Effect of green manuring on the phytosanitary condition of agrocenosis and the yield of winter rye during the development of fallow land

A N Kuzminykh, S I Novoselov and G I Pashkova
Mari State University, Yoshkar-Ola, Russia

E-mail: aliks06-71@mail.ru

Abstract. Land resources were and continue to be one of the main natural resources of any state, the rational use of which depends on its food security, political stability and economic independence. The reformation of the Russian agroindustrial complex in the 90-ies of XX century, due to the transition to market relations, led to the fact that significant areas of arable land have been transferred to the country's deposits. However, now to eliminate the negative phenomena that have arisen in agriculture, it is necessary to involve previously abandoned lands in the circulation, which are often in poor phytosanitary and cultural-technical condition.

Researches on studying of influence of a sideration on optimization of a phytosanitary condition of agrocnosis and the yield of winter rye on sod-podzolic soil of the Eastern part of the Volga-Vyatka zone in the development of fallow lands are conducted. The effectiveness of the use of sideration is revealed. By cultivating of a winter rye on a green manure fallow the phytosanitary condition of crops improves and grain yield significantly increases. Accounting of a contamination of winter rye crops showed that the use of sideration promotes weed control. Preliminary sideration of a fallow land and the subsequent cultivation of winter rye on a green manure fallow reduced contamination of a culture agrocnosis at 18.0-20.0% in comparison with the cultivation on occupy fallow and 11.2-12.2 % – on a fallow land. Winter rye cultivated on a green manure fallow, in comparison with the cultivation on occupy fallow, was exposed less to diseases. The development and distribution of snow mold was lower on 20.0% and 6.1%, root rot – 16.7-17.8 and 13.7 to 15.3% respectively, and the development of Helminthosporium and Septoria blotch – 3.5-11.2 and the 38.4-46.2 % and the spread, respectively, 10.8-13.7 and 24.3-30.8 %, depending on the phenological phases of development and growth of winter rye. The grain yield of winter rye in the cultivation on a green manure fallow was 2.72 t/ha, which 830 kg/ha are more than control variant and on 730 kg/ha in comparison with the placement of a fallow land.

1. Introduction
Among natural wealth of the planet land resources take a special place. Russia is among the countries most endowed with them. Food security, political stability and economic independence of the state depend on how effectively the state uses the land. Before the reform of the agricultural sector, the Russian Federation had arable land amounting to 133-134 million hectares. But since 1992 has been developed and remains a steady tendency of a conclusion from a circulation of arable land of earlier sowed lands. According to official sources now in the Russian Federation arable land are currently out of circulation and does’t use up to 20 million hectares. The greatest reduction of arable lands was in
the Non-Chernozem zone, Lower Volga region, the South of Eastern Siberia and Primorski Krai [1].

The transition to market relations and reformation of the agricultural sector of the Russian Federation led to the fact that a significant part of the country's food was imported from other States. Russia was dependent on food imports – there was a threat to the country's food security. Therefore now one of the priority directions of the country's agricultural development should be a more rational and efficient using of cultivated agricultural lands and the involvement in circulation of previously abandoned lands in the fallow land, which are often for different reasons in condition of degradation.

In the Non-Chernozem zone of Russia, one of the reasons for the instability of high yields of crops is the low level of soil fertility. If 15-20 years ago the increase of crop production in the country was solved largely through the using of chemical agents, in recent years more attention is paid to biological agriculture.

One of the main means of biological agriculture, conservation and improvement of soil fertility, improvement of phytosanitary state of agrocenoses is the use of siderations [2-9].

2. Methodology of research
The purpose of the researches is to determine the effect of green fertilizer on the optimization of the phytosanitary condition of agrocenoses and the yield of winter rye on soddy podzolic soil of the Eastern part of the Volga-Vyatka area by the development of fallow land. The researches carried out in the link of crop rotation in 2010-2012 on the experimental field of Mari State university. Winter rye was cultivated on the following steam predecessors:

- Pure fallow (control);
- Fallow land;
- Green-manured fallow;
- Occupy fallow.

The soil of experimental area is sod-podzolic medium loam, the content of hydrolysis nitrogen was 60-75, mobile phosphorus was 220-230 and exchange potassium was 100-110 mg/kg, pH$_{sol}$ – 6.1. Frequency of experience is triple. The total area of allotment is 60, accounting area is 54 m$^2$.

In an occupy fallow and on green manure cultivated vetch-oats mixture. The processing of pure steam was conducted as black. The harvest of the crops grown in the steam and the plowing of green manure was performed 30 days before sowing of winter rye. With the biological mass of green manure and weed-field vegetation fallow lands in the soil, wrapped respectively 3.62 and 1.16 t/ha of absolutely dry organic matter, including 186.7 and 48.8 kg/ha of NPK. Winter rye (variety Tatiana) were sown in the optimum time for a zone with the norm 6.0 million viable seeds per hectare. Technology of cultivation of winter rye was common for the area. Observations, surveys and analysis were conducted on relevant procedures.

3. Results and considerations
By cultivating of winter crops, field germination of seeds and the number of survivors after wintering are important to ensure the optimal density of the standing of plants per unit of sown area during the growing season. The results of the studies showed that the field germination of winter rye depending on the option was 70.6-73.4 % (table 1). Thus, higher germination was in the cultivation of winter rye on a green manure fallow of 73.2 %. In other options is significantly lower.

Analysis of the spring inventory of winter rye crops showed that, depending on the option, the number of overwintered plants ranged from 181.5 to 232.3 pieces/m$^2$. Records showed that the best overwintered winter rye, hosted by green manure fallow 51.9 %.

Often, the involvement of fallow lands in agricultural circulation is associated with the problem of their extremely unsatisfactory phytosanitary condition. The arable land withdrawn usually goes from the economic circulation into the category of the thrown lands – it is transformed into fallow land, overgrown with weed-field vegetation. Fallow lands become reserves of weeds, pests and diseases of
agricultural crops.

Table 1. Field germination and overwintering of winter rye.

| Versions of the experiments         | Field germination | Overwintering |
|-------------------------------------|-------------------|---------------|
|                                     | pieces/m²         | %             | pieces/m² | %             |
| Pure fallow (control)               | 430.9             | 71.8          | 181.5     | 42.1          |
| Fallow land                         | 424.6             | 70.7          | 190.1     | 44.8          |
| Green-manured fallow                | 439.3             | 73.2          | 228.3     | 51.9          |
| Occupy fallow                       | 428.5             | 70.0          | 198.3     | 46.3          |
| SSD₀₅                               | 2.0               | 1.9           |

Consideration of contamination of winter rye crops showed that application of sideration helps to control weeds. So, prior sideration of fallow land and subsequent cultivation of winter rye by a green-manured fallow reduced contamination of agricultural lands culture in 18.0-20.0 % in comparison with cultivation on the occupy fallow and on 11.2-12.2 % – on fallow land (table 2). However, the use of pure fallow was more effective in weed control.

Table 2. The contamination of winter rye crops, pieces/m².

| Versions of the experiments         | Spring regrowth | Before harvest |
|-------------------------------------|-----------------|----------------|
|                                     | just among them | just among them |
|                                     | juvenile | perennial | juvenile | perennial |
| Pure fallow (control)               | 32       | 22       | 10       | 25       | 15       | 10       |
| Fallow land                         | 41       | 25       | 16       | 36       | 22       | 14       |
| Green-manured fallow                | 36       | 23       | 13       | 32       | 19       | 13       |
| Occupy fallow                       | 45       | 26       | 19       | 39       | 23       | 16       |
| SSD₀₅                               | 2.9      | 2.0      |

Analysis of the weed vegetation structure showed that winter rye crops were mainly clogged with juvenile weed plants. From spring met such weeds as Fumaria officinalis, Caleopsis tetrahit, Senecio vulgaris, Myagrum perfoliatum, Echinochloa crus-galli, Polygonum hidropiper, from wintering – Centaurea cyanus, Matricaria perforata merat, Thlaspi arvense and Capsella bursa-pastoris.

There were few perennial weeds. Of these, the largest spread was Sonchus arvensis, Cirsium arvense, Linaria vulgaris, Convolvulus arvensis and Equisetum arvense.

Winter rye, mostly, amazed pathogenic fungi Fusarium nivale Cas., Helminthosporium sativum Pammel, Septoria nodorum Berk. and root rot (table 3). The spring inventory of winter rye crops showed that the disease caused by the pathogenic fungus Fusarium nivale Cas., it had a uniformly scattered nature of the lesion, which contributed to the favorable conditions of wintering culture in the years of research. Significantly smaller development of the disease, at the same time, was at cultivation of winter rye on fallow land – 1.2 %. And the differences of distribution of this disease between the variants of experience was not significant.

The species composition of root rot pathogens is usually mixed and called mainly by various kinds of pathogenic fungi of the genus Fusarium spp. and by the fungus Drechslera sorokiniana Sacc. Observations of the phytosanitary condition of crops revealed that the development of root rot on winter rye in the cultivation of green-manured fallow was less by 16.7-17.8 % compared with the cultivation of occupy fallow and up to 7.5 % – pure fallows, and the spread of infection is 13.7-15.3 and 7.5-14.0% lower, respectively. If this was the least affected by root rot plants of winter rye cultivated on fallow land.
Table 3. Development and spread of diseases on winter rye crops, %.

| Versions of the experiments | Fusarium nivale Cas. before sowing | Root rot milky wax ripeness before sowing | Leaf spotting Helminthosporium sativum Pammel before sowing | Septoria nodorum Berk. before sowing | Leaf spotting Helminthosporium sativum Pammel earring | Septoria nodorum Berk. earring |
|-----------------------------|-----------------------------------|-----------------------------------------|-------------------------------------------------|---------------------------------|-----------------------------------|-------------------------------|
| **Pure fallow**             | 2.7 R 10.1 P                      | 4.0 R 12.9 P                            | 24.0 R 15.1 P                                    | 1.0 R 3.2 P                       | 2.0 R 7.3 P                        |                               |
| Fallow land                 | 1.2 R 10.0 P                      | 2.8 R 10.2 P                            | 20.3 R 14.2 P                                    | 1.1 R 3.1 P                       | 2.1 R 6.9 P                        |                               |
| Green-manured fallow        | 2.0 R 9.3 P                       | 3.7 R 11.1 P                            | 22.2 R 13.9 P                                    | 0.7 R 2.5 P                       | 1.5 R 4.5 P                        |                               |
| Occupy fallow              | 2.5 R 9.9 P                       | 4.5 R 13.1 P                            | 25.7 R 16.1 P                                    | 1.3 R 3.3 P                       | 2.3 R 6.5 P                        |                               |

Remark: R – disease development, P – spreading disease.

Helminthosporium leaf spot of winter rye called pathogenic fungus Helminthosporium sativum Pammel, and Septoria leaf spot – Septoria nodorum Berk. The results of the diagnosis of damage to crops showed that winter rye, grown on green-manured fallow, in comparison with the cultivation occupy fallow less struck leaf spots. Thus, the development of Helminthosporium and Septoria blotch was below 3.5-11.2 and 38.4-46.2 %, and distribution-respectively 10.8-13.7 and 24.3-30.8 %, depending on the phenological phase of development and growth of winter rye.

An indicator characterizing the overall activity of soil biota is the intensity of decomposition of cellulose by destroying microorganisms. Microbiological activity of the topsoil, on average for years of researches, on variants of experience was high. The stronger activity of soil microorganisms was observed in the cultivation of winter rye by green-manured fallow – 86.0% of linen cloth was decomposed and the degree of activity at the same time was very strong (table 4). In other variants, the percentage of decomposed tissue was 24.8-37.5% lower and amounted to 53.8-64.7%, but the degree of microbiological activity of the soil remained strong. Studies have revealed that the use of green fertilizer significantly increases the microbiological activity of the soil. In comparison with the control pure fallow, the sideration increased the degree of decomposition of linen cloth by 1.6 times.

Table 4. Microbiological activity 0-20 cm of soil layer.

| Versions of the experiments | The proportion of decomposed tissue, % | Degree of activity |
|-----------------------------|---------------------------------------|--------------------|
| **Pure fallow (control)**   | 54.6 strong                           |                    |
| Fallow land                 | 64.7 strong                           |                    |
| Green-manured fallow        | 86.0 very strong                      |                    |
| Occupy fallow              | 53.8 strong                           |                    |
| SSD05                      | 3.4 strong                            |                    |

The results of these studies showed that higher yields of grain and a significant yield increase were in the cultivation of winter rye on a green manure a fallow and was 2.72 t/ha, which is 830 kg/ha more than control variant and 730 kg/ha in comparison with the placement of fallow lands (table 5). In other variants, the yield was 26.9-32.8 % below.
**Table 5.** The grain yield of winter rye.

| Versions of the experiments | Grain yield, t/ha | +,- to control, kg/ha |
|-----------------------------|-------------------|-----------------------|
| Pure fallow (control)       | 1.89              | -                     |
| Fallow land                 | 1.99              | +10                   |
| Green-manured fallow        | 2.72              | +830                  |
| Occupy fallow               | 1.83              | -60                   |
| SSD<sub>05</sub>            | 0.15              |                       |

The analysis of elements of the crop structure gives the most complete idea of the nature of crop yield formation. Analysis of the structure of the crop (table 6) revealed that higher grain yield of winter rye cultivated for green manure fallow, is caused by such elements such as productive tillering – 3.3, the number of grains per spike – 39.9 pieces and weight of 1000 grains – 40.9 g. In other variants, indicators of the structure of crops was somewhat lower.

**Table 6.** Structure of yield of winter rye.

| Versions of the experiments | Productive of tillering | Length of spike, cm | The number of kernels per spike, pieces | Weight of 1000 grains, g |
|-----------------------------|-------------------------|---------------------|----------------------------------------|------------------------|
| Pure fallow (control)       | 3.1                     | 8.9                 | 34.0                                   | 39.9                   |
| Fallow land                 | 2.9                     | 8.7                 | 33.9                                   | 37.3                   |
| Green-manured fallow        | 3.3                     | 10.2                | 39.9                                   | 40.9                   |
| Occupy fallow               | 3.2                     | 8.2                 | 35.4                                   | 39.0                   |

4. Conclusion

So the results of the conducted researches allow to conclude that the use of green manuring in the development of fallow lands could become one of ways of improvement of agricultural lands, obtaining high stable yields of agricultural crops. Studies have shown that the cultivation of winter rye after preliminary sedation of the fallow land improves the phytosanitary condition of crops and significantly increases the yield of grain.

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