙ, ОБРАБОТКА ПОЧВЫ, ТВЕРДОСТЬ, ПЛОТНОСТЬ, ВЛАГОЕМКОСТЬ И СТРУКТУРА ПОЧВЫ

Keywords: LEACHED CHERNOZEM, SOIL CULTIVATION, HARDNESS, DENSITY, MOISTURE CAPACITY AND STRUCTURE OF THE SOIL

http://dx.doi.org/10.21515/1990-4665-206-011

Introduction

Winter wheat prevails over other crops in world agriculture. The Russian Federation is one of the main countries in the world where large and small farms grow wheat. Here, this crop is widespread in all agricultural enterprises. With the selection of new varieties of winter wheat in many regions of Russia, systems of agrotechnical measures have been developed that allow, with the help of soil cultivation and the use of fertilizers, to achieve high yields with good grain quality. Work is being carried out in this direction in the North Caucasus, where winter wheat accounts for almost 60-80% of the territory. Agrophysical characteristics of the soil, including aggregate composition, bulk density, porosity and hardness, correlate with each other and together have a significant effect on the growth and productivity of plants. Studies have shown that the best soil structure in the arable layer was formed by plowing to a depth of 20-22 cm and disking to 8-10 cm in 2-3 tracks. When chisel-growing, the physical properties of the soil in a wet year are equivalent to plowing, and in a dry year - to zero tillage. Lumpiness is the main disadvantage of such soil cultivation before sowing in a dry autumn. The option of direct seeding without soil cultivation was distinguished by the least structure, the highest density of composition and hardness. The best moisture accumulation in the autumn-winter period was observed with chisel-growing and in the option without cultivation (direct seeding). On average, over the years of research, the yield of winter wheat of the Tanya variety when sowing after soybeans was 4.6 t / ha, after plowing at 20-22 cm - 4.9 t / ha, chisel-growing - 4.3 t / ha, disking 4.6 t / ha, with direct seeding in uncultivated soil - 3.5 t / ha. [1-5].

In all natural and climatic zones of the Russian Federation, research institutions are solving the problem of increasing grain production: developing flexible intensive technological operations, while eliminating unnecessary links in outdated technologies. Thanks to this, a sharp increase in grain productivity is achieved. The scientific and technical program for the further development of grain farming in the Krasnodar Territory must be implemented through technical re-equipment of production, the use of new highly productive varieties and the development of intensive technologies, naturally, without additional expansion of sown areas and with a reduction in resource and energy costs. Research has established that moldboard-free soil cultivation can be used both independently and in combination with other traditional methods of various crop rotations, but the best way to use this method is combined with weed control measures. [10].

The current financial situation formed in agricultural production takes into account the study of cost reduction. One of the directions in the resolution is the improvement of existing generally accepted technologies for certain conditions of creation, taking into account the distinctive features of plants in any soil and climate zone. It is necessary to use the land not only intensively, but also logically, and this solution can be found only with the support of improving the technology of growing winter wheat. In order to optimize growth processes, the use of various agrotechnical methods is considered decisive. It has been established that the improvement of the conditions of nutrition, as well as water supply of winter wheat is achieved by a set of agrotechnical events, in particular, the selection of excellent predecessors, differentiated cultivation of the earth, the establishment of the best doses and proportions of fertilizers, sowing at the right time, etc. Such a combined effect of these methods of agricultural technology makes it possible to obtain a large harvest of winter wheat [6-9, 11].

Therefore, the aim of our research was to study the dynamics of the formation of agrophysical indicators of leached chernozem depending on the primary soil cultivation by the predecessor corn.

Material and object of research

The experimental field where we conducted research in 2024 is located in the first department of the educational and experimental farm "Kuban" of the Kuban State Agrarian University. The first department of the educational and experimental farm Kuban KubSAU is located on the second terrace of the right bank of the Kuban River, 5 km from the city of Krasnodar. The first department of the educational and experimental farm Kuban KubSAU is a multifunctional complex consisting of production facilities for the production of crop and livestock products, and is also an advanced farm for the transfer of experience in innovative techniques and technologies. The experimental field is located here. Leached chernozem is most widespread on the territory of the farm.

The experiment studied the dynamics of the formation of agrophysical indicators of leached chernozem against the background of minimizing the primary tillage of the corn predecessor in the technology of cultivating winter wheat of the Bezostaia 100 variety.

Research results

The main tasks of soil cultivation include optimizing its density in accordance with the requirements of the crop.

Density is a basic agrophysical indicator of soil. Table 1 shows the dynamics of soil density in the development phases of winter wheat plants depending on the method of its processing.

Analyzing the table of soil density, we can note that in the soil layer of 0-10 cm with disc stubble cultivation to a depth of 10-12 in the spring tillering phase, the density was 1.16 g/cm^3, and with plowing, the density was lower by

0.08 g/cm^3. However, already in the layer of 10-20 cm, the indicators increased by 0.09 g/cm^3 and by 0.05 g/cm^3 with disc stubble cultivation and plowing, respectively. Considering the underlying layer, namely 20-30 cm, we see that the density indicator with disc stubble cultivation did not increase significantly and amounted to 1.28 g/cm^3, but already with plowing, these same data showed themselves worse compared to the previous layer and were equal to 1.18 g/cm^3. Calculating the average for all the studied layers, one can note that with disc peeling at 10-12 cm the density was 1.25 g/cm^3, and with plowing there was a different figure – 1.13 g/cm^3.

Table 1 – Dynamics of density (do, g/cm3) and weight moisture (Bo, %) of the soil

Soil cultivation	Soil layer, cm							
	0–10		10–20		20–30		0–30	
	do	In	do	In	do	In	do	In
tillering in spring								
Disc peeling (k)	1.16	18.1	1.25	17.5	1.28	17.4	1.25	17.6
Plowing	1.08	20.1	1.13	19.3	1.18	18.7	1.13	19.4
earing								
Disc peeling (k)	1.20	17.3	1.28	16.5	1.31	15.6	1.26	16.5
Plowing	1.11	18.8	1.17	17.7	1.24	16.3	1.17	17.6
full ripeness								
Disc peeling (k)	1.24	17.0	1.31	15.0	1.33	14.1	1.29	14.1
Plowing	1,12	17.4	1.19	14.2	1.32	10.6	1.21	14.1

Continuing to analyze the table and reaching the earing phase, the data showed other figures. So, in the control variant, also known as disk stubble cultivation at 10-12 cm, the density was 1.20 g/cm^3, and with plowing – 1.11 g/cm^3 in the 0-10 cm layer. Further in the 10-20 cm layer with disk stubble cultivation there is a good dynamics of the indicators, since the data increased to 1.28 g/cm^3, and with plowing in the same layer the result increased slightly to 1.17 g/cm^3. The lowest layer we are considering gives the following results: in the control variant the density increased by 0.03 g/cm^3, and in the treatment with a depth of 20-22 cm the same figure increased by 0.07 g/cm^3, all this in relation to the previous layer, and the figures became equal to 1.31 g/cm^3 and 1.24 g/cm^3. Deriving the average from these data, we note that the density of the arable soil layer in the control variant and the variant where the treatment was carried out with a plow corresponds to 1.26 g/cm^3 and 1.17 g/cm^3, respectively.

The extreme of the studied phases is full maturity, where the density in the control variant was 1.24 g/cm^3 and with plowing 1.12 g/cm^3 in the first studied layer. When studying another layer – 10-20 cm – the result we needed increased significantly both with disc stubble cultivation and with plowing, where the data increased by 0.07 and 0.07 g/cm^3, respectively. Finishing with the data in Table 1, we can see that at a depth of 20-30 cm the density was 1.33 g/cm^3 with disc stubble cultivation and 1.32 g/cm^3 with plowing. Calculating the average data for all indicators in the phase of full ripeness of grain filling of winter wheat, we note that in the control the density was 1.29 g/cm^3, and when plowing to a depth of 20-22 cm, these same results were slightly lower and equal to 1.21 g/cm^3.

Analysis of data on the dynamics of soil density in the 0-30 cm layer showed that plowing to a depth of 20-22 cm provides the most optimal indicators. By the time of spring tillering, the soil density in this variant was 1.13 g/cm^3, which has a beneficial effect on the development of the root system of wheat. Shallow soil cultivation led to a higher density of 1.25 g/cm^3. During the growing season, the soil density gradually increased in both variants, reaching 1.21 g/cm^3 by the end of the season after plowing and 1.29 g/cm^3 after shallow cultivation, which is due to natural soil compaction.

For the growth and development of a plant such as winter wheat, hardness is important, since hardness is a property of the soil that characterizes the resistance of the soil to various mechanical treatments.

From Table 2 it can be seen that the soil hardness changed in the same pattern as the density.

Table 2 – Dynamics of soil hardness, kg/cm2

Soil cultivation	Soil layer, cm			
	0–10	10–20	20–30	0–30
tillering in spring				
Disc peeling (k)	3.2	20.3	22.3	15.3
Plowing	4.0	11.1	14.6	9.9
Earing				
Disc peeling (k)	9.5	24.1	30.2	21.3
Plowing	10.1	16.4	24.1	16.9
full ripeness				
Disc peeling (k)	11.5	27.1	36.2	24.9
Plowing	12.1	18.4	26.1	18.9

We recorded its minimum values at the beginning of the spring vegetation of winter wheat in the variant with moldboard tillage (plowing) – 9.9 kg/cm^2, and the maximum - in the phase of full maturity with disk stubble cultivation – 24.9 kg/cm^2.

Thus, in the spring tillering phase of winter wheat, in the variant with disk stubble cultivation in the soil layer from 0 to 10 cm, the indicator was 3.2 kg/cm^2, and with plowing, these same results were higher and amounted to 4.0 kg/cm^2. Already in the 10-20 cm layer, the data on hardness increased by 17.1 kg/cm^2 for the control and by 7.1 kg/cm^2 for plowing. In the deepest layer, which we took for research, the figures were increased to 22.3 kg/cm^2 and 14.6 kg/cm^2 for disk stubble cultivation and plowing, respectively. If we consider the average data on soil hardness in the layer from 0 to 30 cm, then in the variant where there was disc cultivation, the indicator was 15.3 kg/cm^2, and in the variant with plowing, this same indicator was 5.4 kg/cm^2 lower and equaled 9.9 kg/cm^2.

With disk stubble cultivation at 10-12 cm in the earing phase, the desired indicator in the uppermost layer was 9.5 kg/cm^2, and in the case of plowing, these figures were 0.6 kg/cm^2 higher. Following further along the profile, one can note that there is an increase in soil hardness by 14.6 kg/cm^2 and by 6.3 kg/cm^2 in relation to the previous layer for control and plowing. But already in the 20-30 cm layer, the difference has decreased between the options, so in the 1st option this indicator increased by 6.1 kg/cm^2 and became 30.2 kg/cm^2, and in the 2nd option it increased by 7.7 kg/cm^2 and equaled 24.1 kg/cm^2.

Comparing all the data by layers and calculating the average, it is clear that the overall figures were 21.3 kg/cm^2 and 16.9 kg/cm^2 for disc stubble cultivation and plowing, respectively.

In the extreme phase of wheat growth, the studied parameter in the 0-10 cm layer in the control variant is at the level of 11.5 kg/cm^2 and in the variant with plowing it was 12.1 kg/cm^2. In the soil layer from 10 to 20 cm, the obtained results increased by 15.6 kg/cm^2 and by 6.3 kg/cm2. But already in the next layer, a strong growth is observed with disc stubble cultivation from 27.1 kg/cm2 to 36.2 kg/cm^2, and with plowing the growth was from 18.4 kg/cm^2 to 26.1 kg/cm^2.

In this regard, the average values were: 24.9 kg/cm^2 for the control variant and 18.9 kg/cm^2 for the plowing variant.

Thus, plowing provides better soil hardness indicators, which in the spring tillering phase of wheat amounted to 9.9 kg/cm^2 against 15.3 kg/cm^2 for disk irradiation. During the growing season, the soil hardness gradually increased in both variants, reaching by the end of the growing season, respectively, a level of 18.9 and 24.9 g/cm^3.

Our observations of the moisture supply of winter wheat plants showed that by the time the seedlings emerged, the reserves of productive moisture in the one-meter soil layer amounted to 69 mm for disc stubble cultivation and 88 mm for plowing (Table 3).

Table 3 – Humidity (B0, %) and productive moisture reserves (Wпр., mm) in the soil

Soil cultivation	Soil layer, cm							
	0–20 cm		20–60 cm		60-100 cm		0-100 cm	
	B0, %	Wpr, mm	B0, %	Wpr, mm	B0, %	Wpr, mm	B0, %	Wpr, mm
shoots								
Disc peeling (k)	19.1	11	25.5	25	26.9	33	23.8	69
Plowing	22.2	19	24.5	23	31.5	46	26.1	88
tillering in spring								
Disc peeling (k)	17.8	7	21.8	31	23.7	44	21.8	82
Plowing	17.2	6	21.8	29	22.3	36	21.0	71
full ripeness								
Disc peeling (k)	15.2	1	16.2	7	15.8	1	15.8	9
Plowing	14.4	0	15.0	0	15.9	2	15.2	2

At the beginning of the resumption of spring vegetation, they were approximately equal across the experimental variants – 82 and 71 mm, respectively.

In the phase of full maturity, the moisture supply of winter wheat plants was best after plowing, where the reserves of productive moisture in the meter-thick soil layer amounted to 9 mm versus 2 mm after disc stubble cultivation.

The best conditions for crop moisture supply were created with moldboard tillage (plowing), with productive moisture reserves in the meter-thick soil layer from 88 mm (beginning of vegetation) to 9 mm (phase of full maturity), against, respectively, 69 and 2 mm in the control.

The structural (aggregate) composition of the soil is one of the pillars, the foundations of the general fertility of our chernozems. Studying the impact of possible agricultural industries of cultivating certain agricultural crops, an experienced agronomist can establish a connection with the parameters of the agrophysical properties of chernozem and productivity.

By trying to optimize soil characteristics such as density, porosity, and moisture, crop productivity can be increased.

The soil structure is understood as the interconnected aggregates into which the soil is broken down, and they can be of different sizes. They can be either structural, having a shape and size, or structureless, connected into large aggregates and forming a continuous layer, due to which the seeds and root system cannot develop properly.

The size of structural aggregates surrounding winter wheat seeds affects the process of their swelling and germination at low moisture levels at the seed placement depth. When cultivating the soil, one should strive for a leveled surface without clods. Small clods should make up 25–30% of the mass, no larger than 10–30 mm, and soil aggregates smaller than 10 mm should make up 60–65%. To obtain uniform shoots of winter wheat, the large clod fraction is very dangerous. In such a soil condition, shoots appear unevenly, and during overwintering, the root system breaks off, resulting in thinning of winter cereal crops. If the soil structure is finely lumpy, then field germination is high and shoots are uniform and full.

The dynamics of the aggregate composition of the arable layer under winter wheat crops depending on the method of primary cultivation is presented in the table4.

At the beginning of the spring vegetation, the greatest number of agronomically valuable units was observed in the variant with plowing (74.6%), while with shallow cultivation (disc stubble cultivation) there were fewer of them (70.9%).

By the end of the growing season, the amount of agronomically valuable aggregates decreased in all variants, varying from 61.8% to 64.2%.

Table 4 – Aggregate composition of the arable layer under winter wheat crops

Soil cultivation	Size of units, mm		Structural coefficient
	>0.25+<10	<0.25+>10	
	%	%	
tillering in spring			
Disc peeling (k)	70.9	29.1	2.43
Plowing	74.6	25.4	2.93
before cleaning			
Disc peeling (k)	61.8	38.2	1.61
Plowing	64.2	35.8	1.79

At the same time, in areas with surface cultivation, a higher content of clods and dust particles was noted due to the destruction of the upper soil layer. The structure coefficient, both at the beginning and at the end of the growing season, was higher in the variant with plowing (2.93 and 1.79, respectively), compared to the variant with disc stubble cultivation (2.43 and 1.61).

Summarizing all of the above, we conclude that for better growth and development of winter wheat plants, agronomically valuable aggregates are needed, which prevail when plowing to a depth of 20-22 cm in the main soil cultivation, in contrast to disc stubble cultivation to a depth of 10-12 cm. At the same time, plowing to 20-22 cm improves the quality of the soil structure compared to shallow soil cultivation (disc stubble cultivation to 10-12 cm) by

17.1% at the beginning of the winter wheat growing season and by 10.1% at the end of the growing season.

Conclusion

Plowing the soil to a depth of 20-22 cm ensured better initial agrophysical indicators for wheat growth compared to shallow tillage (disk stubble cultivation). The soil density after plowing (1.13 g/cm³) at the time of emergence was optimal for root system development, while after shallow tillage it was higher (1.25 g/cm³). A gradual increase in soil density was observed for both tillage options during the growing season. However, plowing maintained more favorable conditions: the density by the end of the season was 1.21 g/cm³, while after disking it reached 1.29 g/cm³. Plowing also showed better hardness indicators (9.9 kg/cm² in the emergence phase versus 15.3 kg/cm² after disking), which also gradually increased, but remained lower during plowing. The most significant advantage of plowing was the provision of better moisture supply: the reserves of productive moisture in the meter-thick soil layer were 19 mm (at the beginning) and 7 mm (at the end of the growing season) greater than with disc stubble cultivation. Thus, plowing to 20-22 cm improves the soil structure by 17.1% at the beginning and by 10.1% at the end of the growing season, creating more favorable conditions for the growth of winter wheat.

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