# FERTILITY STATE OF FALLOW SOILS OF DRY STEPPE ZONE

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## ABSTRACT

Fallow lands in Kazakhstan are widely represented due to a decline in cereal production in the 90s and wide scale land alienation from agricultural usage. Historically, these lands were used as natural pastures. The current state of fertility of fallow lands has not been studied and there is a need to study the soil and productive characteristics of these soils for their further successful use. The aim of the research was to study the fertility of fallow soils and develop recommendations for improving their fertility. Fertilization and sowing of the wheatgrass on the fallow dark-chestnut soil (Eutric Cambisol) in were studied in a field experiments. The studied soils are characterized by low natural fertility. After application of organo-mineral fertilizers and the sowing of wheatgrass, the fertility of soil is improved as well as the yield of green mass of sowed wheatgrass increased.

*Keywords*: fallow land; soil fertility; wheatgrass; fertilizer; manure

## INTRODUCTION

In the West Kazakhstan region, large areas are allocated to the fallow due to a decline in cereal production in the 90s and wide scale land alienation from agricultural usage. Historically, these lands were used as natural pastures. The current state of fertility of fallow lands has not been studied and there is a need to study the soil and productive characteristics of these soils for their further successful use. When the soil is withdrawal from agricultural use, the agrocenosis is replaced by postagenous phytocenoses, characterized by a completely different composition and vegetation structure (Saljnikov et al., 2015; Tikhomirova and Kenesarina, 2017). Post-agrogenic successions cannot but be reflected in the dynamics of morphology, physical, chemical and microbiological properties of soils. Withdrawal of soil from agricultural use, despite the scarcity of land resources, is considered a worldwide trend of land use. A consequence of this is a radical change in the regularities governing the formation and functioning of soils, which in turn leads them to evolution and a significant change in ecological functions (Rakhimgaliyeva, 2012; Rakhimgaliyeva, 2013). The knowledge of these regularities is important, and the results of studying the processes during these transitions have an unquestionable fundamental and applied significance. In the conditions of dry steppe zone, this question is still poorly understood, while fallow soils acquire ecological significance (Tikhomirova and Kenesarina 2017), because they are often considered as "weed breeding lands". However, they can, like a meadow, have a significant impact on natural environment. In the transformation of arable soils into the fallow state due to changes in vegetation and the termination of tillage the changes in soil formation occurs where the soil gradually acquires a sod layer.

The aim of the research was to study the fertility of fallow soils and develop recommendations for improving their fertility. The objectives were to study content of nutrients in fallow soil after fertilization and to establish the effect of fertilizers on the productivity of fallow soil.

## MATERIALS AND METHODS

The studied territory is located within the Ural Plateau on the watershed section, which is enclosed between the rivers Ilek, Chile and Berezovka, having a common slope to the northeast. The relief can be divided into four geo-morphological regions: 1. undulated hilly plain; 2. weak undulated plain; 3. rugged undulated plain; 4. floodplain of the river Ilek.

The main soil-forming rocks are Quaternary and modern sediments. On the studied territory the predominance of soil-forming rocks of heavy mechanical composition led to the formation of clay and heavy loamy soils. In most cases, the rocks are salted to a different extent.

The climate of the studied territory is very arid warm. Annual precipitation is 200-220 mm, which is in most years is not enough to satisfy plants needs. Therefore, the natural vegetation cover of the area is formed in conditions of insufficient and unstable moisture.

The experiments with fertilization were set in 2013 in Chingiralu district of Ural region on dark –chestnut soils, where 75% of arable lands earlier were used for grain production and now are in fallow state. A wheatgrass was sown in the experiment (*Agropyron* L.). The scheme of the experiment: 1. Natural fallow (control); 2. Wheatgrass; 3. Wheatgrass + 50 tonne manure; 4. Wheatgrass + $N_{30}P_{40}$; 5. Wheatgrass + $N_{30}P_{40}$ + 50 tonne manure. The soil was sampled from ehach of 4 field replication from 0-20 and 20-40 cm.

Content of humus, plant available nutritional elements, cation exchange capacity and exchangeable sodium were determined according to the standard methods (Dospekhov, 1985). Statistical processing of the data was done on Statistica software (Dmitriev, 2009).

## RESULTS AND DISCUSSIONS

In the studied territory the following plant families were identified: *Poaceae* (L.), *Liliaceae* (L.), *Iridaceae* (L.), *Polygonaceae* (L.), *Chenopodiaceae* (L.), *Amaranthaceae* (L.), *Caryophyllaceae* (L.), *Brassicaceae*, *Rosaceae (*L.), *Fabaceae* (L.), *Euphorbiaceae* (L.), *Elaeagnaceae* (L.), *Apiaceae* (L.), *Primulaceae* (L.), *Limoniaceae* (L.), *Convolvulaceae* (L.), *Boraginaceae* (L.), *Scrophulariaceae* (L.), *Lamiaceae* (L.), *Rubiaceae* (L.), *Dipsacaceae* (L.), (*Asteraceae* (L.).

The results of the agrochemical analyses are presented in Table 1. The table shows that the average content of humus in 0-20 cm soil layer on the fallow treatment averaged 3,088 % and in 20-40 см soil layer – 3,040 %. According to the gradation of Orlova and Grishina (1981) these soil belongs to low-humus supply. In the studied dry steppe zone, due to the lack of moisture variegation of soil is appears in spite of the monotype soil (Dark Chestnut) that is characterized by a relative fluctuation in the content of humus.

To determine the need for applying nitrogen fertilizers, it is widely recommended to determine the hydrolysable nitrogen in the soil according to the Kornfield method, which is based on the hydrolysis of organic compounds with an alkali solution. Content of alkaline hydrolysable nitrogen in 0-20 cm soil layer was 77-105 mg/kg soil; and in 20-40 cm was 70-98 mg/kg soil, what indicates high concentration of hydrolysable nitrogen in this soil (Table 1). Alkaline hydrolyzable nitrogen characterizes potential soil fertility (Alzhanova et al., 2013).

According to the concentration of plant available phosphorus the fallow soil of control was characterized with low to moderate supply, while plant available potassium showed moderate supply. The soil CEC was fro moderate to high. Alkalinity was not detected in any variant of fallow soil up to a depth of 40 cm.

All other treatments showed low supply with nitrogen and moderate supply with potassium.

In the treatment with non-fertilized wheatgrass, the soil is low-suplied with humus, and high supplied with hydrolyzable nitrogen (Table 1). Plant available phosphorus and potassium showed low- and moderate supply, respectively.

The magnitude of the mean values showed that the humus content decreases slightly, as does the content of mobile phosphorus and the cation exchange capacity. This is due to the increased removal of nutrients when plowing and sowing of wheatgrass. During mechanical disturbance of the soil that was in a fallow state for long period soil organic matter mineralization is accelerated due to better oxidation and microbial activity.

Application of 50 t. of manure didn't result in changes in soil fertility in one year. However, the green biomass positively responded to organic fertilization. Concentration of hydrolysable nitrogen was good; while concentrations of plant available phosphorus was low to moderate. Soil CEC was from moderate to high. Application of manure increased mean value of humus, nitrogen and phosphorus, while amount of potassium was not changed.

Application of nitrogen-phosphorus fertilizers resulted in increase of the average value of nitrogen in the 0–20 cm layer; while the humus content somewhat decreased, and the profile redistribution of mobile phosphorus was revealed.

Application of organo-mineral fertilizer increased content of plant available phosphorus in 20-40 cm soil layer, while other parameters decreased. Similar results were obtained by Khan et al. (2007) showing that application of only mineral fertilizer resulted in decrease of the content of soil organic carbon, in spite of increased yield and thus increased plant residues returned into the soil (Wu et al., 2015).

Crop yield increased in the treatment with application of organo-mineral fertilizer compared with the fallow treatments (control), indicating that due to the increased crop yield the nutrient removal by plants increased what was reflected in the content of nutrients in soil (Mahmoodabadi and Heydarpour, 2014)

Considering the positive effect of plant residues on soil fertility, weed control was not conducted at the experimental site. Under accelerated grassing of fallow lands, the greatest number of weeds was observed in the wheatgrass of the first year of life. However, wheatgrass is a perennial competitive culture, which is able to gradually oust weed vegetation (Saljnikov et al., 2015).

On the fallow treatment, where the soil was not ploughed the average green biomass yiled of wildly growing plants was 089 t/ha that is significantly less than in other treatments (Table 2).

An important role in increasing the yield of grasses on the fallow lands is played by their processing techniques (Gumarova and Bulekova, 2017). Under plowing of the fallow land and sowing of wheatgrass without fertilizer, green biomass was 1.021 t/ha. Differences in the biomass is explained by the well processing of soil by well loosening of the soil and levelling its surface, which activated microbiological and biochemical processes and created favourable conditions for the growth of perennial grasses.

**Table 1.** Agrochemical characteristics of studied soils

**Tabela 1.** Agrohemijske karakteristike proučavanog zemljišta

| Treatments | 0-20 cm | | | | | |
|---|---|---|---|---|---|---|
| | гумус | N | $P_2O_5$ | $K_2O$ | CEC | Na |
| | % | мг/кг почвы | | мг/100г почвы | мг-экв/100 г.п | |
| Natural fallow | 3.09±0.44 | 86.10±6.60 | 24.48±7.16 | 27.88±0.03 | 34.40±5.58 | 0.087±0.01 |
| Wheatgrass | 2.99±0.49 | 78.75±11.42 | 15.10±2.74 | 27.83±0.03 | 31.10±5.74 | 0.090±0.01 |
| Wheatgrass +50 t manure | 3.42±0.43 | 89.95±6.68 | 29.53±10.45 | 27.83±0.03 | 23.15±2.53 | 0.085±0.01 |
| Wheatgrass +N30P40 | 2.98±0.50 | 92.05±7.87 | 16.35±5.25 | 27.75±0.05 | 27.05±2.20 | 0.093±0.01 |
| Wheatgrass +50т Manure + N30P40 | 2.99±0.50 | 80.85±2.64 | 24.60±10.90 | 27.78±0.06 | 26.05±1.91 | 0.103±0.00 |
| | 20-40 cm | | | | | |
| | гумус | N | $P_2O_5$ | $K_2O$ | ЕКО | Na |
| Natural fallow | 3.04±0.47 | 86.10±5.87 | 19.45±5.84 | 27.85±0.05 | 43.90±1.57 | 0.090±0.01 |
| Wheatgrass | 2.62±0.41 | 86.80±1.90 | 25.98±6.67 | 27.83±0.03 | 28.40±2.20 | 0.090±0.01 |
| Wheatgrass +50 t manure | 3.43±0.42 | 96.25±15.45 | 31.38±7.10 | 27.80±0.00 | 27.30±1.99 | 0.100±0.00 |
| Wheatgrass +N30P40 | 2.52±0.44 | 86.80±1.72 | 23.88±3.52 | 27.78±0.06 | 22.20±4.62 | 0.090±0.01 |
| Wheatgrass +50т Manure + N30P40 | 2.92±0.54 | 82.250±5.43 | 26.85±10.25 | 27.73±0.08 | 28.00±4.43 | 0.100±0.01 |

Application of 50 t/ha of manure resulted in 1.058 t/ha of green biomass of the wheatgrass, while application of nitrogen-phosphorus fertilizer increased green biomass of wheatgrass till 1.094 t/ha. The maximum yield increase was on the treatment with organic-mineral fertilizers, where the green biomass increment was 0.329 t/ha.

The results showed that content of soil humus for the studied period (27 months) didn't changed significantly, but the effect of applied fertilizers was reflected in increase of green biomass.

**Table 2.** Effect of fertilizers on green biomass (t/ha)

**Tabela 2.** Uticaj đubriva na zelenu biomasu (t/ha)

| Field replications | 1. natural fallow (control) | 2. wheatgrass (no fertilizer) | 3. wheatgrass + 50 t. manure | 4. wheatgrass + $N_{30}P_{40}$ | 5. wheatgrass + $N_{30}P_{40}$ + 50 t. manure |
|---|---|---|---|---|---|
| 1 | 0.979 | 0.917 | 1.025 | 1.042 | 1.458 |
| 2 | 0.958 | 0.1104 | 1.229 | 1.146 | 1.250 |
| 3 | 0.791 | 0.1125 | 1.083 | 1.167 | 1.042 |
| 4 | 0.833 | 0.938 | 0.895 | 1.021 | 1.125 |
| Mean value | 0.890 | 0.1021 | 1.058 | 1.094 | 1.219 |
| Difference with the | | + 0.131 | + 0.,68 | + 0.204 | + 0.329 |

| | | | |
|---|---|---|---|
| control (natural fallow), t/ha | | | |
| Difference with the wheatgrass, t/ha | + 0.037 | + 0.073 | + 0.198 |

The productivity of wheatgrass significantly changed upon application of fertilizers, with maximum increase of green biomass was observed in the treatment with both mineral and organic fertilizers (Table 3).

To assess the significance of differences between averages, we calculate the least significant difference (LSD) from the Table 3:

$$\text{LSD} = t_\alpha s_d$$

$$s_d = \sqrt{\frac{2 * MS_{ошибок}}{n}}$$

**Table 3.** Green biomass (t/ha)

**Tabela 3.** Zelena biomasa (t/ha)

| Treatments | Повторности | | | | Суммы вариан-тов | Средние вариантов |
|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | | |
| Natural fallow | 0.979 | 0.958 | 0.791 | 0.833 | 3.561 | 0.890 |
| Wheatgrass | 0.917 | 1.104 | 1.125 | 0.938 | 4.084 | 1.021 |
| Wheatgrass +50 t manure | 1.025 | 1.229 | 1.083 | 0.895 | 4.232 | 1.058 |
| Wheatgrass +N30P40 | 1.042 | 1.146 | 1.167 | 1.021 | 4.376 | 1.094 |
| Wheatgrass +50т Manure + N30P40 | 1.458 | 1.250 | 1.042 | 1.125 | 4.875 | 1.219 |
| Total | | | | | 21.128 | 1.056 |
| LSD | 1.878 | | | | | |

After processing in STATISTICA programme the LSD was 1,878 (Table 4).

**Table 4.** Least Significant Difference (LSD)

**Tabela 4.** Najmanja značajna razlika (LSD)

| Treatments | Treatments | | | | | Confidence intervals |
|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | |
| 1 | | 1,3075 | 1,6775 | 2,0375 | 3,285 | 1,32779 |
| LSD | | 1,8778 | 1,8778 | 1,8778 | 1,8778 | |
| 2 | | | 0,37 | 0,73 | 1,9775 | 1,32779 |
| LSD | | | 1,8778 | 1,8778 | 1,8778 | |
| 3 | | | | 0,36 | 1,6075 | 1,32779 |
| LSD | | | | 1,8778 | 1,8778 | |
| 4 | | | | | 1,2475 | 1,32779 |
| LSD | | | | | 1,8778 | |
| 5 | | | | | | 1,32779 |
| LSD | | | | | | |

Table 4 shows significant differences between mean values of 5$^{th}$ and 1$^{st}$ (control) treatments; between 4$^{th}$ and 1$^{st}$ treatments, and between 2$^{nd}$ and 5$^{th}$ treatments.

The highest green biomass was observed in the 5th treatment (wheatgrass + $N_{30}P_{40}$ + manure) that was greater for 0.3285 t/ha compared to the 1st treatment (control) and for 0.198 t/ha compared to the 2nd treatment (non-fertilized wheatgrass) (Tables 5).

Due to its drought tolerance and longevity, in the conditions of dry steppe the wide-boned wheatgrass is the most promising crop for cultivation under accelerated grassing of fallow lands and provides the greatest productivity of good-quality animal feed.

The second place on the green biomass yield showed the 4th treatment (wheatgrass + $N_{30}P_{40}$), followed by the 3rd treatment (wheatgrass + manure) that yielded in average for 0.037 t/ha compared to the 2nd treatment and for 0.1678 t/ha compared to the control. The analysis of variance confirms the reliability of obtained results (Table 5)

**Table 5.** Analysis of variance
**Tabela 5.** Analiza varijanse

| Variation | ∑ square | ∑ square, % | Degrees of freedom | Dispersions | Dispersions, % | Fisher actual | Fisher theory | Student coef. |
|---|---|---|---|---|---|---|---|---|
| Total | 45,937 | 100,00 | 19 | 2,41775 | 100,00 | | | 2,13 |
| Treatments | 22,653 | 49,31 | 4 | 5,66328 | 78,49 | 3,65 | 3,06 | |
| Residual | 23,284 | 50,69 | 15 | 1,552 | 21,51 | | | |

## CONCLUSIONS

The studied soils are characterized by low natural fertility. After application of organo-mineral fertilizers and the sowing of wheatgrass, the fertility of soil is improved as well as the yield of green mass of sowed wheatgrass increased. Studied soils respond positively to application of organo-mineral fertilizers and can be used in improvement of fallow lands for usage as pasture lands.

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## СТАЊЕ ПЛОДНОСТИ ОТУЂЕНИХ ЗЕМЉИШТА У СУВОЈ СТЕПСКОЈ ЗОНИ

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### SAŽETAK

Otuđena zemljišta u Kazahstanu su široko rasprostranjena zbog smanjenja produkcije zrna 90ih godina i kao posledica otuđenja zemljišta od poljoprivredne upotrebe. Istorijski gledano, ova zemljišta su korišćena kao prirodni pašnjaci. Trenutno stanje plodnosti otuđenih zemljišta nije istraženo i postoji potreba za istraživanjem zemljišnih i proizvodnih karakteristika zbog njihovog daljeg uspešnog korišćenja. Cilj istraživanja bio je proučavanje plodnosti otuđenih zemljišta i izrada preporuka za poboljšanje njihove plodnosti. Đubrenje i setva *Agropyron-a* ispitivani su na eutričnom kambisolu u poljskim eksperimentima. Ispitivano zemljište karakteriše niska prirodna plodnost. Nakon primene organo-mineralnih đubriva i setve Agropyron-a, poboljšavali su se plodnost zemljišta i prinos zelene mase sejane trave.

*Ključne reči:* otuđeno zemljište; plodnost zemljišta; Agropyron; đubrivo; stajnjak

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