

Conference Paper

Preservation of Soil Fertility Using Sidereal Clover

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ORCID:Galina Zelenskay: <http://orcid.org/0000-0002-1537-9207>**Abstract**

This study examined the use of intermediate groundcover sidereal crops, such as perennial leguminous herbs, to conserve soil fertility through enriching the soil with fresh organic matter, an effective and low-cost method. Studies show that the use of direct sowing technology allows the preservation of all plant residues on the soil surface, which ensures the best accumulation of snow in the winter. Through the preservation of numerous biotines from the root system of sweet clover and other cultivated crops, as well as soil channels from earthworms, this direct sowing technology increases the moisture content of the soil and reduces moisture loss. The effectiveness of various soybean, corn and sunflower cultivation technologies with a minimal tillage period was studied. When sweet clover was used for green manure in April, the maximum yield was obtained, and the maximum yield for corn (57.3–82.3 c/ha) was obtained using the no-till technology. As a consequence, the ground cover crop had a noticeable effect on the yield of the second crop rotation - spring wheat, which had a higher yield. The use of direct sowing technology with sweet clover as green manure provided the highest yield of spring wheat - from 37.2 to 39.8 c / ha. The grain quality of spring wheat, placed as the second crop after melilot on green manure, was higher, both under no-till technology and under mini-till technology.

Keywords: biologization, soil fertility, green manure, clover, direct sowing, productivity.

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1. Introduction

Optimization of organic matter in the soil and reduction of energy consumption require a new concept of the resource-saving agriculture. Almost all soils are characterized by degradation [1].

The main reason for poor soil fertility is that the existing farming systems are simplified and do not meet the natural principle of increasing the soil productivity. At the same time, it is necessary to admit that in recent years the country has seen an increase in grain crops; however, an increase in crop production is accompanied by large expenditures

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of labor, energy, increased removal of nutrients, increased aridity of the climate and activation of degradation processes [2-4].

In many regions of the Russian Federation, the use of mineral and, especially, organic fertilizers has decreased, which negatively affects the stability of agricultural production and worsens soil fertility. When we talk about soil depletion and its low fertility, this means that its agrophysical properties have lost their former optimal state, and the organic matter content has decreased by more than 50% [5]. In solving these urgent problems, soil enrichment with fresh organic matter is paramount [6]. To increase the organic matter in the soil, crop residues from cereal straw, sunflower stalks, corn and other crops can be used, but their chemical composition requires additional compensation doses of nitrogen fertilizers. One of the effective and low-cost methods of enriching the soil with fresh organic matter is cultivation of intermediate ground-cover sideral crops, such as perennial leguminous herbs and cruciferous crops [7-8]

Soil enrichment with organic matter activates the soil biota, the biological nitrogen reduces the N: C ratio to 1: 35-40 and activates the microbiological potential of soils [9-11]

Currently, in many farms, field crop rotation is oversaturated with cereal crops whose residues are characterized by a high carbon content [11-13]. Therefore, the use of perennial leguminous grasses as side-cover green manure crops will reduce nitrogen deficiency and activate the soil biota. In our studies, we used yellow clover, which has a number of valuable morphological and biological features, such as unpretentiousness to soil fertility, high resistance to moisture deficiency and low temperatures [14-15]. In addition, sweet clover is easy to introduce into any crop rotation, it has a high seed reproduction rate and increased ability to restore soil fertility.

2. Methods and Equipment

The studies were carried out in the Bogorodsky district of Nizhny Novgorod region on the fields of Iskra LLC in 2016-2019. The soil was light gray forest, light loamy. The depth of the arable horizon was 20-25 cm, the humus content was low - 1.5%; P₂O₅ - 250 mg / kg; K₂O - 180 mg / kg; pH 5.2.

The prevailing weather conditions were different in terms of moisture and temperatures, which made it possible to evaluate the effectiveness of the agricultural methods for increasing crop productivity of crop rotation units. The research was carried out in the field crop rotation link "binary sowing of spring barley with yellow melilot - soybean, corn, sunflower - spring wheat". Two soil preparation technologies were studied: surface

(Mini-till) - disking, 6-8 cm and direct sowing (No-till). Yellow clover was sown in binary sowing with spring barley using Gerardi 117, the barley sowing rate was 3.5 million units / ha, and the clover sowing rate was 4 million units / ha.

Second year sweet clover was used as a ground-side green crop, which was harvested for two periods: the third decade of April and the second decade of May. The control was taken as a variant of spring barley without clover sowing. When choosing the term for using clover for green manure, we took into account the results of our previous studies and climatic conditions of the Bogorodsky district of Nizhny Novgorod region.

According to our data, it is more expedient and profitable to use yellow clover in the stem phase, when the height of plants is no more than 25-30 cm. During this period, there is a lot of moisture in the soil, the plants are quite tender and quickly mineralized. In addition, the root system of sweet clover does not develop during the second year.

3. Results

The maximum accumulation of nutrients in plants reaches the optimal level by the end of April-early May, after which the content of nutrients begins to decline.

Many farmers use clover in the phase of budding and do not get the desired result. During the prolonged vegetation period, clover drains the soil to a great depth, so that the sidual mass is mineralized very slowly. Our studies confirm these findings (Table 1).

Table 1 shows that the extending vegetation period before budding (late May – early June) ensures the high biological productivity. Thus, the biological yield of sweet clover averaged 25.14 t / ha, or 5.68 t / ha more than in the first variant.

With the late use of sweet clover, more NPK is supplied to the soil for green manure. However, the use of this option for soybean, corn and sunflower is impossible, since the soil is very dry and the optimal timing for sowing crops is violated. In our opinion, the third option, where the clover was used for green manure in the phase of budding, can be used for sowing winter or spring wheat with a normal green manure.

In Nizhny Novgorod region, the most acceptable terms for using clover for green manure are the first and second experimental options in combination with a direct sowing technology. The use of the direct sowing technology allowed us to save all plant residues on the soil surface, which provides the best snow accumulation in winter. In addition, this technology increases the moisture soil capacity due to the conservation

of numerous bio-drains from the clover root system, as well as soil channels from earthworms. The direct sowing technology reduces moisture losses through evaporation, as crop residues remain on the soil surface.

TABLE 1: Plant clover residues in the soil and NPK content in biomass (average for 2016-2019)

The phase of development of plants when harvesting for green manure	Plant residues, t / ha			Content of nutrition elements, kg / ha		
	aboveground mass	roots in the soil layer of 0-30 cm	total	N	P ₂ O ₅	K ₂ O
Spring renewal of vegetation, III decade of April	13,80	5,66	19,46	67,3	15,2	34,5
Formation of lateral shoots, II decade of May	15,73	6,95	22,68	92,6	21,3	47,6
Start of budding, III decade of May I decade of June	18,02	7,12	25,14	99,1	22,0	52,6

The studies have found that minimal disturbance in the structure of the upper soil layers using the No-till technology for variants with green sidereal plants contributes to an increase in the number of earthworms in the arable layer. In the control option, the number of earthworms was 1.8 pcs / m², or 13.5 and 14.6 pcs / m² less than with the No-till technology. When using the Mini-till technology, the number of earthworms was higher compared to the control option, but less than with direct seeding by 7.9 and 9.0 pcs / m². With the justified use of clover for green manure, there is a real possibility of the rational use of sediments accumulated in the soil.

In the direct sowing system, a permanent biologically active topsoil covered with plant debris is created. It protects the soil from overheating and cracking, and retains moisture.

In identifying available moisture before sowing spring crops, we determined a significant difference in option 3, where clover vegetated until the second decade of May. According to the available moisture content in the upper soil layer, the difference between the control option and the option with sweet clover harvested at the end of April using the No-till technology was 1.2 mm; with a late harvesting period, it was 3.3 mm less. After harvesting the cover crop, the flow of moisture for transpiration by plants ceases, but the loss of moisture due to its physical evaporation from the soil increases.

In this regard, the non-productive consumption of moisture depends on the thickness of a mulching layer of plant debris on the soil surface and a crop cultivation technology.

Studies have established that during the full germination, the temperature did not exceed 20.2-24.0 ° C, or it was 12.6-8.8 °C less than in the control option.

4. Discussion

The results of the observations indicate that the use of the No-till technology decreases soil desiccation and contributes to the optimal development of plants. Accounting for the yield of soybean, corn and sunflower showed that in Nizhny Novgorod region, the cultivation of a ground-cover sidereal crop in combination using the direct sowing technology increases the crop yield (Table 2).

Table 2 shows that the experimental variant where clover was used for green manure in the third decade of April is efficient. It should be noted that in all the variants with the No-till technology, a steady increase in productivity was obtained. Over the research years, the maximum yield was formed by corn - 57.3-82.3 c/ha.

TABLE 2: The effect of sweet clover on the yield of spring crops with various soil preparation technologies, kg / ha

Options		Effect of sweet clover			Clover effect Spring wheat		
sidereal crop (factor A)	tillage (factor B)	soybeans	corn	sunflower	soybeans	corn	sunflower
No sidereal crop (control)	Mini-till	10,3	57,3	7,6	28,2	25,7	23,1
	No-till	13,2	58,6	10,3	33,0	27,0	24,7
Sweet clover for producing green manure, harvesting in the third decade of April	Mini-till	14,7	66,0	13,0	35,4	32,3	29,9
	No-till	17,3	82,3	14,7	39,8	34,4	33,1
Sweet clover for producing green manure, harvesting in the second decade of May	Mini-till	12,0	62,7	10,3	34,9	31,6	31,7
	No-till	14,3	70,0	12,7	37,2	33,8	33,1
HCP ₀₅ AB		±1,6	±8,4	±2,0	±2,9	±3,0	±2,6

The ground cover crop had a noticeable effect on the second crop rotation link crop yield - spring wheat. At the same time, the best links were the crop rotation “clover of the second year – soy – spring wheat”, where the yield of spring wheat was higher than that of other predecessors. The use of the No-till technology for sowing spring wheat

(the effect of sweet clover for green manure) provided the highest yield - from 37.2 to 39.8 c / ha.

When determining quality of spring wheat grain, an increase in protein was established. In the grain of wheat grown after soybean, whose precursor was clover (option No. 3), the protein content was 12.1% with the No-till technology, and 0.3% more with the minimal treatment. High quality of spring wheat grains grown after clover (option No. 2) was observed for both the No-till and Mini-till technologies.

5. Conclusion

The studies allowed us to conclude that for many farms the use of clover for green manure is promising. With a shortage of manure, clover as a sideral crop should be used to improve soil fertility and productivity of field crops. The effectiveness of sideral crops increases with the use of a direct sowing technology.

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Conflict of Interest

The authors have no conflict of interest to declare.

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