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Influence of mineral nitrogen and organic fertilization on the productivity of grain sorghum

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Abstract. The production of grain sorghum has increased in recent years. The modern varieties are hybrids with high productivity potential appropriate for application of intensive forage grain production technologies. The increased requirements for ecological production necessitate optimization of the nutrition parameters in the conditions of unstable agriculture with unbalanced soil nutrient substance accumulation. The effect of nutrition with mineral nitrogen fertilizer and organic fertilizer Humustim on the productivity of 6 varieties of Euralis Semences, popular in the practice, was tested during 2011 – 2013. In the various climatic conditions fertilization is a highly effective factor for productivity increase. The use of organic fertilizers such as Humustim widens the possibilities of the ecological production.

Keywords: grain sorghum, technology, nutrition, fertilizer

Introduction

Grain sorghum (Sorghum vulgare Pers.) is a valuable forage crop. Its high nutritive value is combined with good productivity and possibility of many-sided use. Regardless of the excellent qualities of sorghum as grain source, its distribution in our country is still limited, and for 2013 the areas with sorghum are only 4339 ha (MAF, Agrostatistics). The observed climatic changes connected with global warming and drought could lead to substantial decrease of forage production. For this reason forage crops with high productivity and adaptation capabilities to the local conditions are necessary. These preconditions renew the interest in sorghum for the agricultural science and practice (Yakimov and Kikindonov, 2008).

Sorghum is comparatively easygoing to the different soil types because of its powerful root system – the water and nutritive substances intake is easy with such a great absorption capability. Despite the possibility of development on whatever soil type, sorghum shows very high receptivity to organic and mineral fertilization, and especially to nitrogen fertilization. The last is a basic element of the crops growth technologies and a mover of the yields (Ivanov, 2008). Its quantity in soil is one of the basic factors for sorghum's high productivity (IPNI, 2012). The bad availability of nitrogen in soil leads to crop's impossibility to deploy its biological potential (Baker and Blarney, 1985; Coclea et al., 2014). The supply of plants with nutritive substances in most cases leads to yield increase up to 20% on the average stocked up soils, and 40 – 50% on the poor soils. The use of mineral fertilizers in most cases ensures the needs of sorghum plants for macroelements, but the quantity of microelements is usually not enough, and they are in a hardly digestible form. That is why, from a physiological point of view, the application of complex leaf fertilizers is especially effective (Slanev, 2014).

The recent years studies prove the high effect of the humus fertilizers such as Biohumax (Nankova et al., 2004) and Humustim (Petrova and Tanova, 2004; Sengalevich et al., 2004; Hailova and Gergova, 2014). Humustim is an ecologically clean organic product. Its basic active substance is potassium humate with high humine acids content. Except the macroelements K, N and F it contains numerous microelements, and this makes it a preferable fertilizer for ecologically clean production.

The aim of the present research is to study the productivity of grain sorghum in dependence with mineral and organic fertilizer application.

Material and methods

The research was conducted during the period 2011 – 2013 at the experimental fields of the Agricultural Institute, Shumen. The soil type is carbonate black soil with 3.3% humus, very high content of CaCO₃ and slightly alkaline reaction of the soil solution (pH 7.4 – 7.8). The content of the basic nutritive elements is: N – 35.0 – 42.0 mg/kg, P₂O₅ – 4.7 mg/100 g, K₂O – 34.0 mg/100 g, B – 1.2 mg/kg, Mn – 45.0 mg/kg, Zn – 0.1 mg/kg, Mo – 0.1 mg/kg. We could specify the soil as poor in nitrogen, phosphorus and zinc, and rich in K and B.

Object of study were the French grain sorghum varieties Alise, Armida, Mistral, Standart, Solaris and Arkansiel – widely used in the practice. In a comparative test, in three-row plots of 8.4 m² and 70 cm between the rows, the effect of fertilization with 200 kg/ha mineral nitrogen and 500 ml/ha organic fertilizer Humustim (recommended by the manufacturer dose for application in grain crops) on the productivity of the varieties is studied. The organic fertilizer Humustim has 12.5% dry matter, including 41.05% ashes and mineral substances, and 58.95% organic matter. 23.4% of the organic matter is humine acids, 7.83% – total potassium, 3.0% – total nitrogen, 1.14% – total P, 3.92% – total Ca, 1.11% – total magnesium. The content of digestible nitrogen is: NH₄ – 142.8 mg/l and NO₃ – 12.6 mg/l, digestible P₂O₅ – 400 mg/l, digestible K₂O – 10245 mg/l, the pH of the solution is 8–9.

The mineral nitrogen was applied before the basic tillage of the ground, and the leaf treatment with Humustim was done in 4th – 6th leaf phase of the sorghum. The growth of the grain sorghum was carried out according to the confirmed technology following sugar beet, in non-irrigation conditions. The statistically significant differences between the tested variants are determined by application of dispersion analysis (Lidanski, 1988).

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Results and discussion

The years of study 2011 – 2013 differ in rainfall quantity and temperature sum, as well as in their distribution from the sowing to the grain sorghum harvest time (Table 1). The first year of study was comparatively dry regarding the total quantity of vegetation rainfalls – 260 mm compared to the normal (measured for a 50-year period) – 310 mm. Their distribution during the vegetation is irregular, which also characterizes the year as unfavorable for the crop development. The continuous and cool spring forced late sowing (12.05 – 15.05). The insufficient rainfall during the winter period before sowing also led to the low water stock of the experimental field. The stable weather in the autumn of 2011 allowed postponing the harvest to the end of September, which to a great extent compensated the unfavorable climatic factors. The climatic conditions in 2012 were extremely unfavorable. There was a late, cool and continuous spring, followed by the most severe drought for the last decade. The unfavorable spring conditions led to irregularly trimmed seedling, and the following dry period strongly affected the grain productivity of sorghum. In 2013 there was a period of 35 days before and after sowing with no rainfalls. This slowed the sorghum germination. Even if the vegetation rainfall sum did not divert from the norm, their distribution during the vegetation was uneven.

Data of crop yield are the most important and systematic index of the technology. The received results for grain sorghum productivity in 2011 are given in Table 2. The mineral nitrogen fertilization shows positive effect on productivity and increases the grain yield of all tested varieties. The most responsive to nitrogen fertilization is Mistral, realizing a yield of 13.4 t/ha. The treatment with Humustim also affects positively the yield – all six tested varieties exceed the control. It should be noted that the fertilization effect is different for the different genotypes. It is mostly tangible for Mistral, Armida and Alise with the use of mineral nitrogen, and for Mistral and Standard – when Humustim has been applied.

The effectiveness of nitrogen fertilization is determined by a number of factors, the most important of which are the presence of sufficient moisture in the soil profile and the density of sowing. The extremely unfavorable conditions of 2012, with the record spring drought and the irregular sowing affected the grain yield results. For its normal vegetation sorghum needs rainfalls of at least 250 mm, with an optimum of 350 – 400 mm, allowing high yield realization (Blum, 1970). The data of the climatic values in 2012 show that the total vegetation rainfalls are only 167.9 mm. Despite that this crop proves its drought resistance and even in such bad conditions the tested hybrids demonstrated comparatively good productivity. Only the differences in the grain yield index between the separate origins and variants of fertilization decrease in comparison with the previous year. In such unfavorable conditions the treatment of grain sorghum hybrids with mineral nitrogen lead to average yield values of 3.05 t/ha, and the treatment with Humustim – to 2.76 t/ha, which exceeds the yield from the control.

The third year of tests was the most favorable for the grain

Table 1. Precipitations and temperatures during the period April-September in the region of Agricultural Institute, Shumen

<table>
<thead>
<tr>
<th>Years</th>
<th>Month</th>
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<th>Rainfalls-mm</th>
<th>Temperature</th>
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<td>Decades</td>
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<td>2011</td>
<td>IV</td>
<td>2.4</td>
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<td>VI</td>
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<td>VII</td>
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<td></td>
<td>VIII</td>
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<td>Total for the period</td>
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<td>Total for the period</td>
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<td>VII</td>
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<td>Total for the period</td>
<td>215.1</td>
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* mean of vegetation rainfalls for 50 years period
Conclusions

The application of the Humustim preparation influences positively the grain yield in the three years of tests. Even in unfavorable climatic conditions the use of mineral and organic nitrogen fertilizers has a positive effect on the productivity of grain sorghum. The effect of fertilization is different for the different grain sorghum genotypes.

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