The phytomeliorating effect of spring rape in rice crop rotation in the Republic of Kalmykia

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Abstract. Mid-crops accelerate rice field soil cultivation and increase rice yields. When spring rape is introduced into the rice crop rotation, the soil acquires an increased ability to restore the soil layer. The bulk density of soil in the rice–spring rape crop rotation decreases by 8 ... 10%. When cultivating rice on a reclamation field, this indicator increases by 4 ... 6%. It has been established that rapeseed crops have phytomeliorative properties, improve the ameliorative state of rice fields, have a positive effect on the fertility of brown semi-desert soil, and increase rice productivity.

1. Introduction
To increase the yield of fodder products, in addition to perennial grasses in rice sieve rotations, it is possible to use mid crops, which also serve as the grandfather's reserve for increasing the crop production from a unit of area. One of such crops in rice crop rotations can be spring rape. During the growing season, mid crops make full use of climatic factors such as heat, moisture and fertility of irrigated areas. Such crops allow the soil to be enriched. Cultivation of intermediate phytomeliorant crops allows rapeseed to use heat, silty moisture and fertility of irrigated lands; the additional volume of rice production is obtained in the form of green artemic fodder. The soil becomes enriched with organic matter due to the receipt of root and mowing plant residues behind the plant. This contributes to an increase in rice productivity and accelerates the processes of soil rape cultivation [1].

As a fodder crop, spring rape is a necessary source of fodder protein. The fodder and nutritional value of spring rape is much higher than in many other agricultural inundated crops. The green mass of rape, which is a valuable type of fodder, has a higher protein content than legumes [2].

The aim of the study is to increase the productivity of rice fields by cultivating spring rape as a phytomeliorant. It also increases the amount of moisture after rice cultivation.

2. Materials and methods
In the conditions of the rice irrigation system, located on the territory of the Federal State Unitary Enterprise "Kharada" of Oktyabrsky District of the Republic of Kalmykia, experiments were conducted to study the formation of the aboveground mass and plant residues of spring rape. The territory of the experimental site is represented by brown semi-desert medium and heavy loamy soils.
with the following indicators: bulk density of the arable layer is 1.27 ... 1.32 t/m\(^3\), down the profile, the bulk density increases and in the 1-meter layer it is 1.68 t/m\(^3\), the nitrogen content in the active layer is low - 35.2 ... 49.1 mg/kg, the content of mobile phosphorus is increased - 36.3 ... 41.2 mg/kg, the content of exchangeable potassium is high - 431 ... 464 mg/kg, the lowest moisture capacity in the layer of 0 ... 0.4 m is 1.12 ... 1.26%. The soils are weakly and moderately saline, the type of salinity is chloride-sulfate, the total of soluble salts in the meter layer is 0.103 to 0.256%. Ground waters are found at a depth of 1.4 ... 2.0 m, chloride-sulphate-sodium-calcium with a salinity of 2.9 ... 4.2 g/l [3].

![Image](image.jpg)

Figure 1. The experiment

3. Results

The important agrotechnical value of spring rape as a catch crop has been established when it is cultivated in a rice crop rotation as a reclamation crop. Inaccessible soil phosphates are converted into forms that are assimilable, which significantly improves the phosphorus nutrition of plants. The aboveground mass of spring rape is rich in protein (up to 32% for absolutely dry matter), vitamins, minerals (phosphorus, calcium, sulfur, etc.). As a green fertilizer with systematic plowing for seven years, the aboveground mass of catch crops increases the content of humus and total carbon by 0.17 and 0.12%, respectively, even with long-term permanent cultivation of rice.

Thus, an increase in the productivity of the main crop in the rice crop rotation, as well as the creation of optimal conditions for the growth and development of rice are possible with the cultivation of catch crops as green fertilizers [4].

It was found that with permanent sowing of rice, the density of soil in the active root layer (0 ... 40 cm) increases by 2 ... 3%. The ability of soil to restore the optimal structure can be improved by including spring rapeseed in the rice-rice link of the rice crop rotation. When cultivating the main crop after reclamation and inclusion of spring rape, soil density reduced by 8 ... 10%.
Figure 2. Seedlings of spring rapeseed on a rice check

An analysis of the data showed that in the rice-spring rape crop rotation link, the total porosity and porosity of aeration increase by 4 ... 6% and 8 ... 11%, respectively. They become optimal in the cultivation of spring rapeseed in the ameliorative field of rice crop rotation. When spring rape is included in the rice crop rotation, the cultivation has a positive effect on the structural condition of soil. During the growing season, spring rape forms a dense herbage, with a significant increase in the aboveground mass and root system. At the same time, the amount of the most valuable soil aggregates with a particle size of 0.25 ... 10 mm increases by 9.96 ... 16.06%, respectively, and the density of soil composition decreases, which favorably affects the development of agricultural crops.

The predominance of aerobic processes in the soil causing the redistribution of soil fractions was observed during the cultivation of a dry land crop. Such processes occur due to a decrease in dusty particles and an increase in the share of valuable aggregates (Figure 3). The structural coefficient increases by 0.55 ... 0.78.

Figure 3. Change in the content of agronomically valuable, blocky and silty particles as a result of spring rapeseed cultivation in the rice crop rotation link
The bulk of rice roots is located at a depth of 20-30 cm. The value of the arable horizon for rice is more important than for many other crops. Improving the nutrition of rice crops and maximizing the preservation of fertility are prerequisites for soil restoration. These conditions are possible only if they are provided with an energy material. An increase in the biological activity of the soil of rice fields and its fertility is possible due to the additional supply of plant residues of spring rape [5].

Table 1. Accumulation of plant residues in the soil after cultivation of spring rape, t/ha

| Nitrogen nutrition level, kg d.w./ha | Sowing norms, million pcs/ha | Crop residues | Weight of roots | Total root and crop residues |
|--------------------------------------|------------------------------|---------------|----------------|-----------------------------|
| without fertilizers (control)        |                              |               |                |                             |
| 1.5                                  | 0.30                         | 1.66          | 1.96           |
| 2.0                                  | 0.35                         | 1.78          | 2.13           |
| 2.5                                  | 0.38                         | 1.97          | 2.35           |
| 3.0                                  | 0.36                         | 1.83          | 2.19           |
| 1.5                                  | 0.41                         | 2.15          | 2.56           |
| 2.0                                  | 0.44                         | 2.37          | 2.81           |
| N\textsubscript{90}                  |                              |               |                |                             |
| 2.5                                  | 0.48                         | 2.68          | 3.16           |
| 3.0                                  | 0.43                         | 2.53          | 2.96           |
| 1.5                                  | 0.60                         | 3.07          | 3.67           |
| 2.0                                  | 0.69                         | 3.23          | 3.92           |
| N\textsubscript{120}                 |                              |               |                |                             |
| 2.5                                  | 0.79                         | 3.35          | 4.14           |
| 3.0                                  | 0.75                         | 3.27          | 4.02           |

According to the data obtained, the total amount of plant residues of spring rape varied from 1.96 to 4.14 t/ha (Table 1). The largest amount of root and crop residues is observed in the variant of nitrogen fertilization at a dose of N120 kg/ha a.i.

When included in rice crop rotations, catch crops contribute to the more active humus formation. Chemical and microbiological soil processes during the decomposition of organic matter change with constant flooding of rice fields. In flooded old arable fields, the decomposition of organic matter occurs at a slower pace due to a weak oxygen supply [6].

The upper arable horizon of the rice paddy soil is usually more fertile. Plowing rapeseed residues into the surface soil horizon of rice fields creates an additional supply of organic matter to the soil, which significantly enhances its biological activity. At the same time, the main nutrients become more accessible for rice plants, the conditions for their absorption are improved. It structures the arable horizon.

4. Conclusion

It was found that rape crops have a phytomeliorative effect on the fertility of brown semi-desert soil, the reclamation state of rice fields improves, and the yield of rice increases. The soil and climatic conditions of the Sarpinskaya lowland meet the biological requirements of spring rape cultivated in a rice crop rotation. The phytomeliorating effect of spring rapeseed in rice crop rotation is as follows: improvement of water-physical properties (porosity of aeration and total porosity increase by 8 ... 11% and 4 ... 6%, respectively); bulk density is reduced by 8 ... 10%; the number of valuable soil aggregates (0.25 ... 10 mm) increases by 9.96 ... 16.06%, the structural coefficient increases by 0.55 ... 0.78; the risk of flooding the territory and the level of groundwater are reduced by 34%. The decomposition of rapeseed residues contributes to the intake of organic matter up to 4.3 t/ha, which increases the humus content by 14 ... 17%, the phytosanitary state of rice checks improves (by 43 ... 76%), and the productivity of rice culture increases by 0.43 ... 0.52 t/ha...
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