Growth stimulators and mineral fertilizers influence on Sudan grass growth, development and productivity

Yu A Laptina¹, O G Gichenkova¹,², N A Kulikova¹ and T L Karpova¹

¹ Volgograd State Agrarian University, 26 University Avenue, Volgograd, 400002, Russia
² All-Russian Research Institute of Irrigated Agriculture, 9 Timiryazev Street, Volgograd, 400002, Russia

E-mail: ylapina82@mail.ru

Abstract. The article considers the results of research on the influence of seeding rates, fertilizers and growth stimulator on the development and productivity of the Sudan grass of the Julia variety in the conditions of chestnut soils of the Volgograd region. In the field two-factor experiment, we studied: factor A - the three seeding rates 1.0, 1.5 and 2.0 million germinating seeds per hectare; factor B - fertilizers and growth promoters: 1. Control without fertilizers; 2. N₆₀ P₆₀ K₄₅ + N₃₀; 3. Growth stimulator Raikat Start; 4. N₆₀ P₆₀ K₄₅ + Raikat Start + N₃₀. The use of mineral fertilizers increased the leaf surface area by 0.3-0.5 thousand m²/ha, the use of growth stimulators increased the leaf surface area by 0.1-0.2 thousand m²/ha, the combined use of mineral fertilizers and growth stimulators increased the leaf surface area by 0.9-1.2 thousand m²/ha. It was found that the highest yield of green mass of Sudan grass, 28.6 t/ha, was formed on the variant with a seeding norm of 1.5 million tons of germinating seeds per ha with the complex application of mineral fertilizers and the growth stimulator Raikat Start.

1. Introduction

Agriculture is the key word. It must be “economically sustainable” with low costs and high productivity [1, 2].

Forage crops are the basis for sustainable livestock production and play an important role in crop rotations and agricultural landscapes [3, 4].

Sudan grass differs from other spring crops by exceptional drought and heat resistance, as well as undemanding to the composition of the soil. However, it is very responsive to additional moisture and intensively accumulates the aboveground mass. The amount of precipitation and air temperature are the main climatic factors that determine the yield of any agricultural crop, including Sudan grass [5].

Although in the strategy of agricultural production adaptive intensification is given to biological factors over chemical ones, the use of man-made means, including mineral fertilizers, is not ignored [6].

The solution of agricultural production ecological and economic problems is possible by using universal organomineral fertilizer, showing biological activity and providing the reduction in the mineral fertilizers non-productive costs [7, 8, 9].

Numerous studies carried out both in our country and abroad showed the essential role of agrochemical agents in regulating the cycle of nutrients in agroecosystems, maintaining soil fertility,
increasing the plants adaptive potential to uncontrolled environmental factors, and changing biological activity and structure of soil microbiota, as well as in solving other important agronomic and ecological problems [7].

Resource-saving technologies for the agricultural crop cultivation can significantly increase their productivity, but at the same time adaptation to the existing soil-climatic and ecological conditions of the region must be carried out [10, 11].

The research aim was to create highly productive agrophytocenoses of Sudan grass in pure sowing by using optimal seeding rates, fertilizers and growth stimulants in the dry steppe zone of the Lower Volga region, followed by the use of fodder from Sudan grass in cattle diets.

2. Materials and methods

The studies were carried out in the period from 2016 to 2020 at the Agrofirm Vostok JSC in the Nikolaevsky district of the Volgograd region. In a two-factor field experiment, the authors studied: factor A - three seeding rates 1.0, 1.5 and 2.0 million germinating seeds per hectare; factor B - fertilizers and growth stimulants: 1. Control without fertilizers; 2. $N_{60}P_{60}K_{45}$ + $N_{30}$; 3. Raikat Start growth stimulator; 4. $N_{60}P_{60}K_{45}$+ Raikat Start + $N_{30}$. The experiment was carried out with the Sudan grass variety Julia.

The soils of the experimental site are chestnut loamy ones, the humus content is 1.6-2.0%, mobile phosphorus is 22-29 mg per kg of dry soil, the lowest moisture content of the active layer is 0.6-1.0 m - 24.2%.

Mineral fertilizers $N_{60}P_{60}K_{45}$ are applied while the main tillage. Growth stimulator Raikat Start in the form of seed treatment and foliar application. $N_{30}$ is applied as a foliar application in the tillering phase of the first mowing.

Generally accepted methods were used when laying out field experiments, carrying out the research and observations.

3. Results and discussion

Field germination or seedlings density, as our five-year experiments showed, depended both on the factors considered in the experiment and on the weather conditions.

On average, for 2016-2020, the density of Sudan grass seedlings on variants with the seeding rate of 1.0 million germinating seeds per hectare ranged from 79.0% on variants without seed treatment by the Raikat Start growth stimulator to 84.8% on variants with seed treatment by Raikat Start. On variants with the seeding rate of 1.5 million germinating seeds per hectare, the germination density was slightly less and ranged from 78.7-78.8% on variants without seed treatment by the Raikat Start growth stimulator to 84.5% on variants with seed treatment by Raikat Start. On the variant with the seeding rate of 2.0 million germinating seeds per hectare, the germination density ranged from 78.3% for variants without seed treatment by the Raikat Start growth stimulator to 83.9-84.0% for variants with seed treatment by Raikat Start (Table 1).

According to factor B (Fertilizers and growth stimulants), seedling density also practically did not depend on the use of mineral fertilizers, the difference was between the variants with seed treatment by the growth stimulant and options without this treatment. The seedling density on the variants without seed treatment ranged from 78.3% at the seeding rate of 2.0 million germinating seeds per hectare to 79.0% at the seeding rate of 1.0 million germinating seeds per hectare. In the variants with seed treatment by the growth stimulant, it ranged from 83.9-84.0% at the seeding rate of 2.0 million germinating seeds per hectare to 84.8% at the seeding rate of 1.0 million seeds per hectare.

Thus, the following can be noted: the Sudan grass dates of sowing and the periods of phenological phases, the duration of the phases and the entire growing season, the density of seedlings varied over the years of research, and also depended on the seeding rates, applied mineral fertilizers and growth stimulants.
In our experiments, plant leafiness was counted at the beginning of the paniculation phase. In all the years of research, the greatest leafiness was observed on the third mowing, the least leafiness was noted on the first mowing, which is most likely due to the fact that during the second and especially during the third mowing, younger plants with less developed stems were used.

On average, for 2016-2020, on the first mowing on the control variant without fertilizers and a growth stimulator, the Sudan grass leafiness when grown in dry conditions in the dry steppe zone of the Lower Volga region was 17.5% at the seeding rate of 1.0 million germinating seeds, at the seeding rate of 1.5 million germinating seeds leafiness of seeds was 0.5% higher, at the rate of 2.0 million germinating seeds was 0.3% higher. On the variants with fertilization, leafiness was 1.8-1.9% higher than on the control variants. Leafiness on the variants with seed treatment by Raikat Start was 3.8-4.2% higher than on the control variants. On the variants with Raikat Start seed treatment and fertilization, leafiness was 5.2-5.6% higher than on the control variants.

On the second mowing, the control variant without fertilizers and growth stimulant was 22.9% at the seeding rate of 1.0 million germinating seeds, at the seeding rate of 1.5 million germinating seeds leafiness of seeds was 0.2% higher, at the rate of 2.0 million germinating seeds was also 0.2% higher than at the seeding rate of 1.0 million germinating seeds. In the variants with fertilization, the leafiness was 1.6-1.8% higher than in the control variants. Leafiness on the variants with Raikat Start seed treatment was 3.2-3.6% higher than on the control variants. On the variants with seed treatment by Raikat Start and fertilization, leafiness was 4.4-4.8% higher than on the control variants (Table 2).

On the third mowing on the control variant without fertilizers and growth stimulant, the leafiness was 34.2% at the seeding rate of 1.0 million germinating seeds, at the seeding rate of 1.5 million germinating seeds leafiness of seeds was 0.4% higher, at the rate of 2.0 million germinating seeds it was also 0.2% higher than at the seeding rate of 1.0 million germinating seeds. On the variants with fertilization, the leafiness was 1.6-1.7% higher than on the control variants.

The leafiness on the variants with Raikat Start seed treatment was 3.2-3.4% higher than on the control variants. On variants with seed treatment by Raikat Start and application of fertilizers, the leafiness was 4.8-4.9% higher than on control variants.

Photosynthesis is one of the main processes in creating crop yields. Moreover, the most important indicators of the plants photosynthetic activity that determine the crops productivity are, first of all, the size of the assimilation surface, the duration and intensity of its work. In our experiments, the size of the assimilation surface and its formation were different, both depending on the seeding rates, nutritional regime, and according to the years of research.

Table 1. Seedling density of Sudan grass, average for 2016-2020.

| Seeding rate (A) | Fertilizers and growth stimulants (B) | Seedling density |
|-----------------|--------------------------------------|-----------------|
|                 |                                      | pcs/m² | %    |
| 1.0 million     | Control without fertilizers          | 79.0   | 79.0 |
| germinating     | N₅₀P₀₀K₄₅ + N₃₀                      | 79.0   | 79.0 |
| seeds per hectare | Raikat Start                          | 84.8   | 84.8 |
| 1.5 million     | Control without fertilizers          | 118.0  | 78.7 |
| germinating     | N₅₀P₀₀K₄₅ + N₃₀                      | 118.2  | 78.8 |
| seeds per hectare | Raikat Start                          | 141.0  | 84.5 |
| 2.0 million     | Control without fertilizers          | 156.6  | 78.3 |
| germinating     | N₅₀P₀₀K₄₅ + N₃₀                      | 156.6  | 78.3 |
| seeds per hectare | Raikat Start                          | 188.0  | 83.9 |
|                 | N₅₀P₀₀K₄₅ + Raikat Start + N₃₀       | 188.0  | 84.0 |
The use of mineral fertilizers increased the leaf area by the first mowing, depending on the seeding rate, by 7.5-8.0 thousand m²/ha. The use of growth stimulants increased the leaf surface area by the first mowing in comparison with the variants without the use of mineral fertilizers and growth stimulants, depending on the seeding rate, by 2.7-3.7 thousand m²/ha. The complex use of mineral fertilizers and growth stimulants increased the leaf surface area in the first mowing by 14.0-14.5 thousand m²/ha (Table 3).

The leaf surface area by the second mowing on the variant with the seeding rate of 1 million seeds per hectare without the use of mineral fertilizers and growth stimulants was 12.9 thousand m²/ha. On the variant with the seeding rate of 2.0 million seeds per hectare without the use of mineral fertilizers and growth stimulants, the leaf area was 1.2 thousand m²/ha more. The maximum leaf surface area in the stem elongation phase on the second mowing in the variant without the use of mineral fertilizers and growth stimulants was in the variant with the seeding rate of 1.5 million seeds per hectare and was equal to 14.6 thousand m²/ha, that is, it was by 0.5 thousand m²/ha more than in the variant with the seeding rate of 2.0 million seeds per hectare and 1.7 thousand m²/ha more than in the variant with the seeding rate of 1.0 million seeds per hectare. The use of mineral fertilizers increased the leaf surface area by 2.6-2.9 thousand m²/ha, the use of growth stimulants increased the leaf surface area by 0.9-1.1 thousand m²/ha, the combined use of mineral fertilizers and growth stimulants increased the leaf surface area by 3.7-4.1 thousand m²/ha.

The leaf area by the third mowing on the variant with the seeding rate of 1 million seeds per hectare without the use of mineral fertilizers and growth stimulants was 6.4 thousand m²/ha. In the variant with the seeding rate of 2.0 million seeds per hectare without the use of mineral fertilizers and growth stimulants, the leaf surface area was 0.5 thousand m²/ha more. The maximum leaf surface area

| Seeding rate (A) | Fertilizers and growth stimulants (B) | Leafiness (%) |
|------------------|--------------------------------------|---------------|
|                  |                                      | 1 mowing | 2 mowing | 3 mowing |
| 1.0 million      | Control without fertilizers          | 15.6     | 20.3     | 30.3     |
| germinating seeds per hectare | N₀P₀K₁₄₅ + N₃₀ | 17.3     | 22.2     | 32.1     |
| 1.5 million      | Control without fertilizers          | 15.3     | 20.0     | 29.8     |
| germinating seeds per hectare | N₀P₀K₁₄₅ + Raikat Start + N₃₀ | 18.1     | 23.7     | 33.1     |
| 2.0 million      | Control without fertilizers          | 16.2     | 21.1     | 30.2     |
| germinating seeds per hectare | N₀P₀K₁₄₅ + Raikat Start + N₃₀ | 16.8     | 21.1     | 31.1     |

Table 2. Leafiness of the Sudanese grass, average for 2016-2020, %.

That is, it was noted that the formation of the assimilation apparatus or, in other words, the leaf surface of Sudan grass grown on dry land in the dry steppe zone of the Lower Volga region is influenced by the growing season meteorological conditions.
by the third mowing in the variant without the use of mineral fertilizers and growth stimulants was in the variant with the seeding rate of 1.5 million seeds per hectare and was equal to 7.0 thousand m$^2$/ha, that is, it was by 0.1 thousand m$^2$/ha more than in the variant with the seeding rate of 2.0 million seeds per hectare and 0.6 thousand m$^2$/ha more than in the variant with the seeding rate of 1.0 million seeds per hectare.

### Table 3. Dynamics of leaf surface growth, average for 2016-2020, thousand m$^2$/ha.

| Experiment variant | 1 mowing | 2 mowing | 3 mowing |
|-------------------|----------|----------|----------|
|                   | Tillering| Stemelgation| Tillering| Stemelgation| Tillering| Stemelgation| Tillering| Stemelgation|
| 1.1               | 7.0      | 15.5     | 20.9     | 4.1         | 9.2      | 12.9      | 2.3       | 4.8         |
| 1.2               | 8.2      | 19.8     | 28.9     | 4.6         | 11.0     | 15.5      | 2.8       | 5.1         |
| 1.3               | 7.5      | 16.8     | 23.6     | 4.3         | 9.7      | 14.0      | 2.5       | 5.0         |
| 1.4               | 9.2      | 25.4     | 34.9     | 4.9         | 11.8     | 17.0      | 3.1       | 5.7         |
| 2.1               | 7.7      | 17.4     | 25.1     | 4.4         | 10.0     | 14.6      | 2.5       | 4.9         |
| 2.2               | 8.9      | 23.8     | 32.6     | 4.8         | 11.5     | 17.3      | 3.0       | 5.6         |
| 2.3               | 8.0      | 19.5     | 28.0     | 4.6         | 10.6     | 15.6      | 2.9       | 5.5         |
| 2.4               | 9.7      | 29.6     | 39.2     | 5.3         | 12.9     | 18.3      | 3.7       | 6.4         |
| 3.1               | 7.4      | 16.6     | 23.5     | 4.2         | 9.6      | 14.1      | 2.4       | 4.9         |
| 3.2               | 8.7      | 23.6     | 31.5     | 4.8         | 11.6     | 17.0      | 2.9       | 5.4         |
| 3.3               | 7.9      | 18.9     | 27.2     | 4.4         | 10.3     | 15.0      | 2.6       | 5.3         |
| 3.4               | 9.4      | 27.5     | 38.0     | 5.1         | 12.5     | 17.8      | 3.4       | 6.2         |

The use of mineral fertilizers increased the leaf surface area by 0.3-0.5 thousand m$^2$/ha, the use of growth stimulants increased the leaf surface area by 0.1-0.2 thousand m$^2$/ha, the combined use of mineral fertilizers and growth stimulants increased the leaf surface area by 0.9-1.2 thousand m$^2$/ha.

It was noted that the formation of the assimilation apparatus or, in other words, the leaf surface of Sudan grass grown on dry land in the dry steppe zone of the Lower Volga region is influenced by the growing season meteorological conditions.

Sudan grass is one of the most valuable annual forage crops, which combines high productivity, nutritional value and aftermath ability. The plants photosynthetic activity is the striking indicator of the production process successful course, it has two main indicators: photosynthetic potential and photosynthesis net productivity, which in turn depend on the leaf surface and the growing season duration.

In our experiments, we observed various photosynthetic activities of the Sudan grass, both according to the years of research, according to mowing, and according to the experiment variants.

The photosynthetic potential of the Sudan grass on average for 2016-2020 is represented in the Table 4.

On average, for 2016-2020, the Sudan grass photosynthetic potential of the first mowing was, on average, 1.86-2.01 times higher than that of the second mowing, and for the second mowing, it was 3.81-4.09 times higher than that of the third mowing.

The total photosynthetic potential for three mowings ranged from 702 to 1313 (thousand m$^2 \times$ day)/ha. It was minimal in the variant with the seeding rate of 1 million germinating seeds per hectare without the use of fertilizers and growth stimulants and amounted to 702 (thousand m$^2 \times$ day)/ha.

In the variant with the seeding rate of 1.5 million germinating seeds per hectare, the total photosynthetic potential for three mowings was 138 (thousand m$^2 \times$ day)/ha more. On the variant with the seeding rate of 2.0 million germinating seeds per hectare, the total photosynthetic potential for
three mowings was 84 (thousand m² × day)/ha less than in the variant with the seeding rate of 1.5 million germinating seeds per ha.

**Table 4. Photosynthetic potential of the Sudan grass on average for 2016-2020.**

| Seeding rate (A) | Fertilizers and growth stimulants (B) | Photosynthetic potential, (thousand m² × day)/ha |
|------------------|---------------------------------------|-----------------------------------------------|
| 1.0 million g seeds per hectare N₆₀P₆₀K₄₅ + N₃₀ | Control without fertilizers | 418 225 59 702 |
| 1.5 million g seeds per hectare N₆₀P₆₀K₄₅ + Raikat Start + N₃₀ | Control without fertilizers | 519 258 63 840 |
| 2.0 million g seeds per hectare N₆₀P₆₀K₄₅ + Raikat Start + N₃₀ | Control without fertilizers | 479 245 62 786 |

With the use of mineral fertilizers, the increase in the photosynthetic potential by 252-267 (thousand m² × day)/ha was noted. When using growth stimulants, the increase in photosynthetic potential on average for 2016-2020 occurred by 111-140 (thousand m² × day)/ha. With the complex use of mineral fertilizers and growth stimulants, the increase in the total Sudan grass photosynthetic potential for three mowings in comparison with the variants without the use of mineral fertilizers and growth stimulants occurred by 464-477 (thousand m² × day)/ha.

The maximum value of the Sudan grass photosynthetic potential on average for 2016-2020 of 1313 (thousand m² × day)/ha was formed on the variant with the seeding rate of 1.5 million germinating seeds per ha and the complex use of mineral fertilizers and growth stimulants. In the variant with the seeding rate of 2 million germinating seeds per hectare, the combined use of mineral fertilizers and growth stimulants, the photosynthetic potential was 50 (thousand m² × day)/ha less.

The Sudan grass photosynthesis net productivity in our experiments also varied, both by the years of research, by mowing, and by the variants of the experiment. It depended both on the Sudan grass seeding rates, on the use of mineral fertilizers and growth stimulants. Moreover, the authors did not find any correlations with photosynthetic potential.

On average, for 2016-2020, the use of mineral fertilizers when growing Sudan grass on the variant with the seeding rate of 1.0 million germinating seeds per hectare led to the increase in the photosynthesis net productivity by 0.1 g/m² per day, on the variant with the seeding rate of Sudan grass 1.5 million germinating seeds per hectare increased the photosynthesis net productivity by 0.2 g/m² per day, and in the variant with the Sudan grass seeding rate of 2.0 million germinating seeds per hectare, the photosynthesis net productivity decreased by 0.1 g/m² per day. The use of growth stimulants in the Sudan grass cultivation increased the photosynthesis net productivity in the variant with the seeding rate of 1.0 million germinating seeds by 0.1 g/m² per day, and in the variant with the seeding rate of 1.5 million germinating seeds increased the photosynthesis net productivity by 0.2 g/m² per day, and in the variant with the seeding rate of 2.0 million germinating seeds, the photosynthesis net productivity was the same as in the variant without the use of mineral fertilizers and growth stimulants (Table 5).
The complex use of mineral fertilizers and growth stimulants increased the photosynthesis net productivity in comparison with similar variants for factor A in variants without the use of mineral fertilizers and growth stimulants on the variant with the seeding rate of 1.0 million germinating seeds by 0.2 g/m² per day, on the variant with the seeding rate 1.5 million germinating seeds it also increased the photosynthesis net productivity by 0.2 g/m² per day, and in the variant with the seeding rate of 2.0 million germinating seeds it increased the photosynthesis net productivity by 0.1 g/m² per day.

The maximum photosynthesis net productivity of Sudan grass when grown in the dry land conditions on chestnut soils of the Lower Volga region, on average for 2016-2020, was 9.3 g/m² per day in the variant with the seeding rate of 1.0 million germinating seeds per hectare with the combined use of mineral fertilizers and growth stimulants. The minimum photosynthesis net productivity of Sudan grass was formed in the variant with the seeding rate of 1.5 million germinating seeds per hectare without the use of mineral fertilizers and growth stimulants and was equal to 8.9 g/m² per day.

In our studies, only one local selection variety, Julia, was used in the cultivation of Sudan grass on dry land. Therefore, the yield of Sudan grass depended only on the prevailing weather conditions during the growing season and also on the variable factors studied in the experiment, namely on the seeding rate and on the applied mineral fertilizers and growth stimulants.

On average, for 2016-2020, the highest yield of Sudan grass green mass in the experiment was formed at the first mowing from 8.1 t/ha on the variant with the seeding rate of 1.0 million germinating seeds per ha without the use of mineral fertilizers and growth stimulants up to 18.1 t/ha on the variant with the seeding rate of 1.5 million germinating seeds per ha with the combined use of mineral fertilizers and growth stimulants (Table 6).

On the second mowing, the yield of Sudan grass green mass ranged from 5.7 t/ha on the variant with the seeding rate of 1.0 million germinating seeds per hectare without the use of mineral fertilizers and growth stimulants to 6.4 t/ha on the variant with the seeding rate of 1.5 million germinating seeds per hectare with the complex use of mineral fertilizers and growth stimulants.

On the third mowing, the yield of Sudan grass green mass ranged from 3.6 t/ha on the variant with the seeding rate of 1.0 million germinating seeds per hectare without the use of mineral fertilizers and growth stimulants to 4.1 t/ha on the variant with the seeding rate of 1.5 million germinating seeds per hectare with the complex use of mineral fertilizers and growth stimulants.

For 2016-2020 on the variant with the seeding rate of 1 million germinating seeds per hectare without the use of mineral fertilizers and growth stimulants was 17.4 t/ha. On the variant with the seeding rate of 1.5 million germinating seeds per ha without the use of mineral fertilizers and growth stimulants was 17.2 t/ha

### Table 5. Average photosynthesis net productivity for 2016-2020.

| Seeding rate (A) | Fertilizers and growth stimulants (B) | Photosynthesis net productivity, g/m² per day | Average for 3 mowings |
|-----------------|--------------------------------------|-----------------------------------------------|----------------------|
| 1.0 million     | Control without fertilizers          | 10.2                                           | 9.1                  |
| g seeds per    | N₀₆P₆₀K₄₅ + N₃₀                      | 11.8                                           | 9.2                  |
| g seeds per    | Raikat Start                         | 11.1                                           | 9.2                  |
| 1.5 million     | Control without fertilizers          | 12.6                                           | 9.3                  |
| g seeds per    | N₀₆P₆₀K₄₅ + Raikat Start + N₃₀       | 10.7                                           | 8.9                  |
| g seeds per    | Control without fertilizers          | 10.7                                           | 8.9                  |
| g seeds per    | Raikat Start                         | 9.1                                            | 6.4                  |
| g seeds per    | Raikat Start + N₃₀                   | 11.4                                           | 9.1                  |
| 2.0 million     | Control without fertilizers          | 12.1                                           | 9.1                  |
| g seeds per    | N₀₆P₆₀K₄₅ + N₃₀                      | 10.8                                           | 9.1                  |
| g seeds per    | Raikat Start                         | 11.6                                           | 9.0                  |
| g seeds per    | Raikat Start + N₃₀                   | 11.3                                           | 9.1                  |

The use of mineral fertilizers and growth stimulants increased the photosynthesis net productivity in comparison with similar variants for factor A in variants without the use of mineral fertilizers and growth stimulants on the variant with the seeding rate of 1.0 million germinating seeds by 0.2 g/m² per day, on the variant with the seeding rate 1.5 million germinating seeds it also increased the photosynthesis net productivity by 0.2 g/m² per day, and in the variant with the seeding rate of 2.0 million germinating seeds it increased the photosynthesis net productivity by 0.1 g/m² per day.
mowings was 1.9 t/ha higher, and on the variant with the seeding rate of 2.0 million germinating seeds per hectare by 1.6 t/ha.

| Seeding rate (A) | Fertilizers and growth stimulants (B) | Yield, t/ha |
|------------------|--------------------------------------|-------------|
| 1.0 million      | Control without fertilizers           | 8.1         |
| germinating      | N_{60}P_{60}K_{45} + N_{30}           | 12.0        |
| seeds per hectare| Raikat Start                          | 9.3         |
| 1.5 million      | N_{60}P_{60}K_{45} + Raikat Start + N_{30} | 14.7       |
| germinating      | Control without fertilizers           | 9.6         |
| seeds per hectare| Raikat Start                          | 13.8        |
| 2.0 million      | N_{60}P_{60}K_{45} + N_{30}           | 11.0        |
| germinating      | Raikat Start                          | 18.1        |
| seeds per hectare| Control without fertilizers           | 9.4         |

The use of mineral fertilizers while the Sudan grass cultivation increased the yield of the Sudan grass green mass in the variant with the seeding rate of 1.0 million germinating seeds by 4.4 t/ha, and in the variant with the seeding rate of 1.5 million germinating seeds by 4.6 t/ha and in the variant with the seeding rate of 2.0 million germinating seeds at 4.7 t/ha.

The use of growth stimulants while the Sudan grass cultivation increased the yield of the Sudan grass green mass in the variant with the seeding rate of 1.0 by 1.3 t/ha, in the variant with the seeding rate of 1.5 million germinating seeds by 1.6 t/ha, and in the variant with the seeding rate of 2.0 million germinating seeds by 1.4 t/ha.

The combined use of mineral fertilizers and growth stimulants increased the yield of the Sudan grass green mass on the variant with the seeding rate of 1.0 million germinating seeds by 7.3 t/ha, on the variant with the seeding rate of 1.5 million germinating seeds by 9.3 t/ha, and on the variant with the seeding rate of 2.0 million germinating seeds by 7.6 t/ha.

The maximum yield of Sudanese grass green mass on average for 2016-2020 was formed on the variant with the seeding rate of 1.5 million germinating seeds per hectare at 28.6 t/ha.

The minimum yield of the Sudan grass green mass was formed on the variant with the seeding rate of 1.0 million germinating seeds per hectare without the use of mineral fertilizers and growth stimulants and was equal to 17.4 t/ha.

Thus, as the carried out research result on identifying and scientifically substantiating of the optimal parameters for the Sudan grass cultivation for green forage and hay on dry land in the dry steppe zone of the Lower Volga region were carried out on the chestnut soils of the Volgograd Zavolzhje region from 2016 to 2020, it was found that the most optimal Sudan grass seeds sowing rate was the rate of 1.5 million germinating seeds per hectare. For these variants, the maximum yield values were obtained.

When studying the mineral fertilizers and growth stimulants actions, as well as their complex action, it was found that the Sudan grass green mass yield maximum values were obtained with the combined use of mineral fertilizers and growth stimulants.
4. Conclusions
Thus, as the carried out research result on identifying and scientifically substantiating of the optimal parameters for the Sudan grass cultivation for green forage and hay on dry land in the dry steppe zone of the Lower Volga region were carried out on the chestnut soils of the Volgograd Zavolzhje region from 2016 to 2020, it was found that the most optimal Sudan grass seeds sowing rate was the rate of 1.5 million germinating seeds per hectare. For these variants, the maximum yield values were obtained.

When studying the mineral fertilizers and growth stimulants actions, as well as their complex action, it was found that the Sudan grass green mass yield highest values were formed with the combined use of mineral fertilizers and growth stimulants (N$_{60}$P$_{60}$K$_{45}$ + Raikat Start + N$_{30}$).

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