ISSN: 2690- 912X

Review Article

Journal of Genetic Engineering and Biotechnology Research

Features of Growth and Development of Sugar Beet Hybrid Plants During the Period of Herbicide Stress

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Submitted: 2024, Nov 04; **Accepted:** 2024, Dec 03; **Published:** 2024, Dec 30

Citation: Zheryakov, E. V. (2024). Features of Growth and Development of Sugar Beet Hybrid Plants During the Period of Herbicide Stress. *J Gene Engg Bio Res, 6*(3), 01-03.

Abstract

The article presents the results of studies of the resistance of sugar beet plants of various hybrids to the negative impact of herbicides. At the initial stages of their growth, the most resistant to the negative impact of herbicides were sugar beet plants of the F1 Skala, F1 Priliv and F1 Burya hybrids. After the second treatment, growth inhibition with an increase in mass deficit was observed in the variants using herbicides. The F1 Skala hybrid was the most resistant to the negative impact of herbicides. In the F1 Priliv and F1 Gorizont hybrids, the effect of the chemical stress factor was assessed as the most toxic. The phytotoxicity of the herbicide combination for sugar beet was noticeably reduced (up to 12-13%), compared with earlier herbicide treatments. After three herbicide treatments, high resistance to the negative effects of herbicides was noted in the F1 Skala hybrid.

Keywords: Sugar Beet, Herbicides, Hybrids, Phytotoxicity

1. Introduction

The sugar industry is important for the Russian economy, as granulated sugar not only acts as a finished product, but is also an important raw material for other goods. The main source of sugar production in Russia is sugar beet, the share of which has exceeded 90% since 2012. Beet cultivation is carried out in 30 regions of the country. Russia occupies one of the leading places in the world production of sugar beet, second only to China in this indicator. Our country has held first place in the world in the cultivation of sugar beet and the production of beet sugar since 2016. Over the past five years, beet production has increased by 14%, reaching an annual mark of 51.3 million tons. The sugar beet production industry in Russia remained stable by the end of 2022. Since 2010, the area of sugar beet crops in the Russian Federation has been fixed at a level of 1027.2 to 1159.3 thousand hectares, with a slight decrease in the area of crop sowing noted in recent years [1]. The analysis showed that the average yield of sugar beet is constantly growing, and over the past 10 years in the Penza region it amounted to 378.4 c/ha (in the Russian Federation 423.5 c/ha), and over the past 5 years - 391.5 c/ha (in the Russian Federation 426.3 c/ha). Sugar beet growing remains one of the most science-intensive, technologically and organizationally complex industries. Despite the achieved successes of the domestic sugar beet complex, producers of agricultural raw materials have difficulties with seed material. The share of foreign-bred seeds in the Russian agro-industrial complex by 2020 reached 98% for sugar beet. Reducing dependence on foreign-bred sugar beet hybrids by developing and promoting domestically bred sugar beet hybrids with comprehensive technological equipment for the sugar beet seed production process is an important area that needs to be developed to ensure food security in the Russian Federation [2-4]. Therefore, one of the most important tasks of seed production is to correctly place varieties (hybrids) in the natural and ecological zones of our country, taking into account the best suitability of each variety (hybrid) to local conditions. The main principle for determining the suitability of a variety (hybrid) to these conditions can be its normal growth and development, ensuring high and stable yields over the years [5,6]. The studies are aimed at assessing the growth and development of sugar beet plants under herbicide stress.

During the period of chemical weed control, sugar beet experiences stress from the effects of herbicides, especially in the early stages of development. Depending on the age of the plants, under the influence of herbicides, the increase in the mass of sugar beet lags behind, the physiological and biochemical processes of formation of the leaf apparatus and root crop are disrupted. The resistance of plants to the damaging effects of pesticides depends on the anatomical, morphological and physiological characteristics of the species, growing conditions, and soil type [7]. The increase in the mass of the root crop depends on the functional activity of the leaves and the formation of the leaf apparatus. Therefore, the adaptation of sugar beet plants to the effects of herbicides through the activation of the growth of the leaf apparatus (the number, mass and area of leaves) can proceed in disproportion with the growth of the root crop [8].

Field experiments were conducted to achieve the objectives. Experiment 1 — a two-factor experiment — was conducted using the randomization method according to the following scheme: factor A — hybrid: 1 — F1 RMS 121; 2 — F1 Rock; 3 — F1 Storm; 4 — F1 Volcano; 5 — F1 Wave; 6 — F1 Tsunami; 7 — F1 Tide; 8 — F1 Horizon; factor B — background: 1 — manual processing (control); 2 — herbicide processing. The agricultural technology used in the experiment was the same as that adopted on the farm. Sugar beet was grown in the fallow link of the grain-fallow-row crop rotation. The predecessor was winter wheat. The seeding rate was 120 thousand pcs./ha. The tank mixture was composed taking into account the number of weeds, their development phase, and species composition.

In the modern system of growing sugar beet using intensive technology, crop protection from weeds using herbicides plays an important role. In recent years, there has been a tendency for the weed infestation of all crops, including sugar beet, to increase, which is a consequence of the introduction of fallow lands into crop rotation, violation of agricultural technology of cultivation, primarily, failure to comply with crop rotation and soil cultivation systems. There has been a significant increase in the number of perennial and hard-to-eradicate annual weeds [9]. The studies were conducted against the background of low and moderate weed infestation of sugar beet crops with a predominance of annual dicotyledonous weeds (84.8-110.7 pcs./m2). In the crop rotation, where herbicide treatment of agricultural crops was regularly carried out, the group of annual dicotyledonous weeds in the sugar beet crop did not differ in a large diversity of species and was represented mainly by pigweed. Among the perennial dicotyledonous weeds, sow thistles and field bindweed were noted.

After the first herbicide treatment, among the studied domestic hybrids, F1 Skala was characterized by the largest plant mass in the initial period: after 6 days, in the variant with manual weeding, the mass of 1 plant was 1.31 g, which is 38% more than that of the F1 hybrid RMS 121. The plant mass of the F1 Volna and F1 Gorizont hybrids was also greater than that of the F1 hybrid RMS 121 - by 0.14 g, F1 Priliv - by 0.13 g, F1 Burya - by 0.12 g, F1 Tsunami - by 0.11 g, and that of the F1 hybrid Vulcan - by 0.09 g. The average daily absolute growth rate of plants in the phase of full shoots for the first accounting period for the F1 hybrid RMS 121 (standard) was at the level of 120-130 g. The studied hybrids of domestic selection can be divided into three groups by plant growth rate: the first is the F1 Vulcan, F1 Tsunami and F1 Buria hybrids with an absolute average daily growth rate of 140-150 g, the second is F1 Volna, F1 Priliv and F1 Gorizont, with a weight increase of 150-155 g per day, the third is the F1 Skala hybrid, whose plants gained more than 180 g in weight per day, which is 46.9% more than the growth rate of the F1 RMS 121 hybrid plants (table).

F1 hybrid	**Old Arable Lands**			
	Weight of 1 plant		**Average daily growth rate**	
	г	**%**	**г/сут./раст.**	**%**
RMC 121 (standard)	0,95	100,00	0,128	100,00
	0,77	100,00	0,099	100,00
Volcano	1,04	109,47	0,143	111,72
	0,87	112,98	0,115	116,16
Tsunami	1,06	111,58	0,146	114,06
	0,89	115,58	0,118	119,19
Storm	1,07	112,63	0,148	115,62
	0,89	115,58	0,119	120,20
Rock	1,31	137,89	0,188	146,87
	1,09	141,56	0,152	153,53
Wool	1,09	114,74	0,151	117,97
	0,91	118,18	0,122	123,23
Inflow	1,08	113,68	0,150	117,19
	0,83	107,79	0,109	110,10
Horizon	1,09	114,74	0,152	118,75
	0,85	110,39	0,111	112,12

Table: Biometric Indicators of Sugar Beet Plants 6 Days After the First Herbicide Treatment, (The Average Weight of One Plant Before Treatment is 0.18,)

Note: The numerator is control (manual weeding), the denominator is during herbicide treatment

It was found that the herbicide used to protect sugar beet during the first chemical treatment had a reliable inhibitory effect on biomass growth. The average weight of 1 plant 6 days after herbicide treatment was 0.88 g. Analysis of biometric data of plants showed that the impact of the stress factor, which in this case was the herbicide, on plants of all hybrids was negative, which was expressed in a decrease in the growth rate and, as a consequence, a decrease in the rate of mass increase. At the initial stages of their growth, the most resistant to the negative impact of herbicides were sugar beet plants of the F1 Skala, F1 Priliv and F1 Burya hybrids, which resumed active growth faster after herbicide treatment: the decrease in the rate of mass increase was 0.028-0.029 g.

After the second herbicide treatment on the control variant (without the use of pesticides), the largest mass of 100 sugar beet plants was obtained when growing the domestically bred hybrid F1 Skala and amounted to 1.166 kg. The F1 hybrid RMS 121, used in this experiment as a standard, lagged behind the studied hybrids in mass accumulation by 32-111 g. The mass of 100 plants of the F1 Vulkan and F1 Tsunami hybrids was 3.4-3.6% greater than the standard hybrid, respectively, but 62-65 g less than the F1 Skala hybrid. The average daily growth rate of the F1 Burya hybrid plants of 1.5 g per day ensured more intensive mass accumulation than the standard F1 hybrid RMS 121. In the F1 Priliv, F1 Volna and F1 Gorizont hybrids, the mass of 100 plants was 1.115-1.118 kg, which is 4.7-5.0% greater than the F1 RMS 121 hybrid, but in terms of mass accumulation intensity they were inferior to the F1 Skala hybrid by 48-51 g.

In the variants with herbicide treatment, growth inhibition with increasing mass deficit was observed, compared to manual weeding, with subsequent adaptation and activation of growth processes that contribute to the restoration of physiological functions of the plant organism. In the standard hybrid F1 RMS 121, the mass of 100 plants was 0.865 kg. The most resistant to the negative impact of herbicides was the hybrid F1 Skala, the mass of 100 plants of which was 961 g. The standard hybrid F1 RMS 121 significantly lagged in growth with herbicide treatment: the average daily rate was 1.230 g. The weight of one plant of the hybrid F1 Burya was 4.82-5.53% more than plants of the hybrid F1 RMS 121. The mass of 100 sugar beet plants after three herbicide treatments was 3.5-4.5 kg. Without the use of chemical treatments, the greatest mass of one plant was noted in the F1 hybrid Skala and was 45.59 g, which is 11.57% more than in the standard F1 hybrid RMS 121. In the other studied hybrids, the accumulation intensity was slightly lower than in the F1 hybrid Skala, and six days after the treatment, the mass of one plant was 44.1-44.5 g. After three herbicide treatments, the differences between the mass of intact sugar beet plants and those exposed to the negative effects of chemical stress factors were significant, and the ability of plants to resist the inhibitory effect of herbicides differed depending on the hybrids. Sugar beet plants, being in a stressful state, stop growing, which is reflected in the intensity of mass accumulation. The lag in mass accumulation in the standard F1 hybrid RMS 121 was 13.15% compared to manual weeding. High resistance to the negative impact of herbicides was noted in the F1 Skala hybrid. Less resistant were the F1 Vulcan, F1 Tsunami, F1 Gorizont and F1 Priliv hybrids - their ability to resume active growth after herbicide stress was estimated at 87.1-87.3%.

Thus, it was established that the phytotoxicity of herbicides for plants of the studied hybrids manifested itself to different degrees. The greatest mass of one plant and the duration of plant depression were shorter in the hybrids F1 Skala and F1 Volna. Accounting for the yield of root crops showed that the advantage in harvesting root crops was with the hybrid F1 Skala, which provided an increase in yield of 11.55-12.16 t / ha or 23.7-24.0% to the average (51.27 t / ha). In second place in terms of root crop yield were hybrids F1 Volna and F1 Gorizont, they additionally received (relative to the average) from 4.41 t / ha to 6.26 t / ha of products or 8.6-12.2%. The lowest yield in the current hydrothermal conditions of vegetation was distinguished by the hybrid F1 RMS 121, the yield of which was 44.86 t / ha.

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