

CROP PRODUCTION

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EXPERIENCE OF BIOLOGIC FARMING IN THE MIDDLE PREDURAL OF RUSSIA

Research article

Abstract

In Russia, there are still few followers of biotechnology in farming. In the Republic of Bashkortostan (RB) it is planned to switch to organic farming only four farms. In one of them - in peasant farm (PF) "Shakirov F.T.," carried out research of the Bashkortostan Research Institute of Agriculture with the aim to study the degree of biologization of the farming system. The farm is located in the Northern Forest Steppe of the republic within the Middle Predural. The relief is rolling plain. The climate is moderately warm and the rainfall is satisfactory. Grey forest soil, humus content - low, phosphorus and potassium - medium and elevated. The forest area of the territory is 13%. In general, the territory of the farm is favorable for the biologization of farming. The development of organic farming began in 2012. The structure of crops changed with the achievement of equal participation of cereals and long-term herbs by 2017 - 50% of the area of ration, absence of clean fumes. The task of reproduction of soil fertility and weed control was taken over by perennial herbs, with the dominance of legume species. During the years of transition to a biological farming system, field crop yields increased and became 1.5-2 times higher than those of ordinary farms in the region. Grain yield for 2014-2018 averaged 2.6-2.8 t/ha, hay of perennial herbs - 4.5 t/ha. The yield of grain of spring wheat after grain crops was 2.45 t/ha, and on a reservoir of perennial herbs - 3.0 t/ha, or 22% more. The soil under the herbs of the 6th year of life had an increased content of mobile phosphorus, exchange potassium and easily hydrolysable nitrogen - a sufficient basis for forming a high yield of cereals going after herbs. Optimal crop yields are achieved without the use of fertilizers. Weed purity is also maintained and no herbicides are required. These factors reduce the cost of cereal cultivation technology, which results in a much higher farm return than the average. Thus, the structure of crops, the way in which soil fertility is reproduced, the yield and the cost of production show successful biologic farming in the farm.

Keywords: biologic farming, crop structure, cereals, perennial herbs, grey forest soil.

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ОПЫТ БИОЛОГИЗАЦИИ ЗЕМЛЕДЕЛИЯ В СРЕДНЕМ ПРЕДУРАЛЬЕ РОССИИ

Научная статья

Аннотация

В России последователей биотехнологий в земледелии еще мало.

В Республике Башкортостан планируют перейти на органическое земледелие всего четыре хозяйства. В одном из них – в КФХ «Шакиров Ф.Т.», проводил исследования Башкирский научно-исследовательский институт сельского хозяйства с целью изучения степени биологизации системы земледелия. Хозяйство расположено в Северной лесостепи республики в пределах Среднего Предуралья. Рельеф равнинно-увалистый. Климат умеренно теплый, обеспеченность осадками удовлетворительная. Почва серая лесная, содержание гумуса – низкое, фосфора и калия – среднее и повышенное. Лесистость территории – 13 %. В целом, территория хозяйства является благоприятной для биологизации земледелия. Освоение органического земледелия началось с 2012 года. Изменялась структура посевов с достижением равного участия зерновых культур и многолетних трав к 2017 году – по 50 % от площади пашни, отсутствия чистых паров. Задачу воспроизводства плодородия почвы и борьбы с сорняками взяли на себя многолетние травы, с доминированием бобовых видов. За годы перехода к биологизированной системе земледелия урожаи полевых культур возрастали и стали в 1,5-2 раза превышать показателей обычных хозяйств района. Урожайность зерновых за 2014-2018 гг. составляла в среднем 2,6-2,8 т/га, сена многолетних трав – 4,5 т/га. Выход

зерна яровой пшеницы после зерновых культур составляла 2,45 т/га, а по пласту многолетних трав – 3,0 т/га, или на 22 % больше. Почва под травами 6-го года жизни имела повышенное содержание подвижного фосфора, обменного калия и легкогидролизуемого азота – достаточная основа для формирования высокой урожайности зерновых, идущих после трав. Оптимальные урожаи зерновых культур достигаются без применения удобрений. Поддерживается также чистота от сорняков, не требуются гербициды. Перечисленные факторы удешевляют технологию возделывания зерновых культур, в результате чего величина прибыли в хозяйстве намного выше среднерайонного показателя. Таким образом, структура посевов, способ воспроизводства плодородия почвы, урожайность и себестоимость продукции свидетельствуют об успешной биологизации земледелия в хозяйстве.

Ключевые слова: биологизация земледелия, структура посевов, зерновые, многолетние травы, серая лесная почва.

1. Introduction

The optimal structure of crops and rational crop rotations solve the task not only of producing the necessary range of agricultural products, but also of reproducing soil fertility. Recently, on the issue of soil fertility, farmers have begun to pay attention to biological methods. Biologization, on the one hand, ensures ecological safety of farming and formation of organic economy. On the other hand, its application is in many cases less costly than traditional farming, which is of great importance at the modern high cost of technology. However, there are still few followers of biotechnology. According to the State Legislative Assembly Committee on Agro-Industrial Complex, the organic economy at us is poorly developed. However, there are great prospects in Russia in this industry - today there are more than 20 million hectares of agricultural land that have not received agrochemicals in the last few years.

Russia now occupies only 0.18% of the world organic market. Nevertheless, Russia has another big plus compared to Europe, which has a shortage of land for organic agriculture - 40 million hectares of land are empty in the country [1]. Organic farming is still emerging in the Republic of Bashkortostan. The first applicants for this method of farming are already facing difficulties. Aware of the problem, one of the agricultural producers asked the Bashkir Research Agriculture to carry out research to analyze the state of agriculture and meet the requirements of its management on an organic basis.

Taking into account the above, we set the goal - to study biological methods of soil fertility reproduction and increase crop production productivity in the conditions of the Northern Forest Steppe and Bashkortostan. In order to achieve the goal, the objectives were defined: 1) to study the structure of crops in PF "Shakirov F.T." Yanaulsky district of RB, to develop directions of their improvement and schemes of crop rotation; 2) to lay down production experience to study the influence of various precursors in crop rotation and methods of soil treatment on the yield of fodder and cereal crops, on soil fertility indicators; 3) to develop recommendations on management of crop rotations, environmentally safe, resource-saving technologies of fodder and grain crops.

2. Methods

Field studies were carried out according to the method of B.A. Dospheov (2011) [1], laboratory - according to GOST 29269-91 (M., 2005) [2].

3. Results

Soil-climatic conditions of the farm are typical for the Middle Predural of the Russian Federation. The relief is rolling plain.

The agroclimatic values of the northern forest steppe are characterized by the following values: the average annual air temperature is 2.9 ° C. Sum of air temperatures for the period above 10 ° C - 2000 ° C. The sum of precipitation for the year is 569 mm, for the 10 ° period is 230 mm, snow height is 50 cm. Period with snow cover is 160 days. Productive moisture in the soil layer 0-100 cm at the beginning of spring according to multi-year data - 165mm, hydrothermal coefficient for the growing period - 1.4 [3].

The soil is grey forest, heavy loamy mechanical composition.

Soil acidity is weak acid, humus content is low. Phosphorus and potassium content are medium and high. Mostly, wealth is accurately contained in the soil of trace elements.

One condition for successful biologic farming is the presence of natural barriers at farm boundaries with neighbouring sites. Such barriers may be, for example, forest areas that limit the intrusion of harmful factors into the Territory: the transport of weeds, diseases and pests, as well as pesticides in the treatment of fields. Thus, the forest area of our farm, calculated on the basis of cartographic materials, is 13% - close to optimal values [4].

The above-mentioned information shows that the landscape, climatic and soil conditions of the farm territory are favorable for the conversion of agriculture into a biological basis.

Systematic development of organic farming in PF "Shakirov F.T." began in 2012, when a complex bean-cereal long-term trauma was sown in field No. 5. This field used to be owned by a neighbouring au pair and had low fertility due to long-term use of cereals in the monoculture without the observance of rational crop rotation, without fertilizers and with deficiencies in soil processing. By then, there were still few perennial herbs in the structure of PF crops - the main regulator of soil fertility, on which the head of the farm placed hope (Table 1).

Table 1 – Changing the structure of crops in PF Shakirov F.T. during development Organic farming

Items No.	Crop Area	Group and Annual Weight							
		2012		2013		2014 - 2017		2018 - 2019	
		hectare	%	hectare	%	hectare	%	hectare	%
1	Steam clean	113	11,8	90	9,3	0	0	0	0
2	Grain	687	71,5	480	50	480	50	510	53,2
3	Perennial herbs	160	16,7	390	40,6	480	50	450	46,8
4	In total on a crop rotation	960	100	960	100	960	100	960	100

Perennial herbs occupied 160 hectares, or one field of six-bed field crop rotation, in 2012. In 2013 - increased to 390 hectares (40.6% of the crop area). In the period 2014-2017, the area of perennial herbs increased to 480 hectares, which was exactly half of all crops. In the last 2018-2019, part of the bed of perennial herbs has been open, and the area under this valuable culture has decreased to 450 hectares, which is 47% of all crops. The proportion of cereals varied over the years according to variations in the area of perennial herbs, from 71% to 50%. The clean steam, which occupied 12 and 9% of the pasha in the initial years, has been completely excluded from the structure since 2014 and has not been used in the following five years. The main functions of the steam field - mobilization of available nitrogen in the soil and control of weeds - were taken over by perennial herbs.

According to the structure of crops, in recent years there has been a certain scheme of rotation of crops in crop rotation. All cultures are represented in one large field crop rotation. If herbs are sown under the cover of cereal crops, the following crop rotation is used: 1) grain perennial herbs; 2-4) perennial herbs of the second to fourth years of life; 5) spring wheat; 6) spring wheat; 7) barley, peas, buckwheat. In case of bloodless planting, the number of fields in crop rotation under perennial herbs increases to four, according to the scheme: 1-4) perennial herbs of the first to fourth years of life; 5) spring wheat; 6) spring wheat; 7) barley, peas, buckwheat. Accordingly, the proportion of cereals is reduced to three fields out of a total of seven. However, there is no significant reduction in grain collection in the last crop rotation due to higher crop yields. Since there is a pattern in the farm - the longer the field is under the perennial herbs, the more fertile the soil becomes.

The system of soil cultivation in subsistence farms should be more intensive than that of conventional field cultivators. Since when trying to minimize soil cultivation, crop clogging will almost inevitably increase, which will require the use of herbicides. In organic farming, the use of pesticides and mineral fertilizers is prohibited, except for natural phosphates, potassium salts, limestone, gypsum, etc. [5]. Observing the above-mentioned limitations, our farm uses a system of waste soil treatment to medium depths (Table 2).

Table 2 – Soil treatment system in 7-Polish grain crop rotation

№ la	Culture	Basic soil treatment (autumn, after cleaning)	Depth of soil, cm
1	Grain perennial herbs 1 g.	Ploughing	23-25
2	Perennial herbs 2 g	—	
3	Perennial herbs 3 g	—	
4	Perennial herbs 4 g	—	
5	Spring Wheat	Ploughing	20-22
6	Spring Wheat	Minimum treatment with traction cultivator	10-12
7	Buckwheat, barley	Ploughing	20-22

In the field where it is planned to place cereals with sub-blooded sowing of perennial herbs, the soil from autumn sails relatively deep, on 23-25 cm. Under the formation wheat for better cutting of turf of perennial herbs we carry out dump treatment to the depth of 20-22 cm. Under the second wheat after perennial herbs at clogging below the threshold of malevolence the field is treated by surface-irrevocable method with heavy cultivator. In the last field of crop rotation, which is more remote from the sowing of perennial herbs, ploughing for 20-22 cm is used for better cleaning from weeds. Such soil treatment, combined with the forty-cleaning influence of perennial herbs, allows to effectively control the phytosanitary state of crops and reproduce soil fertility.

Also, remaining true to the principles of organic farming, the use of mineral fertilizers is completely excluded in the fields of crop rotation. Even organic fertilizers allowed for use in organic farming are not exported to the fields. The maintenance of the nutrient regime of the soil was taken over by perennial herbs, the mechanism of influence of which we will say below.

What positive changes in soil fertility and overall farming have occurred over the years?

During the years of transition to a biologized farming system, the production of field crops has steadily increased in the farm and in recent years the average output from 1 hectare of the sown area has been 1.5-2 times higher than that of the usual farms of the region (Table 3).

Table 3 – Comparative yields of major field crops in PF "Shakirov F.T." and in Yanaulsky district of the Republic of Bashkortostan (By 2014 - 2018 indicators)

Items No.	Culture	Yield, t/ha		Difference		
		PF Shakirov F.T.	Average on the area		t/ha	frequency rate
1	Spring Wheat	2,8	Grain	1,6	1,2	1,75
2	Barley, grain mixture	2,6			1,0	1,62
3	Perennial herbs on hay	4,5 (2,25)		2,0 (1,0)	2,5	2,25
4	Conditional grain productivity 1 ha of crops *	2,55		1,3	1,25	2,0

* - Perennial herbs are converted to grain with conversion to feed unit and the equivalent of oat grain (digit in parentheses).

Grain yield for 2014-2018 averaged 2.6-2.8 t/ha, hay of perennial herbs - 4.5 t/ha. During the same years, the hectare strength of crops in Yanaulsky district, where the farm is located, was significantly lower and amounted to: for cereals 1.6 t/ha, perennial herbs per hay - 2.0 t/ha, one-year herbs per hay - 2.0 t/ha.

The main factor increasing productivity of crop rotation fields was the link of perennial herbs. This is evidenced by the high yield of crops placed after years of herbs, as well as by the indicators of improvement of soil and phytosanitary situation in fields of years of herbs and fields going after years of herbs. In order to detect the positive influence of perennial herbs, a production experiment was carried out.

The first version of the production experience was matched by sowing spring wheat on grain crops in the most distant field of crop rotation from herbs (5th culture after herbs). In this field less developed and more clogged sowing was formed compared to the neighboring field, where wheat was placed on a reservoir of perennial herbs. The abundance of weeds was 2 on the A.I. Maltseva scale, which corresponds to the average degree of clogging. The grain yield was 24.5 c/ha (Table 4).

Table 4 – Spring wheat grain yield depending on predecessors

Variant	Precursor	Crop clogging, points	Wheat grain yield, t/ha	Difference	
				t/ha	%
1	Cereals in the last 4 years	2	2,45	—	—
2	Perennial herbs (clover) 3 years of life	1	3,00	+0,55	22

The second option is spring wheat on a reservoir of perennial herbs. History of the field: in 2015 clover of the meadow was sown. In 2017, after the second bite of herbs, the field was autumn ploughed. In 2018, spring wheat was sown on the stratum. The seeding was exceptionally clean of weeds.

Clogging is only 1 point on the 4-point scale of A.I. Maltseva (single weeds). The grain yield was 3.0 t/ha, which is 22% higher than the wheat yield for grain precursors. Thus, experimental crops have shown that as a result of the favorable follow-up of perennial herbs, a weed-free spring wheat stem with high grain yield is formed.

The effect of perennial herbs on soil fertility is known to depend on their yield and age. The more phytomasses develop perennial herbs and the more time they affect the soil, the more fertile the soil becomes. In order to detail this factor, the yields of green and dry mass were taken into account in two fields of perennial herbs, which differ in the age of the herbage (Table 5).

Table 5 – Herbal condition and yield of perennial herbs depending on their age

No field	Age of herbs	Species composition of herbal (Dominant species)	Grass-standing height, cm	Yield for 2 bites, t/ha		Yield difference	
				Green mass	Dry mass	t/ha	%
1	2 years	Trifolium pratense (other species are still suppressed)	55-60	48,2	9,64	—	
2	6 years	Medicago sativa + Bromus inermis (the rest fell out in the old years of life)	65-70	35,6	7,01	2,63	27

In both fields the trauma mixture of the same composition was sown - clover, oatmeal, brome, lucerne. But in field No. 1, almost all of the grass consisted of a meadow clover. The rest of the species have so far, in their second year of life, been suppressed. The young grass in this field formed the highest yield: green mass - 48.2 and dry mass - 9.64 t/ha. The productivity six-year-old, old-age, herbage in the first field was considerably smaller size - 7.01 t/hectare of dry weight. The relative difference in yield was 27% in favor of the young herbal. Thus, as they age, herbal plants of perennial herbs significantly reduce the yield of green and dry mass.

The effect of perennial herbs on the fertility of the soil of the farm did not differ much according to the productivity and duration of cultivation (Table 6).

Table 6 – Effect of perennial herbs on soil fertility in arable layer (0-20 cm), mg/kg soil

Age of herbs	Species composition of herbal (Dominant species)	pH	Hr	P ₂ O ₅	K ₂ O	N - easy hydrolyzed
2 years	Trifolium pratense	5,33; sour	4,87	121,1	100,9	93,2
6 years	Medicago sativa + Bromus inermis	6,05; close to neutral	2,93	90,9	112,5	90,4

In terms of the effect on the content of mobile nutrients in the soil, herbs of different ages hardly differed. The mobile phosphorus contained 91 to 121 mg per 1 kg of dry soil, exchange potassium from 101 to 112 mg/kg (average and increased content of both nutrients), easily hydrolysable nitrogen from 90 to 93 mg/kg (high availability for cereals). Soils under herbs varied significantly in acidity. Under the herbs of the second year of life, the soil had an acidic reaction with a pH of 5.33 and a hydrolytic acidity of 4.87 mg/100mg of soil (Table 6). Under the six-year-old herbal of the lucerne and brome, the soil had a close to neutral reaction, with a pH of 6.05. The hydrolytic acidity was also negligible here - 2.93 mg/eq. per 100 g soil. It can be assumed that perennial herbs under farm conditions stabilize the reaction of the soil solution, preventing sub-acid. Consequently, the beneficial effect of perennial herbs is aimed at maintaining sufficient nutrient content and optimal soil solution response.

Soil fertility in PF "Shakirov F.T." is maintained and reproduction by biological method by cultivation of legumes and cereal perennial herbs in crop rotation. Bioclimatically induced crops of cereals and fodder crops are obtained without the use of mineral and organic fertilizers. In fields of grain crops, going after many years of herbs, relative purity from weeds is maintained due to phytosanitary follow-up of herbs. Accordingly, herbicides are not required to control clogging. These factors reduce the cost of grain cultivation technology.

The yield of cereals in the area where traditional farming technology is used, without using the biological method of soil fertility reproduction, is 1.5 - 1.8 times lower than in PF "Shakirov F.T." The average for the last 4 years is 1.37 - 1.58 tons/ha. The economic efficiency of field crops cultivation was compared on average by area and in experimental economy. In order to observe the principle of the only difference, the total area of the conditional medium-scale 10 - field crop rotation was taken equal to 960 hectares with the crop rotation of this farm. Significant profits from the main crop groups in the area are provided only by cereals, with a profitability of 87%. Perennial and one-year-old herbs on hay are loss-making, with negative profitability of 35 and 47%. The average value of profit on crop rotation is slightly higher than 2 million rubles, profitability - 49%. The profit of single-size crop rotation from the analyzed farm, more than 6 million rubles, is 3 times higher than the district indicator. In conclusion, it should be noted that the biologized technology of cultivation of cereals and perennial herbs in PF "Shakirov F.T." contributes to the formation of a yield exceeding the district level by almost 2 times, improvement of soil properties and reduction of costs for production of a unit of production.

Conflict of Interest

None declared.

Конфликт интересов

Не указан.

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