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Photosynthetic Activity and Phyto Soil-Reclamation Features of Grain Sorghum Crops On Saline Soils of the Caspian Lowland.

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ABSTRACT

The results of studies which determine the photosynthetic activity of grain sorghum are presented. It was found that the variant with the differentiated irrigation of 0.4+0.8 m appeared to be the most effective one in its influence on the sorghum phytomass formation. Leaf area indices, FPP and CHPF indicate the superiority of the middle-grade kind Food 227. The direct correlative relation between a leaf surface area of a plant and the photosynthetic capacity of grain sorghum crops was established. The experiment are provided to determine the removal of toxic water soluble salts from the soil by grain sorghum due to the different levels of wetting.

Keywords: sorghum, irrigation mode, moistening depth, phytomass, photosynthetic potential, net photosynthesis productivity, phytomelioration, salts, desalination.

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INTRODUCTION

Sorghum is an important grain, fodder and industrial crops. Annually about 50 million ha is provided for sorghum sowing in different countries. However, this culture is not widespread in Russian Federation, although it has the ability to adapt well to different soil and climatic conditions.

The great advantage of sorghum is its ability to grow on saline and alkaline soils. According to the studies conducted in the republic of Dagestan, sorghum removes salts and harvest from soils splendidly, including chlorides and sulfates [1].

In the arid regions of the North Caucasus, in particular in the Republic of Dagestan, the increase of feed grain production without the extensive use of sorghum is a difficult problem. The most important reserve of the yield increase concerning this valuable fodder crop is the introduction of cultivation adaptive technology, which provides not only the obtaining of a consistently high yield, but also saves the soil fertility and environment [3,4].

During the cultivation of crops the major factor is the photosynthetic activity of plants. 90-95% of the harvest dry biomass is developed in the process of photosynthesis. Therefore, the comprehensive study of the plant photosynthetic activity dynamics in development phases is an urgent task.

The experiment was based on the following scheme: 1. 0.8 m of a soil layer moisturizing (control); 2. The wetting of 0.6 m; 3. The wetting of 0.4 m; 4. The differentiated wetting - 0.4 + 0.8 m (up to removal phase - 0.4 m, and during the rest of the period - 0.8 m).

GROWTH DYNAMICS

In our studies we stated the following. On the average, during the years of research, within the initial period of sorghum development the plant height was a negligible one. Thus, among the mid ripening it ranged from 14 to 16 cm. This is explained by the fact that during this period sorghum plants develop the system of roots. The values shoots - tillering of the average daily gain during the interphase period were small and varied within the range of 0.5 cm per day. During the period of tillering - output in a tube the growth increased by 1.5-2.0 times [4].

Due to the fact that by the phase of the output in a tube sorghum plants developed a sufficient root system. Then an enhanced growth of aboveground weight gain was observed, and during the removal phase the plant height ranged from 96 - 104 cm at control. The average daily gains were highest ones and ranged between 2.0-2.7 cm per day.

During the rest vegetation period the internal development of sorghum plants was observed. Due to this the growth rate dropped to 0.5-0.9 cm/day - the grade Food 227; it decreased to 0.8-1.0 among Khazine 28 and up to 0.8-1.3 cm per day during the early-maturing variety - Stork. By the end of the growing season the average growth rate dropped to a minimum.

The analysis of the height values and an average daily gain of sorghum plants according to dampening options showed that the most optimal values are added with the 4-th variant, where the differentiation of a wetting depth is provided (0.4 + 0.8 m).

LEAF AREA DEVELOPMENT

The possibility and degree of solar radiation by plants, and their productivity is largely determined by the leaf device area [2,3].

In our studies, the highest leaf area during all phases of determination and during all years was formed by the sort Food 227. During the period of leaf device maximum deployment - during the phase of removal - the average value in all irrigation modes made 56.9 thous. m^2 per 1 ha, which is 16.1% more than in the control group (Figure 1).

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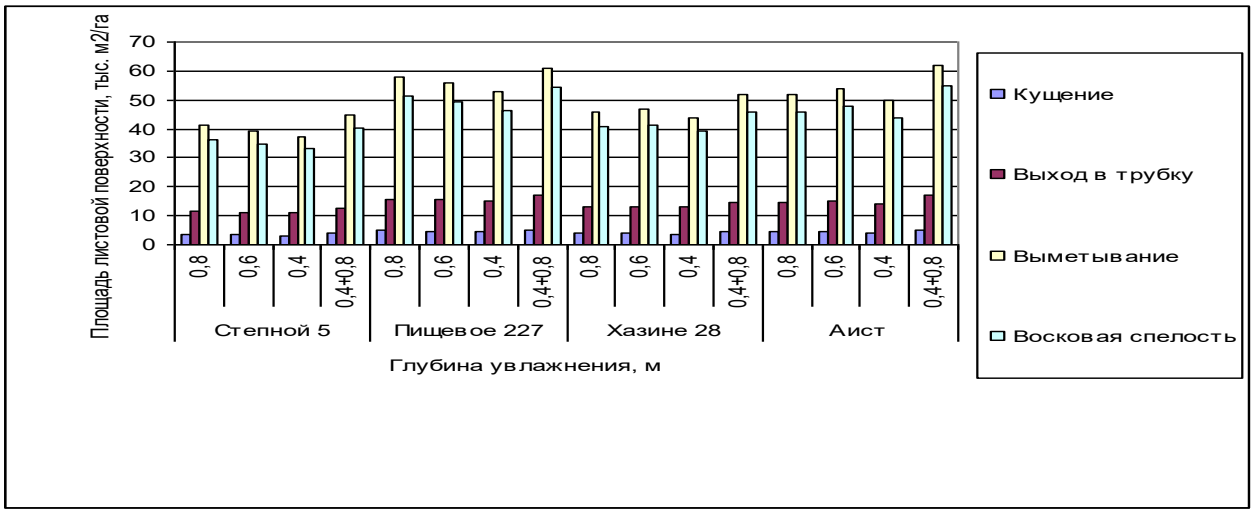

Fig. 1. The area of grade leaf surface and grain sorghum hybrids according to development phases due to the different depths of soil wetting

These data show that more early-maturing varieties - Khazine 28 and Stork develop 2,5-4,9% more leaf device than the control.

The peculiarity of the grain sorghum leaf device development, including the studied varieties, is the maintaining of high rates of leaf areas before full ripeness - 22,5-23,6 thous. m^2 per 1 ha. This feature allows to use the leaf and caulescent mass of this culture for silage grain after the harvest of the crop grain part.

DETERMINATION OF PHOTOSYNTHETIC POTENTIAL

Despite the achievement of leaf surface area high levels the middle early maturing variety Khazine 28 and early-maturing variety Stork have low photosynthetic potential in comparison with the standard. This is due to a relatively short period of these varieties cultivation. So, the variety Khazine 28 during the period of the sign maximum manifestation has on the average in all variants of irrigation mode 37.4 thousand m^2 of leaf area per 1 ha, and the early maturing variety Stork makes 38.3 thousand m^2, which makes 0.9 thousand and 1.8 thousand m^2/ha more than during the control. But the first of these varieties has the growing period of 121 day, the second - 103 days, which is 24 and 42 days less respectively than the variety Steppe 5 zoned in the zone. This difference within the growing season length contributed to FPP decrease among early maturing varieties, though they have a better developed lead device than that the control variety.

The best FPP indicators among the tested varieties, as well as along the leaf surface area, are provided by the middle-ripening variety Food 227.

The performed studies showed that the soil wetting depth has a significant influence on sorghum FPP development. The reduction of the soil wetting depth from 0.8 m to 0.6 m reduces its index by 3.4%, the corresponding reduction to 0.4 m reduces it by 5.1%. However, the differential wetting by 0.4 during the first half of the growing season, and by 0.8 m during the subsequent period does not reduce the FPP of sorghum. It remains within the control option of irrigation.

The analysis of obtained data along the area of leaf surface of sorghum varieties and hybrids in connection with the studied wetting depths and FP of crops gives the grounds to assert that there is a direct correlation between indices expressed by the regression equation:

У= 0,0004x +0,8653 at R= 0,7814.

This relationship could be closer if the deviations in terms of the second part of FP - the duration of the plant development phases according to tested varieties was not so significant.

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VEGETATIVE MASS DEVELOPMENT

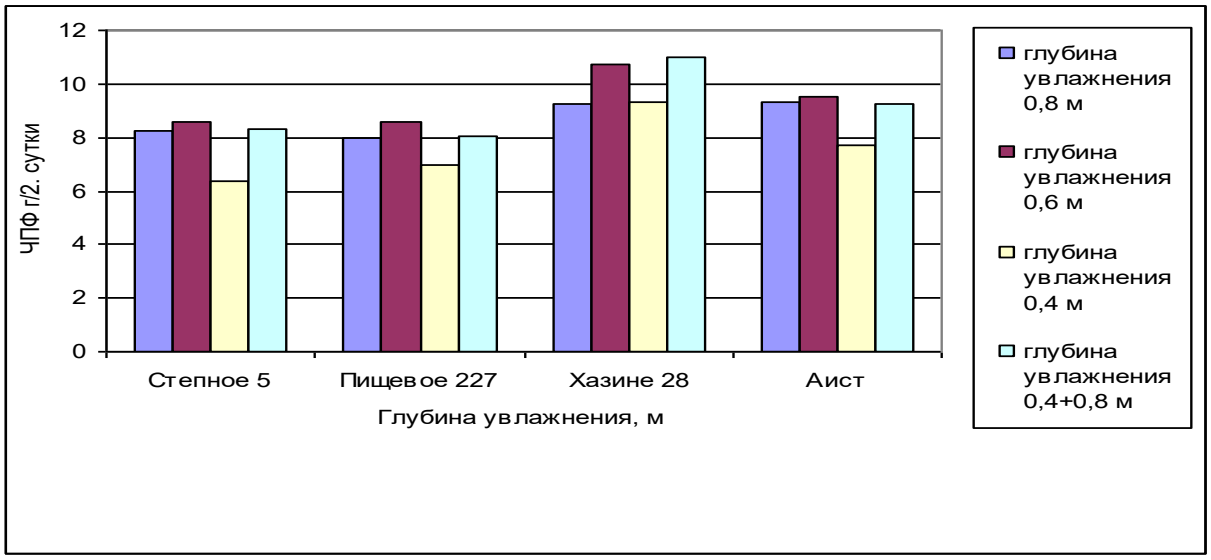
The grain sorghum for grain yield development creates a large vegetative mass, reaching 36.0 ... 42.3 t/ha at the humidity of 65 ... 68% [5]. The tested varieties can be divided into two groups according to a specified feature. The first group may include the variety Food 227, Khazine 28 and Stork. The yield of their raw phytomass reaches 37.6 ... 38.2 t/ha and exceed the control by 23.9 ... 26.9%. The second group may include Steppe 5 (the control), Khazine ultra early ripening, Zernogradskoye 53 and Early ripening 98. The average yield of their raw mass which ranges from 30.1 to 32.3 t/ha during the years of study, depending on the depth of soil wetting.

The largest collection of raw mass is provided by Khazine Class 28 - 38.2 t/ha on average along soil wetting depths. In comparison with it Food 227 and Stork are reduced by 2.4% and 1.6% respectively, and the shortage of hybrid Steppe 5 mass included in the current register of varieties on the area of the North Caucasus taken by us as the control makes 20.9%.

The option with differentiated irrigation to the depth of 0.4 + 0.8 m turned out to be the most effective one according to this indicator. Its increase in relation to the control in this variant made 13.2% on the average according to studied varieties.

A significant influence on the collection of sorghum raw phytomass is provided by the depth of soil wetting during irrigations, the constant wetting of soil at 0.8 m and 0.6 m reduces the collection of sorghum crude organic mass almost by the same amount - on the average by 1.6% and 2 ,4 % according to varieties. The further reduction of this level to 0.4 m resulted in a shortfall of 8.0 t/ha (20.0% in relation to the best wetting variant).

The achievement of high levels concerning sorghum biomass accumulation helped to increase the net productivity of photosynthesis (NPP). Its value, which indicates the accumulation of 1 g of phytomass dry matter on $1m^2$ of leaf surface during a day, was the greatest one during the growing of such early-maturing variety as Stork - 7 g/m^2 per day on the average for all irrigation variants. It was 45.8% higher according to Khazine 28 variety. The minimum value inferior to Food 227 by 21.6% is received according to the standard - Steppe 5 (Figure 2).



Глубина увлажнения - Wetting depth / ЧПФ г/2 сутки - NPP g/2 per day / Степное 5 - Steppe 5 / Пищевое 227 - Food 227 / Хазине 28 - Khazine 28 / Аист - Stork

Fig. 2. Net photosynthesis productivity of grain sorghum varieties and hybrids depending on soil wetting depth

Some decrease of the wetting depth from 0.8 to 0.6 m did not affect the development of leafy mass yield, but the further reduction of this level to 0.4 m resulted to the shortfall of 5.6 t/ha of raw (1.7 t/ha of dry one) weight.

The most effective variant, according to its influence on the development of sorghum phytomass, is the variant with the differentiated irrigation within 0.4 + 0.8 m. Its increase in relation to the control made 13.2%.

Thus, the indicators of leaf area, the FPP and NPP indicate the superiority of middle-grade Food 227. A certain interest is represented by the variety Khazine 28 and Stork, which provide a sufficient time for the preparation of fields for winter crop sowing after harvesting.

SALT REMOVAL

Sorghum with a strong root system, uses the moisture of deep soil horizons efficiently, preventing the rise of salts from these horizons in a topsoil.

This productivity, as well as sufficient salt resistance combined with heat resistance, makes this culture an effective developer of saline soils or the soils exposed to repeated salinization after washing.

Our studies on saline soils were performed to determine the removal of toxic soluble salts from the soil by grain sorghum due to the different depths of wetting.

The obtained data indicate that their total number within 1 m of soil is not changed significantly according to the experiment options (Table 1). At that it was noted that the amount of harmful salts is reduced by 1.34-1.48 t/ha during the growing season. The difference between the variants is not so great and it makes 4.1-4.4% from the initial amount.

Table 1: The removal of harmful salts from 1 meter layer of weakly salted brackish soil by grain sorghum at different depths of moistening (t/ha)

Wetting depth	Soil layer	Original content	By the end of vegetation	Balance ±
0,8	0-0,25	2,34	1,02	-1,32
	0,25-0,50	3,41	3,05	-0,36
	0,50-0,75	10,58	11,79	+1,21
	0,75-1,00	17,29	18,25	+0,96
	0-1,00	33,62	32,24	-1,38
0,6	0-0,25	2,29	0,83	-1,46
	0,25-0,50	3,50	3,05	-0,45
	0,50-0,75	10,62	11,71	+1,59
	0,75-1,00	16,64	17,73	+1,09
	0-1,00	32,55	31,13	-1,42
0,4	0-0,25	2,52	0,63	-1,89
	0,25-0,50	3,48	2,74	-0,72
	0,50-0,75	11,34	11,74	+2,40
	0,75-1,00	15,82	17,09	+1,27
	0-1,00	33,14	31,66	-1,48
0,4+0,8	0-0,25	2,19	0,84	-1,35
	0,25-0,50	2,64	2,31	-0,33
	0,50-0,75	10,72	11,97	+1,25
	0,75-1,00	16,18	17,08	+0,90
	0-1,00	32,73	31,19	-1,34

A particular interest in our study is presented by water-soluble salts along the soil horizons due to the applied irrigation modes. Thus, during the appointment of vegetation irrigations with the soil wetting expectation by 0.8 m at the end of the vegetation period the amount of harmful salts in the upper (arable) layer is reduced by a relatively smaller value than during wetting by 0.6 m - 9.6%. The purpose of irrigations taking into account the wetting of a layer by 0.4 m reduces the amount of salts in this layer by 43% (0.57 t/ha) as compared to the control. Their significant reduction as compared to the control is indicated according to the

specified variants by 25.0% and 2.0 times in the layer of 0.25-0.50 meters respectively. Within the variant with a differentiated irrigation the reduction of harmful salts was observed within the control ones.

CONCLUSIONS

Thus, the indicators of a leaf area, FPP and NPP indicate the superiority of middle-ripening variety Food 227. A definite interest is represented also by the variety Khazine 28 and Stork which remain a sufficient period after harvesting to prepare a field for winter crop sowing.

From the mentioned above it follows that the desalinization of the upper layers of soils up to 0.5 m, and especially up to 0.25 m occurs more intensively if a soil is wetted more weakly, i.e. when downward flow of water are performed more often. Within the variants with a relatively deep soil wetting the amount of vegetation irrigation decrease caused by this leads to a relatively lower washing of water-soluble salts from the plowing and the subsurface layer of soil.

SUMMARY

In extreme arid conditions of the Caspian Lowland on irrigated lands one may cultivate grain sorghum successfully. The main condition for the development of high yields is the use of differentiated irrigation.

CONFLICT OF INTEREST

The author acknowledges that the presented data do not contain any conflict of interest.

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