Forecrop Influence on Humus Formation under Novgorod Region Conditions

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Abstract. In the article, the data on the study of the forecrop influence on the spring wheat yield and humus formation in grain-fallow and grain-row crop rotations under the conditions of the D. P. Pavlyuk peasant farm household (PFH) of the Novgorod region is provided. It has been found that the yield of spring wheat and the accumulation of plant residues and humus in the soil in the crop rotation system is greatly influenced by the forecrop. Thus, as a result of the studies carried out to explore the influence of the forecrop on the yield and humus formation, it has been found that the forecrop has a great influence on the yield of grain and the accumulation of plant residues and humus in the soil in the crop rotation system. In grain-row crop rotation, spring wheat, sown after potato, demonstrated the highest grain yield (about 5.5 tonnes per hectare) and provided the output of root and crop residues of more than 6 tonnes per hectare. This led to the maximum formation of humus in the soil (about a tonne per hectare). In the grain-fallow crop rotation, the cultivation of wheat after pure fallow provided a grain yield per unit area of about 4.5 tonnes per hectare. Furthermore, 0.74 tonnes of humus were produced in the crop rotation system for the formation of the yield of the following crops. Repeated sowing of wheat provided a low grain yield of the spring grain crop. Permanent sowing of wheat formed the least amount of plant residues and humus. The humus formation was only 0.54–0.59 tonnes per hectare. This confirms the unreasonableness of using permanent sowing of wheat.

1. Introduction
Currently, in order to save resources in agriculture, the importance of soil organic matter is increasing, the reproduction of which is a prerequisite for stable agriculture [1]. The most valuable organic material of the soil is humus, the source of which is the organic remains of higher plants, microorganisms, and animals living in the soil [2].

In the crop rotation system, forecrops have a great influence on soil properties, including humus formation [3]. In addition, they also affect the growth and development of the following crops [4]. Therefore, when cultivating any agricultural crop, including wheat, it is important to ensure their rational sequence. It should ensure the maximum accumulation of soil organic matter [5]. When evaluating forecrops in the crop rotation system, it is necessary to know what effect it has on humus formation and on the growth and yield of the following crops [6].

Due to biological characteristics and cultivation technologies, field crops are an important factor in the reproduction of organic matter. In field agroecosystems, the largest part of the plant material of crops is alienated. Thus, after harvesting field crops, significantly less plant residues remain, which has a noticeable effect on the formation of humus [7].
In any crop rotation, humus formation depends on the amount of post-harvest residues. Each crop produces its residues differently. Thus, in the cultivation of high-yielding grain crops, the ratio of the main and by-products is 1:1.1, in the cultivation of potato – 1:0.14. Post-harvest residues include roots, stem bases, and crop residues in the fields. During decomposition, these residues enrich the topsoil with organic and mineral substances [8]. An increase in the yield of grain crops also leads to an increase in the amount of crop residues in the fields when these crops are harvested [9].

Currently, wheat grain is widely used in field fodder production. It is a valuable concentrated animal feed [10]. In conditions of intensive farming, in crop rotation systems, it is necessary to select agricultural crops taking into account their humus formation potential.

2. Material and research methods
The experimental part of the study of the forecrop influence in the crop rotation system on the yield of spring wheat and the formation of humus in grain-fallow and grain-row crop rotations under the conditions of the D. P. Pavlyuk peasant farm household of the Novgorod region was carried out on soft spring wheat of the “Daria” variety during 2017–2020.

Spring wheat variety is “Daria”. The tuft is upright-semi-upright. The ear is pyramidal, of medium density, white. The weight of 1000 grains is 33–38 g. This is a mid-season variety with a vegetation period of 85–95 days. Resistant to lodging. Regarding bread quality, it is valuable wheat.

The experiment was carried out on medium acid soddy-podzolic, heavy soil highly supplied with labile phosphorus and potassium. Thus, in all respects, the soil of the experimental site belonged to the category of highly cultivated soils.

Before establishment of the trials, soil analysis was carried out at the Novgorodskaya agrochemical service station. The determination of salt pH was carried out by the electrometric method; of mobile phosphorus – by the Kirsanov method; exchangeable potassium – on a flame photometer.

In the experiments, the wheat yield was taken into account by the cut-sample method in the phase of full grain ripeness.

3. Results and discussion
The leading crop in the D. P. Pavlyuk PFH crop rotation is spring wheat of the mid-season “Daria” variety, cultivated in grain-fallow and grain-row crop rotations. The farm household receives up to 5.5 tonnes of grain from a hectare of wheat. The forecrops of wheat are pure fallow, potato, and spring wheat.

Spring wheat is demanding on soil fertility and field cleanliness since its crown roots develop much more slowly than in case of other spring grain crops. Therefore, the harvesting of spring wheat grain was greatly affected by the forecrop in the crop rotation system (figure 1).

The highest yield of the grain crop was noted after the cultivation of potato when mineral fertilizers were applied in full dose. Therefore, due to the sufficient accumulation of nutrients and the cleanliness of the fields, spring wheat provided about 5.5 tonnes of grain per hectare. At the same time, the increase in yield, compared with permanent sowing of wheat, was about 67%.

In pure fallow, the farm household carried out activities aimed at accumulating moisture and nutrients for the following crops. The grain harvest from a hectare of wheat cultivated after pure fallow amounted to about 4.5 tonnes. At the same time, the increase in yield, compared to the control, was more than 37%.
Figure 1. Forecrop influence on spring wheat yield.

In repeated sowing, the wheat quickly became weedy. The most common weed was barnyard grass, a spring annual plant. The abundance of barnyard grass in the crops of spring wheat led to a high weeddiness level, the appearance of diseases, the deterioration of the conditions of mineral nutrition, as well as to a significant decrease in the yield. The grain yield in this variant was the lowest and amounted to about 3.3 tonnes per hectare.

When studying the influence of the forecrop on the formation of humus in grain-fallow and grain-row crop rotations, it was found that crop rotation crops had a great influence on the formation of wheat yield and, consequently, on the yield of root and crop residues and humus formation (table 1).

Table 1. Humus formation in various types of crop rotations.

| Crop rotation type | Crop rotation crop | Input of post-harvest residues, t per ha | Humus formation, t per ha |
|--------------------|--------------------|----------------------------------------|--------------------------|
| Grain-fallow       | Pure fallow        | –                                      | –                        |
|                    | Spring wheat       | 3.59                                   | 0.74                     |
|                    | Spring wheat       | 3.26                                   | 0.54                     |
| Grain-row          | Potato             | 4.9                                    | 0.25                     |
|                    | Spring wheat       | 6.01                                   | 0.9                      |
|                    | Spring wheat       | 3.96                                   | 0.59                     |

In pure fallow, the farm household carried out activities aimed at accumulating moisture and nutrients for the following crops. Therefore, in the grain-fallow crop rotation, the yield of spring wheat cultivated after pure fallow was about 4.5 tonnes. At the same time, 0.74 tonnes of humus were produced in the crop rotation system to form the yield of the following crops. Due to the high weeddiness level, permanent sowing of spring wheat demonstrated a decrease in yield by 27%, compared with wheat cultivation after pure fallow. The formation of humus also decreased and amounted to 0.54 tonnes per hectare.

The lowest amount of humus was formed by potato. The yield of 35 tonnes per hectare provided the input of plant residues in the amount of 4.9 per hectare, which corresponded to the formation of 0.25 tonnes of humus per hectare.
In this grain-row crop rotation, spring wheat, sown after potato, formed the highest grain yield and ensured the output of root and crop residues of more than 6 tonnes per hectare. This led to the maximum formation of humus in the soil (about a tonne per hectare). The heavily weedy repeated sowing of spring wheat after cultivation formed 34% less humus, which corresponded to 0.59 tonnes of humus per hectare.

4. Conclusion
Thus, as a result of the studies carried out to explore the influence of the forecrop on the yield and the formation of humus in grain-fallow and grain-row crop rotations in the conditions of the D. P. Pavlyuk peasant farm household of the Novgorod region, it has been established that the forecrop does have a great influence on the yield of grain and the accumulation of plant residues and humus in the soil in the crop rotation system.

In the grain-row crop rotation, spring wheat, sown after potato, produced the highest grain yield (about 5.5 tonnes per hectare) and provided the output of root and crop residues of more than 6 tonnes per hectare. This led to the maximum formation of humus in the soil (about a tonne per hectare).

In the grain-fallow crop rotation, the cultivation of wheat after pure fallow provided a grain yield per unit area of about 4.5 tonnes per hectare. At the same time, for the formation of the yield of the following crops, 0.74 tonnes of humus were produced in the crop rotation system.

Repeated sowing of wheat provided a low grain yield of the spring grain crop. Permanent sowing of wheat produced the least amount of plant residues and humus. Humus formation was only 0.54–0.59 tonnes per hectare. This confirms the unreasonableness of using permanent sowing of wheat.

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