EFFECT OF NITROGEN FERTILIZERS ON NUTRIENT REGIME OF SOILS FOR SWEET SORGHUM UNDER DIFFERENT SUPPLY OF SOILS WITH LABILE PHOSPHORUS

Nokerbekova N. K., Suleimenov E. T., Sarsenbayev B. A.

Republic of Kazakhstan, Almaty, 050010, Abay Avenue 8, Kazakh National Agrarian University
LLP «Kazakh Research Institute of Agriculture and Plant Growing»
RSE «Institute of Plant Biology and Biotechnology»

Abstract

The research results showed that the content of labile elements of nutrition in the soil in connection with the nitrogen fertilization in the initial phases of growth and development of sweet sorghum plants has not changed significantly. The tendency of changing in the content of nutrients remained for both backgrounds of supply of soils with labile phosphorus.

Key words: *sweet sorghum, variety, background, fertilizers, nitrate nitrogen, labile phosphorus, exchangeable potassium*

INTRODUCTION

Sorghum is an old and widespread crop culture in the world of farming. It is cultivated in arid, semi-arid zones and in the zones of insufficient moisture of 85 countries around the world on an area of over 50 million hectares. The sorghum in our country is used as food and feed crops for the production of cereals, sugar syrup, feed grain, silage and green mass for feed and hay. In different parts of the world the possibility of obtaining a stable harvest of this crop under severe drought is shown while it's impossible to do it with other species [1]. Sometimes the growing of sugar beet or cane is not possible because of climatic conditions, so then such a cereal like sweet sorghum comes to the aid [2].

In its external appearance the sweet sorghum constitutes a shrub which generally does not exceed a height of three and a half meters. Sweet sorghum or *Sorghum saccharatum* is included in the list of some of the most drought-resistant plants known to modern science. The main difference of sweet sorghum is in the chemical composition of plants. The chemical composition of the juice which is produced from sweet sorghum stalks unlike grain and paniculate plant species comprises about 20% of sugar of natural origin [3,4].

Sorghum is a culture of multiple use. Its grain is a valuable concentrated fodder for all kinds of animals and birds. Sorghum harvested in the phase of milk-wax and wax ripeness is used for the preparation of pelleted feed. Green mass of sweet sorghum in its fresh form is used to feed animals, as well as silage, haylage and hay are prepared from it. 100 kg of green mass contain 24–26 feed units, silage 20–22 feed units and hay 49 feed units. Sorghum grows well after grazing and can be used to create annual pastures. 100 kg of grain contain 119 feed units. 65–70% of starch, 11–15% of lysine-rich protein and 3,5–4% of lipids are accumulated in the grain [5]. Currently, the sweet sorghum is used in three main areas – food processing, bioenergy, as well as the production of feed for domestic animals [6,7].

In order to increase crop yields by improving the nutrition it is necessary to know the physiological role of the individual elements in plant nutrition and the need for them in the individual phases of growth and development.

Seasonal dynamics of nutrient elements in the soil is influenced by a complex interaction of different factors: on the one hand, it is affected by the factors contributing to the accumulation of dynamic connection of the nitrogen, phosphorus and potassium, in particular, the use of fertilizers, favorable weather conditions, and on the other, factors that reduce the content in the soil (removal and volatilization, consumption of plants, soil immobilization of nutrient elements, etc.).

Despite the relatively undemanding to soil fertility and the ability to produce food items the sorghum is responsive to the application of mineral and organic fertilizers. Sorghum provides grain harvests even without the additional application of mineral nutrition to the soil possessing a strong development of a high capacity to assimilate the root system. Therefore there is formed an opinion about the weak responsiveness of sorghum to increase the level of mineral nutrition and relatively less removal of nutrients from the soil compared with corn that is necessary to produce a crop. Sorghum really economically consumes nutrients for the formation of one quintal of grain: 75% of nitrogen, 60% of phosphorous and 90% of potassium from the amount that consumes corn. Multi-year research conducted in different areas of the country convincingly provides a high degree of responsiveness of sorghum to organic and mineral fertilizers.

Nitrogen promotes intensive plant growth, increase in leaf surface area and all vegetative mass in sorghum. The highest yields under irrigation are obtained by the introduction of high doses of nitrogen.

Phosphorus also plays an important role in the life of plants. Doses of phosphorus contributed by sorghum is generally lower than the nitrogen for 1,5–2 times and constitute 45–60 kg/ha for rainfed and 90–100 kg/ha for irrigation. Phosphorus has an effect on starch hydrolysis, thus accelerating the germination of seeds. Therefore, the part of the dose of phosphorus (10–15 kg/ha) is appropriate to apply locally at sowing.

Potassium positively effects on the accumulation of starch and sugar in grain sorghum. Sorghum is fully self-sufficient with potassium due to its removal from the soil while grain harvesting of 5,0 t/ha. During higher yields (8,0–10,0 t/ha) there is a certain deficit of it, so there is a need to apply 40–60 kg/ha of potassium in combination with other fertilizers.

However, phosphate and nitrogen fertilizers negatively affect the field germination of seeds during the joint introduction with seeds. Therefore, it is advisable to apply fertilizers away from the seeds and deeper than its sowing and locally. Every quintal of fertilizers applied in such a way is paid with the growth harvest 3–3,6 times higher than during applying a complete mineral fertilizer under the spread of cultivation.

Soil fertility is largely determined by the presence of nutrients in it, especially nitrogen. Applying nitrogen fertilizers is one of the factors that enhance a nitrogen regime of the soil [8,9].

The main form of accessible stocks of nitrogen of the soil is nitrates. As it is known, nitrates are not absorbed by the soil-absorbing complex, so that they are subject to considerable migration in the soil profile. The study of soil nitrate regime is of great importance, since the level of effective fertility of the soil is directly dependent on its content of nitrates. Their high mobility in the soil, as well as intense uptake by plants leads to significant fluctuations of the nitrate content during the vegetation period.

Agricultural science and practice of agricultural production long ago have proved an inexpedient of applying the nitrogen fertilizers in nitrate form into the main plowing because of strong leaching them out of the root layer of the soil.

METHODOLOGY OF THE RESEARCH, FACILITY AND EXPERIMENTAL DESIGN

Experimental studies with laying of field experiments were conducted on irrigated light-brown soils with different levels of supply of soils with labile phosphorus. The experimental design consisted of the following variants: 1. Control (without fertilizers); 2. N50 (feeding at a phase of 3-5 leaves); 3. N100 (feeding N50 at a phase of 3-5 leaves + N50 at a phase of 5-7 leaves). Experiments were laid on two supply backgrounds (average – background 1 and increased – background 2) with labile phosphorus.

The objects of research were sweet sorghum varieties of domestic breeding –«Kazakhstanskoye 16» and «Kazakhstanskoye 20». Field experiment was conducted in three replications using farming techniques adopted for this area. The research involved modern physio-biochemical and agrochemical

approaches for plant research. Biological growth parameters such as plant height, panicle length, number of nodes and the number of lateral shoots were studied. Dry biomass of different organs was determined by measuring and weighing [10]. Features of growth and development, the biological productivity of sweet sorghum varieties were investigated in terms of field experiments. Phenological observations of plant growth and development were conducted during the vegetation period. All research results are subjected to statistical analysis of Udolskaya N.L. [11] and computer programs Excel 97, ANOVASYSTAT 2007.

In our studies, the content of nutrient elements in irrigated light-brown soils tended to decrease due to the vegetation process regardless of supply of soils with labile phosphorus and sweet sorghum varieties. The content of nitrate nitrogen depended on applying of nitrogen fertilizers into the extra feeding at different phases of plant development. Thus, in the experiment for Kazakhstanskoye 16 variety on a background with an average supply of soils with labile phosphorus (background 1) at the phase of 3-5 leaves on average within two years the content of nitrate nitrogen in the studied options was 24,4-24,5 mg/kg of the soil, so then when applying the N50 it was increased to 27,6 mg/kg at the tillering phase and 24,3 mg/kg at the flowering phase during the content on a control was 23,1 and 18,4 mg/kg respectively (Table 1). For Kazakhstanskoye 20 there was obtained similar data. In the control variant there was observed an impoverishment from 24,2 to 18,9 mg/kg of the soil as long as the growth and development of plants. Applying nitrogen fertilizer doses of 50 and 100 (50+50) kg application rate increased nitrate nitrogen content to 5,0 and 5,4 mg/kg respectively.

Table 1. The content of nitrate nitrogen in the soil for sweet sorghum, mg/kg of soil, average for 2015-2016.

Experiment variants	Background 1						Background 2					
	Kazakhstanskoye 16			Kazakhstanskoye 20			Kazakhstanskoye 16			Kazakhstanskoye 20		
	1	2	3	1	2	3	1	2	3	1	2	3
Control	24,5	23,1	18,4	24,2	23,2	18,9	25,1	24,1	19,2	24,5	23,5	19,4
N_{50}	24,6	27,6	23,5	24,6	27,7	22,6	24,9	27,6	22,5	25,0	28,9	22,8
N_{100}	24,4	27,6	24,3	25,1	28,2	24,3	25,0	28,1	23,4	25,3	28,9	24,4

More increased supply of soils with labile phosphorus had no significant influence on the content of nitrate nitrogen for both Kazakhstan 16 and Kazakhstan 20 varieties. These experiments also remained a similar pattern on the content of nitrate nitrogen.

Phosphorus as a fertilizer element in the life cycle of plants plays a crucial role. Relative and absolute phosphorus content in the plant several times less than, for example, nitrogen and potassium. However, in terms of physio-biochemical functions, much less energy functions its absolute weight in a biological cycle is equivalent to the nitrogen.

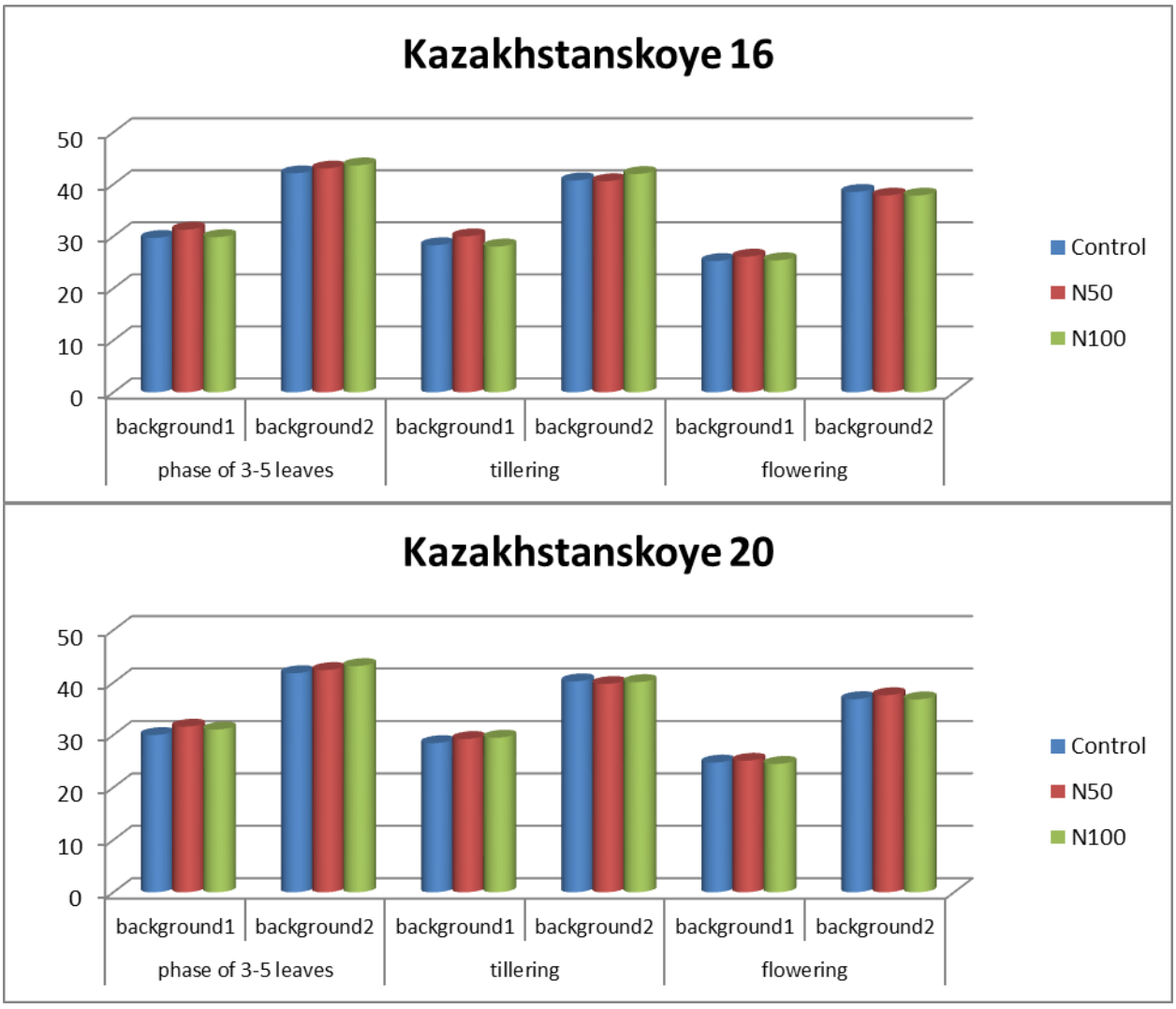
In contrast to nitrate nitrogen, the phosphorus by reaction with mineral part of the soil is absorbed by it, and depending on soil conditions, in some cases to a greater degree, in others to a lesser. It has some difficulty in conducting accounting of fast phosphorus during the vegetation period.

The absorption of phosphorus by plants and the extent of its use are largely determined by the content of this element in the soil. The availability extent by plants of labile phosphates depends on the physico-chemical properties of soil of this type, the biological characteristics of plants, and other factors. The content of labile phosphorus extracted with 1% of ammonium carbonate solution to a certain extent characterizes the phosphate regime of calcareous soils.

As shown by the data, by the period of intense growth and development of sweet sorghum, the content of labile phosphorus in the soil was reduced which is associated not only with its consumption, but also the physico-chemical processes occurring in the soil as a result of the interaction of fertilizer phosphorus with soil components.

Summarizing the results of two years data of our research it was shown that the content of labile phosphorus in the soil due to a feed fertilizer with nitrogen fertilizers has not changed significantly. Thus, in the control variant on a background 1 for Kazakhstanskoye 16 and Kazakhstanskoye 20 varieties the average seasonal content of labile phosphorus in tilth top soil was 27,8 and 27,7 mg/kg of soil, then at the variants with different doses of nitrogen fertilizers (variants 2 and 3) it was 29,1-27,8 and 28,6-28,3 mg/kg respectively (Figure 2). This pattern was also observed on the background of increased supply of soil with labile phosphorus. An average seasonal content on fertilized variants for the above mentioned varieties was 40,5-41,2 and 39,9-40,1 mg/kg of soil with the content on a variant without fertilizers 40,4 and 39,6 mg/kg of soil respectively.

Figure 1. The content of labile phosphorus in the soil for sweet sorghum, mg/kg of soil, 2015-2016.



Sweet sorghum has a high need for potassium. It absorbs it more than any other element.

Potassium is consumed by plants in large quantities, but its availability from the soil is frequently insufficient for them as the exchange form of potassium is only 1-4% of the total content. According to the consumption of labile forms of potassium by plants there is occurred an incomplete recovery of them due to their non-exchange forms. Thus, in the analysis of soil samples for the content of labile potassium therein the obtained results are meant to be an indication of the soil supply for these elements. The degree of supply of carbonate soils with labile potassium is judged on the content of exchangeable potassium extracted with 1% of carboammonium hood.

As shown in average two-year results of research the potassium status of light-chestnut soils for a sweet sorghum did not change in connection with the application of nitrogen fertilizers (Table 2). The highest content of exchangeable potassium in the tilth-top soil was noted at the beginning of the vegetation period (May – the phase of 3-5 leaves of plants) when young plants are still poorly absorbed it and it was within 339-346 and 328-348 mg/kg respectively for Kazakhstanskoye 16 and Kazakhstanskoye 20 varieties. Its content was 328-352 and 319-349 mg/kg of soil respectively during the application of nitrogen fertilizers. The content of exchangeable potassium remained at the same level in the experiments with high supply of labile phosphorus.

Table 2. The content of exchangeable potassium in the soil for sweet sorghum, mg/kg of soil, average for 2015-2016

Experiment variants	Background 1						Background 2					
	Kazakhstanskoye 16			Kazakhstanskoye 20			Kazakhstanskoye 16			Kazakhstanskoye 20		
	1	2	3	1	2	3	1	2	3	1	2	3
Control	346	339	325	348	345	328	344	334	322	348	344	326
N_{50}	352	342	326	349	337	320	345	327	307	351	340	320
N_{100}	344	335	328	353	343	319	345	331	311	350	340	324

CONCLUSION

Thus, our research results showed that the content of labile elements of nutrition in the soil in connection with the nitrogen fertilization in the initial phases of growth and development of sweet sorghum plants has not changed significantly. The tendency of changing in the content of nutrients remained for both backgrounds of supply of soils with labile phosphorus.

REFERENCES

1. Alabushev A.V., Anipenko L.N. Effectiveness of grain sorghum production // Rostov-on-Don: WAD «Kniga», 2002.- 192 p.
2. Shepel N.A. The sorghum // Volgograd.- Committee on printing. - 1994.- 448 p.
3. Y,. A. Sani, M. M. Jaliya, M. U. Makeri, S. I. Sunusi and A. A. Yari. Sorghum: Production, Processing, Marketing and Utilization // By IdrisIdris 79.- May 2013 - P.1 – 28
4. C. Wayne Smith, Richard A. Frederiksen John Wiley & Sons, Sorghum: Origin, History, Technology, and Production. USA. Texas A.&M. university 25 déc. 2000. - 824 p.
5. Shepel N.A. The sorghum is an intensive culture // Simferopol: Tavriya, 1989.- 191 p.
6. Gorbunov V.S., Kolov O.V., Yefremova I.G. An increase of sugar content in sweet sorghum in the arid conditions of the Low Volga // Corn and sorghum. – 2011. - №4.- P.- 4-7.
7. Sarsenbayev B.A., Kirshibayev E.A., Kamunur M., Baiseitova G.A., Sarybayeva E.A., Nokerbekova N.K. Biotechnology for bioethanol from the stalks of sweet sorghum (*Sorghum saccharatum (L.) Pers.*) // Biotechnology, theory and practice.- Astana.- 2013.- №3.- P.-61-64.
8. Korenkov D.A. Agrochemistry of nitrogen fertilizers, M.: Nauka, 1976, 228 p.
9. Zhurbitskyi Z. Theory and practice of the greenhouse experiment // M., «Nauka». - 1969.- 230 p.
10. Dospekhov B.A. Methodology of the field experiment // M.: Agropromizdat, 1985. - 351 p.
11. Udolskaya N.L. Introduction to biometrics // Alma-Ata: Nauka Kaz. USR, 1976. - 85 p.