Influence of organic fertilizers on the water and food regime of meadow-chernozem soil

Igor Bobrenko¹, Natalia Goman^{1*}, Victor Kormin¹, Nadezhda Trubina¹, and Marina Sklyarova¹

¹Omsk State Agrarian University named after P.A. Stolypin, Institutskaya pl., 1, Omsk, 644008, Russian Federation

Abstract. The research is based on the results of studying the effect of solid organic fertilizers based on cattle manure (cattle) of various storage periods on the supply of productive moisture and the chemical composition of meadow-chernozem soil. The studies were carried out at LLC RUSKOM-Agro, Omsk region in 2017-2018. The application of organic fertilizers significantly increases the content of nitrate nitrogen (from very low to very high levels), mobile phosphorus and potassium. In the first year of aftereffect, manure doses continue to have a significant impact on the nutrient regime of the soil. Moisture reserves before sowing were characterized as good (133-154 mm) without significant changes when applying manure.

1 Introduction

The soil cover of Siberia is very diverse, and the water and food regime of soils used in agriculture depends on various causes of natural and anthropogenic origin [1-5].

Moisture security is the leading factor in soil fertility and determines the receipt of high and stable yields of grain crops. Soil moisture becomes especially important in the forest-steppe and steppe conditions, where the productive moisture of the soil layer is a limiting factor with high heat supply. With an insignificant and unstable atmospheric moisture during the formation of the biological crop yield, the role of a regulator that mitigates atmospheric drought is played by spring reserves of productive moisture in the soil. Optimization of the water regime in dry farming is a very difficult problem. Therefore, the search for ways of a more complete and rational use of precipitation in the conditions of intensification of agriculture is of particular relevance.

Moisture reserves in the soil, their distribution is determined by many factors: the amount of atmospheric precipitation, agrohydrological and physical properties of the soil, the content of organic matter and basic nutrients, biological characteristics of plants, agrotechnical measures, including the use of mineral and organic fertilizers, various soil treatments, the placement of crops in crop rotation [6-9].

* Corresponding author: nv.goman@omgau.org

The dietary regime of the soil affects the yield of agricultural crops [10-12]. Organic fertilizers contain a significant amount of nutrients and, when used in agriculture, a positive effect on soil fertility in various soil and climatic conditions is noted, which also affects the level of productivity of cultivated plants [13-16].

2 Methods and equipment

The research was carried out at the experimental plots of LLC RUSKOM-Agro in the Omsk region and at the Department of Agrochemistry and Soil Science of the Federal State Budgetary Educational Institution of Higher Education Omsk State Agrarian University in 2017-2018. The studied object was the spring wheat plants Pamyat Aziev; the soil was meadow chernozem, low-power, low-humus, heavy loamy. Content in the soil before sowing N-NO₃ - 2.14-10.2, P₂O₅ - 146-195, K₂O - 294-425 mg / kg.

The location of the plots on the experimental site is systematic. The experiment was repeated three times. Plot area - 20 m²; accounting area - 16 m². Agrotechnics are common for the zone.

Laboratory studies were carried out at the Department of Agrochemistry and Soil Science of the Federal State Budgetary Educational Institution of Higher Education Omsk State Agrarian University. In soil samples, the content of nitrate nitrogen with disulphophenolic acid was determined according to Grandval-Lyazh; the amount of mobile phosphorus and potassium - from one extract according to Chirikov (GOST 26204-84).

3 Results

In the absence of reliable forecasts for the precipitation of the growing season, it is of practical importance to identify the role of soil moisture reserves before sowing on the formation of agricultural crops. Assessment of the relationship between pre-sowing soil moisture reserves and yield, based on long-term stationary experiments on chernozem soil in the southern forest-steppe of Western Siberia, showed that the reserves of productive moisture in the soil in the 0-100 cm layer determined the yield of crops [7]. In our studies, the moisture reserves before sowing spring wheat were and were characterized as good (133-154 mm) without significant changes in the variants of the experiment (Table 1).

Table 1. Reserves of productive moisture in the soil before sowing wheat in the 0-100 cm layer, depending on the duration of storage and doses of cattle manure, mm, 2017-2018.

Option	Storage duration (months)				
	4	6	8	10	12
Control	2017				
	138	135	133	140	142
	2018				
	151	148	154	146	152

Indicators of productive moisture reserves in the tillering phase and after harvesting wheat in the soil layer 0-30 cm are presented in Table 2 and are also typical for the zone.

Table 2. Productive moisture reserves in the soil in the tillering phase in the 0-30 cm layer, depending on the duration of storage and doses of cattle manure, mm, 2018.

Option	Storage duration (months)				
	4	6	8	10	12
Act (2017)					
Control	16,3	15,6	15,6	14,8	16,2
20 t / ha	15,0	15,8	16,3	15,7	15,9
30 t / ha	14,6	17,1	15,1	18,1	15,2
40 t / ha	15,4	17,7	14,6	17,8	17,5
50 t / ha	14,7	16,9	14,8	17,8	15,9
60 t / ha	14,6	16,7	19,8	19,0	16,2
Aftereffect (2018)					
Control	15,2	15,3	18,5	14,7	19,1
20 t / ha	15,5	15,7	17,5	16,1	18,5
30 t / ha	16,1	15,2	18,0	14,7	16,0
40 t / ha	19,2	18,0	14,3	14,4	15,4
50 t / ha	17,5	16,0	16,7	19,3	16,8
60 t / ha	16,2	15,9	14,7	17,1	16,3

Table 3. Productive moisture reserves in the soil after harvesting wheat in a layer of 0-30 cm depending on cattle manure, mm, 2018.

Option storage duration (months) / dose, t / ha	Layer soil, cm	Action		Aftereffect	
		%	mm	%	mm
Control	0-20	28,4	36,5	33,3	47,3
	20-40	23,2	28,7	24,3	31,3
	40-60	23,2	34,8	17,7	20,5
	60-80	18,6	28,1	15,0	18,0
	80-100	16,9	23,7	14,5	16,5
	0-100		151,8		133,6
4/60	0-20	33,2	47,1	28,5	36,7
	20-40	29,2	43,1	26,3	36,1
	40-60	19,2	24,4	21,4	30,1
	60-80	16,3	21,6	18,9	28,9
	80-100	14,0	15,0	19,7	32,1
	0-100		151,2		163,9
6/60	0-20	33,3	47,3	27,6	34,7
	20-40	27,2	38,3	22,8	27,7
	40-60	16,4	17,1	16,9	18,4
	60-80	14,8	17,4	15,3	18,8
	80-100	15,8	20,4	16,1	21,3
	0-100		140,5		120,9
8/60	0-20	33,0	46,6	21,5	21,3
	20-40	26,7	37,1	20,6	22,4
	40-60	24,5	38,2	22,2	32,2
	60-80	18,3	27,2	17,6	25,3
	80-100	16,9	23,7	17,7	26,1
	0-100		172,8		127,3
10/60	0-20	34,2	49,2	25,0	29,0
	20-40	21,4	24,4	19,9	20,8
	40-60	15,8	15,6	16,0	16,1
	60-80	14,5	16,6	15,1	18,3
	80-100	15,7	20,1	16,1	21,3
	0-100		125,9		105,5
12/60	0-20	27,6	34,7	25,6	30,3
	20-40	19,5	19,8	20,2	21,5
	40-60	14,9	13,2	19,4	24,9
	60-80	11,5	8,2	15,9	20,5
	80-100	12,4	10,2	13,3	12,9
	0-100		86,1		97,2

When applied, organic fertilizers affect the content of available nutrients in the soil [8,13,17]. The studies have studied the effect and aftereffect of 1-year doses of manure on the fertility of meadow-chernozem soil. It should be noted that there is a significant increase in the level of nitrate nitrogen in the soil under the action of fertilizer. The provision of wheat plants with nitrate nitrogen in the germination phase increased by more than 1.5-2.0 times with the introduction of 40-60 t / ha of manure with a storage duration of 8-12 months. The content of nitrate nitrogen in the soil was at the level of 20.5-29.1 mg / kg soil (in the control 9.1-11.8). By the time of harvesting, the content of this element according to the variants of the experiment began to differ less significantly due to its consumption by wheat plants (Table 4).

With the aftereffect of manure in the first year, the provision of wheat plants with nitrate nitrogen in the germination phase increased by more than 1.5 times with the introduction of 40-60 t / ha of manure with a storage duration of 8-12 months. The content of nitrate nitrogen in the soil is 12.6-18.0 mg / kg of soil (in the control 10.4-11.4). The reason for this increase is the decomposition of organic matter of manure, the processes of ammonification and nitrification. Correlation analysis established the dependence of the content of nitrate nitrogen in the soil on the doses of fertilizers in action in the germination phase:

4 months of storage	$y = 0,156x + 9,07$	$r = 0,90$
6 months of storage	$y = 0,121x + 11,02$	$r = 0,67$
8 months of storage	$y = 0,149x + 10,30$	$r = 0,75$
10 months of storage	$y = 0,187x + 9,61$	$r = 0,81$
12 months of storage	$y = 0,086x + 11,49$	$r = 0,71$

The supply of wheat plants with mobile forms of phosphorus under the action of manure is very high and the need for plants in this element is virtually absent (Table 5).

Table 4. Influence of storage duration and doses of cattle manure on the content of nitrate nitrogen in the soil in the 0-40 cm layer, mg / kg of soil.

Option	Storage duration (months)				
	4	6	8	10	12
Seedlings act					
Control	9,1	11,5	10,5	10,0	11,8
20 t / ha	12,1	12,0	12,6	12,2	12,3
30 t / ha	13,8	15,6	15,2	16,0	14,7
40 t / ha	14,4	14,0	18,4	20,5	21,4
50 t / ha	15,8	14,2	19,6	23,2	25,7
60 t / ha	17,1	16,1	20,6	24,5	29,1
aftereffect					
Control	10,4	11,4	10,1	10,1	10,2
20 t / ha	12,0	11,8	12,1	12,9	10,9
30 t / ha	12,5	13,5	12,2	14,5	11,5
40 t / ha	12,6	13,1	14,4	15,8	15,4
50 t / ha	14,2	15,2	15,6	16,2	16,6
60 t / ha	15,1	15,1	16,6	16,8	18,0
Cleaning act					
Control	4,2	7,4	5,6	6,6	5,4
20 t / ha	5,3	7,3	7,9	7,5	5,9
30 t / ha	6,6	8,5	6,0	7,3	5,5
40 t / ha	8,5	8,4	8,5	6,5	6,8
50 t / ha	8,9	8,3	8,4	8,3	6,7
60 t / ha	9,6	8,2	7,7	7,7	7,9
aftereffect					
Control	3,2	2,1	2,3	1,4	1,8
20 t / ha	4,8	2,5	4,5	2,2	3,9
30 t / ha	6,0	5,8	3,9	5,4	3,9
40 t / ha	5,1	4,7	3,2	5,9	3,9
50 t / ha	5,9	4,4	4,1	5,5	4,7
60 t / ha	4,4	5,3	5,4	5,9	5,6

Application of manure in doses of 40-60 t / ha after 10-12 months of storage increases the content of mobile phosphorus (according to Chirikov) in the soil by 19-71%. With the aftereffect of manure in the first year, the effect on the phosphorus content is even greater than in the action and it increases from 190-208 mg / kg in the control to 235-314 mg / kg at doses of 50 and 60 t / ha. The reason is that during that period there was a large mineralization of manure.

Table 5. Influence of storage duration and doses of cattle manure on the content of mobile phosphorus in the soil in the 0-20 cm layer, mg / kg of soil.

Option	Storage duration (months)				
	4	6	8	10	12
seedlings act					
Control	189	193	204	208	205
20 t / ha	235	265	255	235	258
30 t / ha	245	288	255	248	274
40 t / ha	260	255	268	258	292
50 t / ha	250	245	272	262	312
60 t / ha	245	250	274	270	354
aftereffect					
Control	190	195	204	208	205
20 t / ha	215	225	215	235	228
30 t / ha	223	228	235	245	234
40 t / ha	250	235	248	256	244
50 t / ha	260	245	252	261	300
60 t / ha	275	250	274	271	314
seedlings act					
Control	145	153	197	137	198
20 t / ha	156	153	176	142	218
30 t / ha	190	182	212	186	296
40 t / ha	150	120	202	174	249
50 t / ha	219	191	147	237	253
60 t / ha	219	245	159	164	323
aftereffect					
Control	159	178	254	278	284
20 t / ha	197	174	144	174	202
30 t / ha	226	180	164	221	198
40 t / ha	150	154	202	263	256
50 t / ha	215	224	160	231	284
60 t / ha	226	269	162	342	288

Observations of the potassium regime of the culture showed that the content of mobile potassium (according to Chirikov) in the soil is very high - 402-512 mg / kg of soil (Table 6). When manure is applied, the potassium content in the soil increases by more than 10-24%. The aftereffect of manure in the first year increases the content of mobile potassium in the germination phase from 303-399 in control to 340-602 mg / kg in fertilized variants.

Table 6. Influence of storage duration and doses of cattle manure on the content of mobile potassium in the soil in the 0-20 cm layer, mg / kg of soil.

Option	Storage duration (months)				
	4	6	8	10	12
seedlings					
act					
Control	434	402	408	403	399
20 t / ha	440	416	421	435	425
30 t / ha	461	437	426	453	468
40 t / ha	464	454	430	406	453
50 t / ha	480	442	452	453	506
60 t / ha	492	453	464	446	512
aftereffect					
Control	319	317	342	303	399
20 t / ha	340	386	381	435	435
30 t / ha	481	457	396	503	568
40 t / ha	384	424	397	406	413
50 t / ha	400	382	392	473	546
60 t / ha	380	463	405	486	602
seedlings					
act					
Control	362	375	438	350	350
20 t / ha	362	375	450	388	550
30 t / ha	400	400	438	538	462
40 t / ha	400	325	475	562	462
50 t / ha	388	438	450	488	475
60 t / ha	350	438	350	425	612
aftereffect					
Control	388	325	488	588	338
20 t / ha	462	350	450	450	362
30 t / ha	500	538	462	350	450
40 t / ha	525	400	550	425	438
50 t / ha	462	462	538	350	512
60 t / ha	562	488	438	412	612

4 Conclusion

Thus, per year the introduction of cattle manure in doses of 20-60 t / ha has a positive effect on the nutrient regime of the soil. The optimal storage time should be considered 8-12 months. With the introduction of manure of this storage duration in a dosage of 40-60 t / ha, the supply of plants from an average gradation turns into a very high one (more than 20.0 mg / kg of soil). The content of available phosphorus and potassium also increases significantly.

In the first year of the aftereffect, manure doses continue to affect the nutrient regime of the soil. When manure is applied for 8-12 months, the storage duration at doses of 40-60 t / ha, the supply of plants from an average gradation in nitrate nitrogen goes into high (more than 16.0 mg / kg of soil). The content of available phosphorus and potassium also increases significantly.

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