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Influence of Alfalfa Varieties on Changes in the Composition of Mobile Forms of Phosphorus in the Soil in the South-Eastern Kazakhstan

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Development of the agrarian complex of the Republic of Kazakhstan in the nearest future is aimed at increasing productivity and sustainability of land cultivation. Successful resolution of this problem depends on compliance and timely performance of the activities envisaged by the technologies of agricultural crops cultivation. In modern conditions, with limited agricultural resources, the most popular are resource-saving technologies that ensure production of quality products at a low cost of labor, material and financial resources. In recent years, the trend to reduction of soil fertility and environment pollution requires intensification of crop production, by more complete involvement of inexhaustible natural resources into the process and environment formation, through its biologization, rather than through synthetic and technological methods and techniques. In addressing these issues a significant role is played by perennial legumes, which make it possible to simultaneously address the issues of amelioration and improving soil fertility, growth, yield and content of protein in the forage, improving the ecosystem in general. Alfalfa (Medicago sativa L.) is one of the most important forage legumes in many countries. Our research is aimed at studying the influence of alfalfa varieties grown with various dosages of fertilizers on changes in the composition of mobile forms of phosphorus in case of irrigation of soils of the South-East of Kazakhstan. Three fertilizer dosages were used for the study: P_2O_5 – 60 kg/ha, P_2O_5 – 90 kg/ha, and P_2O_5 - 120 kg/ha. The study involved 6 varieties of alfalfa. The research showed that all experiments in the subsurface soil layer did not reveal significant differences in the indicators of mobile phosphates content in the soil between the reference and the fertilized variants. However, due to the varietal features of each variety of alfalfa, various amounts of mobile phosphorus remained in the soil after the vegetation season.

Key words: Alfalfa, fertigation, soil, mobile phosphorus, alfalfa varieties.

In the conditions of intensive development of economic relations and ensuring food security of the country, rational and efficient use of land resources, particularly of agricultural lands, plays an important role. Land resources of the Republic of Kazakhstan are 272.5 million ha, including 222.5 million ha of agricultural lands. According to the Agency for Land Resources Management of the Republic of Kazakhstan, as of June 1, 2005, out of the 188.9 million ha of pastures, extreme degradation has been reached in 26.6 million ha, the area of saline lands was 94.9 million

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ha, and the area of lands susceptible to erosion processes was over 90 million ha. In the Republic, the area of lands subject to water erosion amounts to 5 million ha, including 1.0 million ha of pastures and the majority of these is concentrated in the Southern and South-Eastern regions. World's agricultural practice shows that the use of fertilizers increases productivity of agricultural production, which is a decisive factor in increasing soil fertility (Eleshev R. E., 2008). Soil fertility is primarily determined by its structural composition, i.e., by the ability of the soil to form aggregates of a certain size from the elements of the solid phase. The structure is the fundamental property of soil, which determines its water, air and food regimes, and affects its physical and biological indicators. Soil's ability to decompose after cultivation into aggregates of certain size largely depends on the degree and the rate of soil wetting profile, and soil density. In addition, soil structural composition and structure quality largely depend on the type of plants cultivated in crop rotation, and on the complex of agro technical measures for cultivation, i.e., on the technology of agricultural crops cultivation. Intensive technologies, which were based on a high level of chemicalization, i.e. on the system of mineral fertilization, high dosages of herbicides, means of protection against diseases and pests without incorporating crop residues and optimum quantity of organic fertilizers into soil, had a negative impact on soil structure (A. V. Yugov and Siso A.V., 2008). A sharp decrease in capital investments into irrigation and agriculture, introduction of nutrients with organic and mineral fertilizers into soil result in a real threat of reducing the level of soil fertility and, consequently, the yield of agrophytocenoses. Acuteness of the problem can be reduced through using ecological ameliorative methods, using sideration of perennial grasses, environmentally safe irrigation and biohumus as fertilizers (Kuznetsova, E. I., *et al*.), 2014).

Forage production in the Republic of Kazakhstan has been and remains a priority sector of agriculture, since the level of forage production and its quality influence availability of domestic livestock products for the population, and to a large extent, food supply security of the Republic. Since 2011, the "Increasing Export Potential of Cattle Meat Production" project has been implemented, and the project of developing distant-pasture cattle rearing has being started in accordance with the approved "Agribusiness 2020" program. Efficiency of the animal breeding sector mainly depends on availability of full-fledged and diversified green and pasture forage, as well as on availability of certain amount of concentrated forage in the summer grazing period, availability of rough, juicy and concentrated forage during stable keeping in winter. In each of these periods, animals should receive abundant quantities of all necessary nutrients, micro and macro elements, as well as vitamins. Perennial grasses are of exceptional importance. Along with performing the tasks in the area of forage production, perennial grasses also perform important environmental functions, solving the problem of restoring fertility of arable lands, and protection of agricultural lands from manifestations of negative desertification processes. Seeds of forage crops intended for obtaining juicy and green fodders, which are indispensable for the development of dairy cattle breeding, reduced considerably. In recent years, about 1 million tons of juicy forage has been preserved in the Republic per year, while the need is 6.6 million tons. (Abstracts of the report of the Vice-Minister at the forum of the Fodder Cropping Ministry, 2013). Transition to the new economic conditions of production attaches particular importance to ensuring the potential of the cultures, including the conditions of stress manifestations of extremely continental climate. On this basis, the important role in solving the problem of achieving sustainable productivity of forage lands depends on proper selection of perennial grasses breeds and the conditions of their creation (Didenko, I. L. and Chekalin, S. G., 2011).

Development of the agrarian complex of the Republic of Kazakhstan in the nearest future is aimed at increasing productivity and sustainability of land cultivation. Successful resolution of this problem depends on compliance and timely performance of the activities envisaged by the technologies of agricultural crops cultivation. In modern conditions, with limited agricultural resources, the most popular are resource-saving technologies that ensure production of quality products at a low cost of labor, material and financial resources. Insufficient forage reserves and level of feeding, insufficient level of animals' productivity and nucleus breeding, narrow range of forage fed – this is not a complete list of problems in livestock breeding. High productivity of agricultural animals may be achieved through improvement of the genetic potential and ensuring high level of full-fledged and balanced forage for agricultural animals. The governing factor of sustainable livestock breeding development is the provision of full-fledge and balanced forage for the livestock. Nowadays, one of the factors that contribute to insufficient development of livestock breeding and livestock and poultry productivity is insufficiency of forage reserve. Currently, the basis of forage reserves are natural pastures and hayfields, field forage production and formula feed industry (Sadvakassov, S. S., and Usipbaev, N. B., 2015; The Program for Development of Agriculture in the Republic of Kazakhstan in 2013-2020 "Agribusiness - 2020").

Studies performed on various soil types showed that phosphate fertilizers have different effect on alfalfa hay yield, in some cases contributing to its increase, and in other cases - to its decrease. On soils with low availability of available phosphorus (determined by standard methods for particular soils), high efficiency of using phosphorus fertilizers is observed. On soils with high content of mobile phosphates, introduced phosphorus had no significant effect on alfalfa yield. Phosphate fertilizers also have positive aftereffect on the yield of hay. Efficiency of phosphate fertilizers is also influenced by the duration of their introduction. Alfalfa has special sensitivity to the conditions of phosphorus nutrition during the first three weeks of life. In case of its deficiency, depression of physiological activity is observed, which cannot be avoided in subsequent periods of the growing season even in case of sufficient supply of phosphorus to alfalfa. Therefore, high efficiency of phosphate fertilizers is ensured when they are introduced before planting, during plowing. It should be noted that deeper placement of fertilizers is necessary especially in the steppe regions, where the use of phosphorus results in crop yield increase of up to 70% (Izotov, V. I., 1983). According to the foregoing, we have performed research for studying mobile phosphates in soils with alfalfa.

METHODS

Research location

The field experiments were performed in the Kazakh Research Institute of Agriculture and Plant Growing, in the Karasai district of the Almaty region, located in the foothill zone (740 m above the sea level), 25 km to the West from Almaty, where the climate is characterized by relatively mild winters, cool and wet spring, hot summer and dry autumn.

The average daily temperature of above +5ºC is observed 219 days per year (+10ºÑ - 181 days, +15ºÑ - 135 days). In the lowland South-Eastern districts of the Almaty region, sustainable transition of average daily temperature from negative values to positive (through 0ºÑ) occurs between March 5 and 10. In January, which is the coldest month, the average temperature varies between "1.9 ºC and "7.6 ° C, in July, which is the hottest month, between +27.8°C and +31.4°C, respectively. The frost-free period in most areas of the Almaty region is 5-6 months.

The average annual precipitation is 332-645 mm, the maximum rainfall occurs between March and June. In arid years, the rainfall may be 1.5-2.0 times less than the norm; in wet years, it is as many times more.

The duration of the snow cover period in the lowlands of the Almaty region is 1.5 to 3.0 months. Snow depth does not exceed 15-20 cm.

The soil is light-brown, loamy, with humus content between 1.7% and 3.0%, and total nitrogen - up to 0.2%. The total phosphorus content is 0.16%; potassium content is about 2.0%. The groundwater depth ranges between 5 and 30 m.

Variants	4	P_2O_5-3	P_2O_5-3	P_2O_5-3	P_2O_5-3	P_2O_5-3	P_2O_5-3
	3	P_2O_5-2	P_2O_5-2	P_2O_5-2	P_2O_5-2	P_2O_5-2	P_2O_5-2
	2	P_2O_5-1	P_2O_5-1	P_2O_5-1	P_2O_5-1	P_2O_5-1	P_2O_5-1
	1	Reference	Reference	Reference	Reference	Reference	Reference
	Variety	NS Alfa	Banat Vs	NS Mediana	Nera	Nijagara	Kokorai

Research procedure and objects

The research was performed in accordance with the following methods: Methods of field experience (Dospehov B. I., 1985); Method of Agrochemical Research (F. A. Yudin, 1980).

Agricultural technology in the experiment was consistent with the recommendations adopted for crops production. The following was used for the study: three dosages of fertilizer – (Ð$_2$Î$_5$ – 60 kg/ha, Ð$_2$Î$_5$ – 90 kg/ha, Ð$_2$Î$_5$– 120 kg/ha). The experiment was repeated 3 times. The plot length was 15 m, its width - 1 m, and the sowing rate was 16 kg/ha. The plot for one variety was 15 m^2. The scheme of a single repetition experiment:

In the studies, we used alfalfa varieties from the Serbian Institute for Field Crops and Vegetable Production (5 clone), and for comparison with the standard, we used the domestic Kokorai variety, which is allowed for use in the Republic of Kazakhstan (State Register of achievements on breeding approved for use in the Republic of Kazakhstan, 2012).

Characteristics of the foreign (Serbia) alfalfa varieties

Banat VS is an early variety, it features rapid initial growth (23.2 cm, 15 days after the spring equinox) and has a fast regeneration ability after mowing (26.4 cm). Tolerance to drought and low temperatures (of the wheat) is similar to that of NS Banat ZMS II. The plant height during the mowing period is 67 cm (like with the NS Banat ZMS II variety). In the structure of the harvest, the share of leaf mass is 50 %. Proteins content is 20.1%. It ensured good results on soils with light and medium-heavy mechanical composition, the green mass yield is 85-100 t/ha and that of hay is 18-20 t/ha; it is tolerant to intensive use (frequent mowing).

NS-Alfa is a synthetic variety created by crossing samples from France, Sweden, Germany and Serbia. NS-Alfa requires deep fertile soils, but can be grown on heavy hydrogenic soils. Dormancy of the variety is 4 to 5. It is tolerant to low temperatures, drowning, and to intensive use (frequent mowing). It is the most tolerant variety to most frequent alfalfa diseases. It features strong tilling capacity, and the plant height during mowing is 80-100 cm (depending on mowing and the time of the year). The share of leaf mass in the yield structure may exceed 50%. Protein content in the dry matter is 20-22%, depending on the stage of plant development at the time of mowing. NS-Alfa has high genetic potentiality for the yield of green mass (over 80 t/ha), and hay (over 20 t/ha). It is recommended for intensive use (5 or more mowings per year), and in case of irrigation it reaches 6 mowings per year.

Nijagara is a variety that is highly tolerant to most alfalfa diseases, tolerant to droughts and low temperatures (winter killing). When compared to other Serbian alfalfa varieties, it reaches the mowing height 5 to 7 days later. The share of the leaf mass at the start of flowering is over 50%. The leaves have dark green color, it has tender and thin stems, the flowers are mostly purple to dark purple, with 5% of multicolor flowers (yellow-green and purple), which indicates the presence of yellow genes of alfalfa. The variety features high protein content in the dry matter (22% on the average). Dormancy (resting level) is 4-5. The variety has branch roots, since its parents have a certain

Table 1. Mobile phosphorus content in soil (by Machigin) depending of alfalfa varieties, mg/kg

Fertilizers variants	Soil layer, cm	Alfalfa varieties						
		NS Alfa	Banat VS	NS Mediana	Nera	Nijagara	Kokorai (Control)	Average
Control	0-20	33.1	35.2	33.5	34.1	33.3	34.0	33.9
	20-40	17.5	19.9	19.2	18.4	18.1	18.5	18.6
P_2O_5 60 kg/ha	0-20	35.0	43.3	41.5	38.9	38.9	35.5	38.8
	20-40	17.9	19.2	22.0	17.9	21.3	21.0	19.4
P_2O_5 90 kg/ha	0-20	35.1	55.3	46.9	46.5	39.3	38.9	43.7
	20-40	19.2	26.1	26.1	25.2	20.3	17.5	22.4
P_2O_5 120 kg/ha	0-20	72.7	61.8	68.5	57.3	59.7	41.9	60.3
	20-40	25.0	26.1	21.3	33.1	20.3	19.2	24.2

percentage of yellow alfalfa, and therefore it is suitable for cultivation on degraded soils (heavy hydrogenic soils and acidic soils in the mountainous areas). It is recommended for extensive systems of usage (3-4 mowings). The genetic potentiality for yield of green mass is over 80 t/ha, and hay yield is about 20 hw/ha.

Nera is an early variety (it always remains in the first group of varieties for mowing). It has been created by individual selection of samples from Greece, Spain, Iran, and the NA Banat variety. It is a real representative of blue alfalfa (Medicago sativa ssp. sativa complex). Dormancy (resting level) is 5. It is recommended for intensive use (4 to 5 mowings per year). Nera features a deep root system, a higher level of resistance to droughts, rapid regeneration after mowing and excellent quality (protein content is 20.7%). It provides high yields of green mass (> 80 t/ha) and hay (> 20 t/ha) on soils with light and medium-heavy mechanical composition.

NS-Mediana: the variety has been created by individual selection from local populations, using the method of the intervariety hybridization between the blue and yellow alfalfa (Medicago sativa L. x Medicago falcata L.). It is recommended for deep and fertile soils; however, it grows well on heavy hydrogenic soils. It is resistant to droughts and low temperatures. The variety may be grown in various agroecological conditions in the mountainous regions and in the border areas of alfalfa growing. In the structure of the harvest, the share of the leaf mass at the beginning of flowering is about 50%. The NS-Mediana variety is characterized by high forage quality, the average crude protein content is 21.0%. Protein content depends on the stage of development and the period of mowing. Dormancy (resting level) is 5. This alfalfa variety is intended for 4 to 5 mowings per year. Its genetic potentiality for hay harvest is about 20 t/ha.

RESULTS AND DISCUSSION

Mobile phosphates dynamics in soil

Alfalfa features high consumption of phosphorus, and high response to introduction of phosphoric fertilizers. Also, alfalfa responds to introduction of phosphorus stronger than other crops, regardless of nitrogen and potassium

Table 2. Content of mobile I_2O_5 in the arable soil layer (0-30 cm) on the example of the NS Mediana alfalfa variety, mg/kg

Fertilizers variants	Autumn Mowing 1	Spring aftergrowth	1 year Mowing 1	Mowing 2	Mowing 3	Spring Aftergrowth	Mowing 1	2 year Mowing 2	Mowing 3	Mowing 4
Control	32.6	33.5	28.5	26.9	27.2	31.0	15.3	15.0	14.9	15.0
I_2O_5 60	38.3	41.5	20.4	20.0	36.3	36.3	19.8	20.1	17.2	17.0
I_2O_5 90	41.2	46.9	22.4	21.3	21.1	39.9	37.5	30.2	30.4	27.0
I_2O_5 120	56.8	68.5	33.7	32.5	32.0	57.2	45.4	44.1	45.2	45.0

availability in soil. When phosphate fertilizers are introduced, better development of generative organs and formation of larger seeds is ensured.

According to the results of the study performed in the Republican Scientific - Methodical Center of Agrochemical Service during the previous years (2000-2010), 99.0% of irrigated soils in the South-East of the Republic is characterized by low and very low humus content. Almost the entire studied area of arable land (95.7%) features low content of mobile forms of nitrogen, over half of the soils is characterized by low to medium content of mobile phosphorus, which is an indicator of high need for nitrogen and phosphate fertilizers of the crops grown on these soils (Mirzakeyev, E. K. *et al*., 2010; Auezov, A. *et al*., 2005). It is the low level of effective soil fertility that is the cause of low crop productivity, and one of the key prerequisites to high output of using fertilizers in the South-East of the Republic. However, it should be noted that the level and the system of fertilizer introduction in conventional technologies that exist in the region today do not have noticeable effect on the yield of hay and the yield of alfalfa seeds. Therefore, our research was focused on establishing the effects of varieties and fertilizers dosages on the changes in mobile phosphates content in the soil. The results of studying the phosphate state of the soil are presented in Table 1.

As can be seen from the data presented, the original mobile phosphates content in topsoil (0-20 cm) was on the average of 33.9, 38.8, 43.7 and 60.3 mg/kg in the 1st, the 2nd, the 3rd and the 4th experiments, respectively. It has been noted that, after introduction of fertilizers for each variety of alfalfa, various amounts of mobile phosphorus remained in the soil after the vegetation season. This can be explained by varietal characteristics in relation to the use of phosphorus.

Mobilization of available forms of soil phosphorus occurs die to their transition from the inaccessible phosphorus-organic compounds into the mobile form; due to phosphorus removal by plants, the phosphate balance in the soil is disturbed, its restoration is possible through the transfer of phosphate ions from the internal structures of soil particles to the upper layers (Karpinski N. P. and Zamyatina, V. B., 1958). In the variants with introducing phosphorous fertilizers, an additional factor for increasing its content in the soil by 2% is water-soluble phosphorus of the fertilizers, whereby phosphorus is transferred into the forms that cannot be extracted by 1% ammonium extract. However, it should not be assumed that phosphorus is retrograded; it mainly transforms into less mobile forms, still available for plant nutrition (Chirikov, 1966; Ponomareva, 1971; Sdobnikova, 1971).

Due to the fact that the nature of mobile phosphates dynamics in the soils of various experiments did not differ fundamentally, we focused on a more detailed analysis of $Ð_2Î_5$ dynamics only in the 1st experiment.

All experiments in the subsurface soil layer did not reveal any significant differences in the indicators of mobile phosphates content in soil between the reference and fertilized variants. This indicates that on light-chestnut soils of South-Eastern Kazakhstan, migration of phosphorus fertilizers does not occur, it is mostly fixed in the place of its introduction (in the topsoil). Thus, our data confirm that there is no appreciable migration of phosphorus fertilizers in the light chestnut soils of the South-East of Kazakhstan.

As can be seen from Table 2, the highest mobile phosphates content in soil was observed in the variant with introduction of 120 kg of the fertilizer. In the other variants, the content of mobile phosphorus corresponded to the level of fertilizers. This makes it possible to determine the influence of phosphate fertilizers introduction into soils with various levels of phosphorous availability on the yield of alfalfa. It was found that high content of mobile forms of phosphorus is observed in soils where phosphorous fertilizers had been introduced, as compared to the reference variant.

The content of mobile phosphates in the variant of $Ð_2Î_5$ 120 kg/ha increased to 68.5 mg/kg. During the alfalfa vegetation period in the 1st and 2nd year, the content of mobile phosphates in soil gradually decreased as follows: 1st mowing – 15.3: 2nd mowing – 15.0: 3rd mowing – 14.9, and 4th mowing -14.0 mg/kg.

For the NS Mediana variety, during the 2nd vegetation, i.e. in the autumn and winter period, the content of mobile phosphorus in the soil increases again, and by the spring, in the phase of regrowth at the P_{120} variant, the content of $Ð_2Î_5$ reaches 57.2 mg/kg.

Thus, in the topsoil, the content of mobile phosphates, depending on various levels of fertilizers introduction, decreases from spring to autumn. And an increase in the content of mobile phosphates in soil is observed in autumn-and-winter period. This can explain that after the spring regrowth, the need for mobile forms of phosphorus in alfalfa plants increases, therefore, until the end of the vegetation season, a decrease in its content to 32.6 mg/kg was observed. In the autumn and winter periods, 1 and 2 year alfalfa did not show any particular difference in varieties and variants.

CONCLUSIONS

As a result of studying the influence of alfalfa varieties with various dosages of fertilizers on the changes in the composition of mobile forms of phosphorus in case of irrigating light-chestnut soils of the South-East of Kazakhstan, the following conclusions can be made:

- All experiments in the subsurface soil layer did not reveal any significant differences in the indicators of mobile phosphates content in soil between the reference and fertilized variants. However, due to the varietal features of each variety of alfalfa, various amounts of mobile phosphorus remained in the soil after the vegetation season;
- The highest content of mobile phosphates in soil was observed in the variant with the introduction of 120 kg of fertilizers, in all other variants, the content of mobile phosphorus corresponded to the level of fertilizer;
- After the spring regrowth, the need for mobile forms of phosphorus in alfalfa plants increases, therefore, from spring until the end of the vegetation season, a decrease in its content was observed.

It should be noted here that in performing the study, we used only the resources and the methods available for us. By introducing modern methods, the work in the subject area of this research may be developed further.

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