Effect of organic fertilizers on spring wheat grain yield

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Abstract. The research is based on the study of the effect of solid organic fertilizers based on cattle manure of different storage life on the yield of spring wheat. The studies were carried out in 2017-2018 at RUSKOM-Agro LLC in Omsk Region. It was established that 3.1-7.2 kg of nitrogen, 2.1-7.2 kg of phosphorus and 2.1-3.5 kg of potassium are introduced from each ton of organic fertilizer. The most effective active dose is 60 t/ha (with a storage duration of 8 months) – the increase made 1.51 t/ha, with a yield in the control version – 2.04 t/ha. The best dose in the afterinfluence was 60 t/ha (with a storage duration of 10 months) – the increase made 1.24 t/ha, with a yield in the control version – 2.09 t/ha. The cost recovery of the applied fertilizer unit (1 ton of manure) was the highest using 40 t/ha per year in action and 20-60 t/ha in the afterinfluence with a storage duration of 12 months.

1. Introduction
The soil cover of Siberia is quite diverse, and the effect of fertilizers in agriculture depends on various circumstances [1-5]. The application rates of nesting manure depend on its amount in a farm, soil and climatic conditions, state of cultivation and fertilized crops. Higher application rates are used the northern regions compared to drier southern regions; in sod-podzolic, deficient in nutrients soils they are used in larger quantities than in chernozem soils [6-9].

The level of mineral nutrition affects crop yields [10-12]. Organic fertilizers contain a significant amount of food elements and when used in agriculture they positively affect the productivity of cultivated plants [13-17].

2. Methods and Equipment
The studies were carried out in 2017-2018 at the experimental sites of RUSKOM-Agro LLC in Omsk Region and at the Department of Agrochemistry and Soil Science of Omsk State Agrarian University. The object of the study included liquid manure stored for 2, 4, 6, 8, 10, 12 months; spring wheat Memory of Asiev, soil – meadow-chernozem minor, low-humic, heavy loamy. The content in the soil before sowing: N-NO₃ – 2.14-10.2, P₂O₅ – 146-195, K₂O – 294-425 mg/kg.

The plot arrangement in the experimental site is systematic. The replication of the experiment – three. The plot area – 20 m²; accounting area – 16 m². Agricultural methods – generally accepted for the zone.

The laboratory studies were carried out at the Department of Agrochemistry and Soil Science of Omsk State Agrarian University. The content of nitrate nitrogen with phenoldisulfonic acid in soil samples was determined by Grandval-Liage; amount of labile phosphorus and potassium – from one extract according to Chirikov (GOST 26204-84).
3. Results

One of the main purposes of the study was to analyze the physicochemical composition of straw nesting manure of cattle depending on storage duration.

Information on the chemical composition of organic fertilizer based on cattle manure was obtained after analyzing the samples taken from storing bunkers at the storage site in Sosnovskoye LLC of Kormilovsky municipal district of Omsk Region (Table 1).

Table 1. Effect of storage duration on physical and chemical properties of manure

| Storage duration, months | pH | Dry matter, % | Organic matter, % | Nutrient concentration, % | Mass fraction of toxic element impurities (total ratio), mg/kg |
|--------------------------|----|---------------|-------------------|---------------------------|-------------------------------------------------------------|
|                          |    |               |                   | Total nitrogen (N)        | P₂O₅  | K₂O  | Pb  | Cd  | Hg  | As  |
| Standard                 | 6.0-8.5 | 25.0          | 50.0              | 0.30                      | 0.20  | 0.20 | 130 | 2.0 | 2.1 | 10  |
| 4                        | 8.5  | 17.8          | 87.1              | 0.31                      | 0.21  | 0.21 | 2.17| 0.41 | 0.03 | 0.20 |
| 6                        | 8.9  | 21.7          | 88.8              | 0.48                      | 0.38  | 0.23 | 2.11| 0.25 | 0.05 | 0.12 |
| 8                        | 8.8  | 21.4          | 82.4              | 0.49                      | 0.41  | 0.30 | 2.20| 0.61 | 0.11 | 0.32 |
| 10                       | 8.6  | 23.2          | 76.4              | 0.63                      | 0.51  | 0.30 | 2.31| 0.53 | 0.05 | 0.42 |
| 12                       | 8.6  | 23.2          | 70.8              | 0.72                      | 0.72  | 0.35 | 2.01| 0.32 | 0.10 | 0.18 |

The physical and chemical properties of manure depend on the storage duration. The longer the manure is stored, the higher the content of elements, the less humidity, and better the fertilizing properties. Nitrogen content in tested samples varied from 0.31 to 0.72% depending on manure storage duration, phosphorus – from 0.21 to 0.73, potassium – from 0.21 to 0.35%. At the same time, the excess of MPC for heavy metals was not observed. The content of dry matter naturally increases, while the organic matter decreases.

The chemical composition of manure is also important to determine the amount of supplied nutrients to the soil; both for calculating the balance of nutrients in crop rotation and for determining fertilizer doses for specific crops. The supply of feed elements with introduced doses of manure depends on its storage duration. Moreover, the higher the dose and longer the storage duration, the more NPK will enter the soil (Table 2).

Table 2. Supply of feed elements with different doses of manure depending on storage duration, kg/ha
The studies made it possible to conclude that 3.1-7.2 kg of nitrogen, 2.1-7.2 kg of phosphorus and 2.1-3.5 kg of potassium are introduced with each ton of organic fertilizer. Thus, as the storage time increases, the fertilizing properties of the manure are improved. At the same time, environmental indicators (the content of heavy metals) are not exceeded.

Meteorological conditions during the years of the experiments varied significantly. The growing season of 2018 was characterized by cold weather (the deviation from the average summer temperature in May was -4.8 °C, in June and August it was -0.8 and -0.9 °C, respectively). At the same time, the amount of precipitation in May exceeded the average long-term value by 39% (in June and August – by 12 and 8%, respectively).

The yield of spring wheat grain in 2018 in almost all options and storage periods was as good as the yield obtained in 2017 with more favorable growing conditions (Table 3). The data analysis shows that only in the control option, without the use of manure, wheat yields in 2018 were slightly less than in 2017. The yield was higher in options with various doses of manure of different storage duration by 0.4-11.1%. Moreover, the maximum yield excess in 2018 was noted with a manure storage life of 12 months. Probably, higher moisture availability of the growing period in 2018 contributed to higher efficiency of manure.

| Option, t/ha | Storage duration (months) | 4 | 6 | 8 | 10 | 12 |
|--------------|--------------------------|---|---|---|----|----|
|              | yield | gain | yield | gain | yield | gain | yield | gain |
| 0 | 2.07 | - | 2.07 | - | 2.03 | - | 2.07 | - |
| 20 | 2.27 | 0.20 | 2.33 | 0.26 | 2.43 | 0.40 | 2.46 | 0.39 |
| 30 | 2.47 | 0.40 | 2.67 | 0.60 | 3.07 | 1.04 | 2.80 | 0.73 |
| 40 | 2.53 | 0.46 | 2.73 | 0.66 | 3.25 | 1.22 | 2.90 | 0.83 |
| 50 | 2.70 | 0.63 | 2.80 | 0.73 | 3.30 | 1.27 | 3.27 | 1.20 |
| 60 | 2.75 | 0.68 | 2.80 | 0.73 | 3.40 | 1.37 | 3.33 | 1.26 |
| LSD05 | 0.21 | 0.18 | 0.15 | 0.29 | 0.19 |  |

The comparison of the effect of manure on the yield of spring wheat grains shows that in the second year after the application of a dose of manure of different storage duration the effect is
positive. On average, in terms of experimental options, the yield for the afterinfluence (2018) ranged from 91.8 to 94.7% of the yield in 2017. When the manure was stored for 12 months, the average yield in the options was higher at the afterinfluence.

The agronomic efficiency of fertilizers varied depending on manure storage duration and doses from 13.2 to 38.8 kg/t per year of action and from 7.3 to 23.3 at the afterinfluence (Table 4). With the action of manure, the most agronomically effective dose was 40 t/ha of manure with a storage duration of 12 months – the cost recovery of a unit of added fertilizer (1 ton of manure) was the largest – 38.8 kg of grain; the least effective – when adding 60 t/ha of manure of 4-month storage duration, where it amounted to 13.2 kg of wheat grain per ton of fertilizer.

In the afterinfluence, all doses of manure with storage duration of 12 months were most effective. The cost recovery of the added fertilizer unit (1 ton of manure) amounted to 20.3-24.5 kg of grain, and the smallest – with 40 tons/ha, where it amounted to 7.3 kg of wheat grain (4 months of storage).

### Table 4. Agronomic efficiency (cost recovery) of organic fertilizers, kg/t

| Option | Storage duration (months) | Action 4 | Action 6 | Action 8 | Action 10 | Action 12 | Afterinfluence 4 | Afterinfluence 6 | Afterinfluence 8 | Afterinfluence 10 | Afterinfluence 12 |
|--------|---------------------------|----------|----------|----------|-----------|-----------|----------------|----------------|----------------|----------------|----------------|
| 20 t/ha|                           | 18.0     | 17.5     | 20.0     | 22.0      | 27.0      | 9.5           | 13.0           | 14.5           | 8.5           | 24.5          |
| 30 t/ha|                           | 15.6     | 18.0     | 35.3     | 24.7      | 27.0      | 8.3           | 13.0           | 15.7           | 9.7           | 20.3          |
| 40 t/ha|                           | 13.5     | 18.8     | 31.0     | 22.5      | 38.8      | 7.3           | 10.3           | 20.3           | 15.8          | 23.3          |
| 50 t/ha|                           | 14.0     | 17.0     | 27.0     | 25.8      | 24.0      | 10.0          | 10.2           | 21.0           | 21.4          | 23.6          |
| 60 t/ha|                           | 13.2     | 15.8     | 25.2     | 23.2      | 22.2      | 8.8           | 8.8            | 18.3           | 20.7          | 21.3          |

### 4. Conclusion

According to the results of studies, 3.1-7.2 kg of nitrogen, 2.1-7.2 kg of phosphorus and 2.1-3.5 kg of potassium are introduced with each ton of organic fertilizer. As storage time increases, manure fertilizer properties improve. In action, the most effective was the use of manure at a dose of 60 t/ha (with a storage duration of 8 months). The increase was 1.51 t/ha with a yield in the control option of 2.04 t/ha. The best dose in the afterinfluence was 60 t/ha (with a storage duration of 10 months). The increase was 1.24 t/ha, with a yield in the control option of 2.09 t/ha. The cost recovery of the added fertilizer unit (1 ton of manure) was the highest using 40 t/ha per year in action and 20-60 t/ha in the afterinfluence with a storage duration of 12 months.

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