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Restoration and use of fallow lands disposed of from agricultural use

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Abstract. The article presents the results of research on the development of fallow lands in the dry steppe zone of the West Kazakhstan region. The main goal of the work is to develop methods for the effective use of waste land and the flow of organic matter into the soil. The issues of the development of an optimal mechanism for the restoration of abandoned lands and the creation of a forage base for animal husbandry are considered. Experimental studies were carried out to determine the agrophysical and agrochemical parameters of soils in the initial state and annually, at the end of the growing season. The data on the yield of perennial forage grasses and their two- and three-component mixtures are presented. As a result of the research, the main parameters of the fertility of dark chestnut soils in the dry steppe zone of the Urals were determined, the agrophysical state of the soils was assessed, data on changes in the aggregate composition and the accumulation of root mass under various grasses and their mixtures were obtained. Analysis of the data obtained from three-year studies showed that in rainfed conditions of the region, it is possible to get good shoots of leguminous and cereal grasses. Starting from the second year of the life of the grasses, it was possible to carry out two cuttings, and a significant increase in yield can be noted for all variants of the experiment. Sowing of perennial grasses, especially of their mixtures, improves the aggregation of the soil, which is also especially noticeable in the 2nd and 3rd years. The total number of agronomically valuable aggregates 1-3 mm in size in the 0-40 cm layer increased by an average of 52%, and water-resistant aggregates - by 17% compared to the control option. Perennial grasses and their mixtures leave behind a significant amount of root mass. The humus content for three years of cultivation of leguminous-cereal perennial grasses increases from 0.08 in the grasses to 0.21% in alfalfa.

1. Introduction

Today, more than half of the population lives below the poverty line. The position of Kazakhstan, like that of many countries of the world, is also very difficult. In the course of reforms related to the transition to market relations, agriculture received a blow, from which it has not been possible to recover so far. The basis of all agriculture has suffered especially - the fertility of the soil, which does not receive fertilizers, is being lost. Half of the cattle, poultry and sheep have been cut out.

In recent years, significant areas of arable land have been withdrawn from crop rotation due to their varying degrees of salinity, low fertility and unprofitable grain farming. The arable land, transformed into a fallow land, is overgrown with weeds unsuitable for pasture use, and is a breeding ground for numerous pests. In addition, today one of the global problems of mankind is evident - the growing process of desertification.

In many parts of the world, abandoned land has led to significant changes in vegetation composition, plant diversity, and soil fertility [1].

Therefore, the best option for using such lands is considered to be tinning with perennial grasses, due to which two major tasks of agricultural production are simultaneously resolved: 1) ensuring a progressive increase in soil fertility elements by improving its structure and increasing the supply of organic matter, and 2) promoting the creation of a stable forage base for animal husbandry.

Multifunctional agriculture, along with food and feed production, contributes to the conservation of biodiversity, enhances soil fertility, mitigates the effects of climate change and environmental degradation, and contributes to the socio-economic viability of rural areas. Biomass production to enhance soil fertility from perennial grass mixtures in fallow lands can support biodiversity and carbon sequestration in soil, coupled with reductions in greenhouse gas emissions [2].

Perennial crops increase soil fertility, soil protection, climate regulation, pollination, pest and weed control, and landscape aesthetics compared to maize. They also score lower in biomass production than maize, confirming the trade-off between provision and regulation of ecosystem services. However, one should take into account additional positive factors provided by perennial grass mixtures, such as reducing the cost of mineral fertilizers, pesticides and tillage, as well as the significant effect of the previous crop, which increases the yield of subsequent crops [3].

Replacing perennial grasses with annuals not only leads to lower yields, but also contributes to a number of external costs. In particular, annuals with a shallow root system lead to deeper drainage and, therefore, to a greater potential for the development of salinity and acidity, as well as to large volumes of low-quality water runoff into streams [4].

The results of studies on the effect of annual and perennial grasses involved in vapor succession on the chemical and biological (microbial biomass, mineralization and enzymatic activity) characteristics of soils show that root biomass, pH, KCl, basal respiration and fluorescein diacetate activity were significantly higher under perennial grasses than under annuals and bare soil. Nitrate levels, total carbon, total nitrogen, microbial biomass and acid phosphatase were higher under perennials. This proves the general hypothesis that perennial grasses have a greater effect on the soil than annuals [5].

Thus, perennial grasses reduce soil acidity, increase the amount of absorbed bases, and increase the amount of mobile forms of nitrogen and potassium [6].

Annual crop systems converted to bioenergy perennial crops tend to accumulate C in the soil, which is likely due to increased root formation and reduced soil tillage [7].

Man-made desertification is a problem that plagues drylands around the world, but the factors supporting the degraded state are often unclear. As a result of a number of studies, it was found that several factors contribute to a stable degraded state - these are the absence of seeds, hydrological properties of the surface and a high level of spatial connectivity (absence of perennial vegetation and other surface structure to retain water, litter, seeds and sediments) [8].

Perennial grasses improve the structure of the soil, increase and maintain its fertility. When using feeds based on legumes and cereals, as the most natural for most animals, their life expectancy increases, the quality of the final product improves both in terms of consumer indicators and in terms of environmental safety [9].

Agricultural systems are increasingly under pressure from global warming and increased competition for arable land. Perennial grasses have the potential to solve both problems: they are drought tolerant crops and do not claim to be highly productive agricultural land, since they can be grown on fallow land [10].

In our research work, we tried to pose and resolve the issues of developing fallow lands for the conditions of Western Kazakhstan. In this regard, the following tasks were set: 1) to select herbs with the highest productivity and, at the same time, with good structure-forming properties; 2) to study the dynamics of the growth of plant mass by years and mowing and, especially, by individual components of grass mixtures; 3) find out the dynamics of the accumulation of root residues, organic matter and nutrients in the soil; 4) to trace the process of formation of agronomically valuable aggregates under various herbs and mixtures.

2. Materials and methods

In order to create sown hayfields and pasture lands, they tested clean sowing of alfalfa variety Uralskaya blue, sainfoin - variety Peschaniy, sweet clover - expeditionary wild-growing specimen, perennial forage crops - wheatgrass, variety Uralsky narrow-spiked, and lomkokolosnik variety Sitnikovy.

The next options were double mixtures - alfalfa and one of the cereals and triple - alfalfa and two cereals.

All field experiments were carried out in areas that were left from under grain crops.

The experimental site is located in the dry steppe zone west of the city of Uralsk, 20 km, where grain was sown at one time and due to the inexpediency of grain farming, these sites were abandoned and passed into the category of deposits.

Single-species sowing of forage crops was sown in a row method with a row spacing of 15 cm, with a seeding rate of 3.0 million / ha, alfalfa - 4.0 million / ha of germinating seeds.

In double and triple mixtures, the sowing method remained the same, the seeding rate was reduced to 1.5 and 2.0 million / ha, respectively. Plot area 100 sq. m, 4-fold repetition.

In all field experiments, the following counts and observations were carried out.

- Phenological observations. The date of germination, the full onset of the development phase, when 75% of the plants entered it, is noted. In cereal fodder crops, the following were noted: shoots, emergence into the tube, heading and flowering; in legumes - also seedlings, stemming, budding and flowering.
- During the flowering period, the linear height of the forage plants was noted, for which purpose, in each experiment, 25 plants were measured in two non-adjacent replicates in the diagonal direction.
- The biological yield of hay and pasture mass was determined by mowing the mass of grass stand from 1 square meter plots.
- The dynamics of plant density was calculated on fixed meter plots or running meters in 3-fold repetition on each plot of the experiment in the spring during the period of full regrowth and before going into winter. Based on these data, we determined the field germination and safety of plants during the growing season.
- The chemical composition of the herbage was determined in the laboratory of Zhangir Khan WKATU and Oral Zher LLP.
- Crop data were subjected to analysis of variance according to B.A. Dospekhov.
- Agrochemical analysis of soil samples was carried out before laying and at the end of each growing season.

3. Results

For the better development and preservation of the herbage of forage crops in the first year of life, production cutting was not carried out, only the biological yield of green mass was determined.

In the first year, only legumes provided fodder. In the clean sowing, 45.3 c / ha of green mass of sweet clover, 28.2 c / ha of alfalfa and 29.4 c / ha of sainfoin were harvested. In the year of sowing, cereal crops only intensively bush, but they did not form an accounting mass.

A completely different picture develops in the herbage of the second year of life, when already a certain part of the harvest is made up of cereal grass. In terms of the weight of the crop in clean crops, the advantage is on the side of the grain grove - 58.4 c / ha. The next one in terms of yield was sainfoin - 54.3 c / ha, followed by sweet clover with a yield of 48.3 c / ha. On all crops, two yield counts were carried out.

Significantly high yields provided double mixes where alfalfa and cereals were sown. Thus, a mixture of alfalfa with a grate for two cuttings provided 42.1 centners / ha of green mass.

In the third year of life, the herbage in the experimental crops became more or less stabilized. Clean sowing of alfalfa and lump grate made it possible to make two counts of yield each. The total weight of these crops was 57.6 and 54.8 c / ha of green mass. This yield is significantly higher than in the second year of life (table 1).

Table 1. Productivity of green mass of forage crops and their mixtures by years of life, kg / ha (sowing in 2013).

Cultures and their mixtures	1st	2st	3st	The average
Alfalfa	28.2	33.0	57.6	37.2
Donnik	45.3	48.3	-	31.2
Sainfoin	29.4	54.3	60.8	48.1
Narrow-ear wheatgrass	-	58.4	51.8	36.7
Lomkokolosnik sitnikovy	-	38.2	54.8	31.0
Alfalfa + wheatgrass	21.5	39.6	79.0	48.6
Alfalfa + grate	19.8	42.1	83.7	50.1
Alfalfa + wheatgrass + grate	17.4	39.2	90.8	49.7

Also, high yields in the third year of life were provided by double grass mixtures. In triple mixtures in the third year of life, the yield was 90.8 c / ha.

According to the program, an analysis of the chemical composition and nutritional value of plants was carried out. The nutritional value of perennial grasses was determined by such indicators as total nitrogen, crude protein, fiber, fat, BEV.

The data obtained show that alfalfa is allocated in terms of the content of digestible protein - 15.33%, in other crops the percentage of protein varies from 10.49 to 14.98%. In terms of crude fiber content, wheatgrass and a double mixture of alfalfa + wheatgrass prevail.

To assess the structure of the soils, an aggregate analysis was carried out. The aggregate composition of the soils of the plot was determined before the experiment was laid in the first year of research, in five places of the experimental plot, which was taken as a control option and under various herbs and their mixtures at the end of each growing season.

The analysis of the results of dry sieving for all variants in comparison with the initial data shows that the percentage of the fraction less than 0.25 mm and more than 10 mm has decreased, i.e. there are fewer dusty and lumpy particles. In the first year of life of grasses, their beneficial effect on aggregation was insignificant, within 1-3% percent for each fraction, then in the second and third years of life, the positive effect increased significantly. The total number of agronomically valuable aggregates 0.25-10 mm in size in the 0-40 cm layer increased by an average of 51% compared to the control option. The structural condition has improved. It should also be noted that in the first two years, the effect of the variants was uneven, but in the third year of the life of grasses, their effect on improving the soil aggregation is noticeably leveled.

Analysis of the chemical properties of soils is of primary importance in soil research. On its basis, the provision of the soil with the elements necessary for plant nutrition, the chemical characteristics of the soil are determined.

The results of determining the chemical composition of soils under the variants of the experiment in the second year of life are presented in table 2.

The table shows that the humus content in comparison with the first year increases from 0.08 in the grate to 0.21% in alfalfa. As for the mobile forms of nitrogen, a significant increase is observed. The content of phosphorus and potassium also increases, on average by 6.8% and 15%, respectively.

The results of studies on the accumulation of root mass in the soil on all plots were determined at the end of the growing season - at the end of September. Soil samples - two per plot - were taken in the form of monoliths measuring 20 cm x 30 cm x 20 cm from two soil layers (0 ... 20 cm and 20 ... 40 cm).

The data on the determination of the root mass are shown in table 3.

Table 2. Results of the chemical analysis of the soil.

Option name	Humus,%	Easily hydrolyzable nitrogen, mg / kg	Nitrate nitrogen, mg / kg	Mobile phosphorus, mg / 100g	Mobile potassium, mg / 100g
Before setting up the experience	2.42	38.8	39.4	2.72	47.9
Alfalfa	2.63	45.9	48.4	3.02	58.7
Zhitnyak	2.51	40.4	44.2	2.86	51.3
Volosnets	2.50	41.7	43.6	2.84	50.1
Sainfoin	2.59	43.6	45.3	2.90	55.8
Alfalfa + wheatgrass + volost	2.58	43.8	47.1	3.12	57.4
Alfalfa + Volosnec	2.60	42.4	46.3	2.95	56.2
Alfalfa + wheatgrass	2.56	44.1	46.8	2.98	57.8

Table 3. Accumulation of root mass by years of plant life, c / ha.

Number of options	1st year	2nd year	3rd year
1	3.6	32.35	44.8
2	4.4	21.5	58.9
3	3.1	27.49	46.5
4	9.1	8.3	-
5	3.8	33.93	51.3
6	5.3	24.84	52.5
7	7.3	23.29	55.9
8	6.0	26.6	51.8

In all grasses and grass mixtures, the bulk of the roots is distributed in the upper (0-20 cm) layer, ranging from 76 to 88% in relation to the entire root mass in the 0-40 cm layer. In cereals, a rapid decrease in the accumulated mass is observed when deepening into the soil.

In general, in the third year of the life of perennial grasses, as in the previous one, there is an increase in the root mass, if in the first year this indicator varied from 3.1 to 9.1 c / ha according to variants, in the second - from 21.5 to 33.93 c / ha, then after three years of grass cultivation, these indicators were respectively 44.8 and 58.9 c / ha.

4. Discussion

Field germination of seeds of perennial grasses was good for all variants of the experiment, the average indicator was 35%. The percentage of germination is slightly higher than that of the others in wheatgrass - 47% and sweet clover - 41.6%. The lowest percentage of germination - 23.3% - was observed in the grate when sown together with alfalfa.

Further observation of the number of plants shows that plant loss occurs from the grass stand both in summer and in winter. Already in the first year of life on crops in 2013, by the fall, from 41.7 to 66.4 percent of the plants from seedlings were preserved. This should apparently be explained by the biological characteristics of crops and the possibility of soil conditions for their growth and development.

Calculation of regrown perennial grasses in the spring of the second year of life shows that during the winter period there is a loss of plants, regardless of the culture. The best percentage of overwintering was noted in wheat grass - 89.2 and in alfalfa in grass mixtures - on average 88.8%. The rest of the crops retained plants by 60 percent or more, with the exception of sweet clover - 41%.

Analysis of these data shows that in the second year, the herbage of all crops has more or less stabilized quantitatively, and sweet clover, as a two-year culture, began to fall out. By the fall of the second year, 2 melilot plants remained per 1 m^2, which is 6.2% of the previous spring count.

The main reason for the greater loss of plants, in our opinion, is the process of self-thinning. The self-thinning process is often observed in perennial grasses, especially in thickened crops, which is probably associated with allelopathy. The second reason may be that the temperature regime during the period of acceleration of seedling (the first month of the life of grasses) was less favorable.

These data indicate that for all crops we obtained grass stands of sufficient density, although with age, due to competition for living space, some plant species are replaced by others.

In the year of sowing, only leguminous crops gave an accounting forage mass. In the double mix, the yield consisted of almost 90% alfalfa. In a mixture of two cereals and alfalfa, consisting of pure alfalfa, yields are lower than in double mixtures, which we attribute to competition for living spaces.

Mowing was carried out in the phase of the beginning of alfalfa flowering, since in addition to the quantitative and qualitative indicators of herbage, one of the main tasks of our research is to track the process of formation of agronomically valuable aggregates and the accumulation of root mass by them. It is known that perennial grasses, especially alfalfa, systematically harvested before flowering, regardless of growing conditions, have an underdeveloped root system compared to those harvested during the flowering period. A similar pattern was found in the increase in water-resistant structural soil aggregates. This explains the relatively low indicators of the nutritional value of the studied forage crops.

The number of durable (waterproof) aggregates changed noticeably, especially in the third year of the life of herbs and their mixtures. The number of these units increased by an average of 17%. This can be explained by a more developed root system of grasses in the third year of life and, accordingly, a higher percentage of mineralization of small roots.

On average, by the end of the third year of the life of perennial grasses, about 20-25% of root residues fall out of the account due to small roots that die off during the growing season. Dead small roots under favorable conditions of humidification and air access are mineralized within 25-30 days. Subsequently, the products of mineralization are partially used by the herbs themselves, and the other part is used for the gross accumulation of calcium, potassium, nitrogen and phosphorus in the soil. Calcium is of particular importance, since, in chemical interaction with soluble humus, it forms the so-called active humus, which, impregnating lumps of soil, makes them water-resistant.

The developed root system, which took shape in the second year, creates the preconditions for an increase in the content of soil organic matter in subsequent years. An increase in the amount of carbon deposited in the root system, and in subsequent years, turning into the soil, can also be called one of the positive aspects of sowing perennial grasses. Also, the root system of perennial grasses binds soil aggregates, which prevents the most fertile topsoil from being washed away by melt water. The potential to bind atmospheric nitrogen with leguminous grasses significantly slows down the processes of reducing nitrogen reserves in the fertile horizon.

5. Conclusion

As a result of the research, the main parameters of the fertility of dark chestnut soils in the dry steppe zone of the Urals were determined, the agrophysical state of the soils was assessed, and data on changes in the aggregate composition and the accumulation of root mass under various herbs and their mixtures were obtained.

Analysis of the data obtained showed that in rainfed conditions of the region, it is possible to get good shoots of perennial legume-cereal grasses. Starting from the second year of the life of the grasses, it was possible to carry out two cuttings, and a significant increase in yield can be noted for all variants of the experiment.

Our studies allow us to draw a practical conclusion that a noticeable improvement in the aggregation of compacted and significantly sprayed dark chestnut soil requires at least three years of exposure to herbs and their mixtures.

Perennial grasses and their mixtures leave behind a significant amount of root mass. In all grasses and grass mixtures, the bulk of the roots is distributed in the upper (0-20 cm) layer, ranging from 74 to 98% in relation to the entire root mass in the 0-40 cm layer.

Analysis of the data obtained based on the results of testing single-species perennial forage crops, their double and triple mixtures showed that in the conditions of the region it is effective to create sown forage lands.

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