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Influence of Sowing Time on the Main Indicators of Photosynthesis of Soy Corps in Conditions of Fore-Caucasus

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Abstract

The paper studies the influence of sowing time on the main indicators of photosynthesis of soy corps in conditions of Fore-Caucasus. The highest biological yield of dry biomass was accumulated by the breeds after the first sowing period (6.92 t/ha for Zernogradskaya 2, 7.55 t/ha for Selekta 201 and 8.16 t/ha for Renta). The breeds have the highest net photosynthesis productivity was noted for the first two sowing periods. The third sowing period falls behind for this indicator by 5--6 %. Renta breed in terms of the quantity of dry biomass generated during one day calculated for the area of leaves of one square meter had a significant advantage. The highest crop productivity of studied breed was noted after the first sowing period. The productivity of the seeds was as follows: 1.93 t/ha for Zernogradskaya 2, 2.14 t/ha for Selekta 201 and 2.39 t/ha for Renta. In terms of the coefficient of the business efficacy of soy, the first sowing period is the best one.

Keywords: sowing periods, breeds, dry matter accumulation, biological yield of dry biomass, coefficient of business efficacy, seed yield.

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1. Introduction

Acute deficit of food or fodder protein is relevant for many countries. In Russia it reaches one million tons a year. The crisis in economy caused the situation when only a half of the population is provided by minimal protein consumption norm. The deficit can be mitigated by vegetable protein, including soy as an important source of it.

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In the world's farming industry, soy holds the fourth place after wheat, corn and rice; it holds the first place among the grain, bean and oil crops. Its farming area reaches 91.4 mln ha, while the total yield is more than 209.6 mln tons.

Thanks to the growing demand for high-protein and oil feedstock, expanding usage of fodder, food, medical, industrial application and high profitability, the production of soy continues to grow outpacing other crops [3, 4].

Having high adaptability, soy grows well in countries with both hot and moderate climate. Currently it is grown in 68 countries from the 42nd parallel in the southern hemisphere to the 56th parallel in the northern one. The main producers and exporters of soy are: the USA (65.0M tons), Brazil (25.0M tons), China (14.8M tons), Argentina (13.4M tons), India (4.0M tons). The main importers are: EU countries, Asia, Oceania, Latin America [5].

In Russia, soy is cultivated on the area of 1205K ha, the total grain yield amounts to 1215K tons, the average yield is 1.0 t/ha. This preserves the tendency of increasing sowing areas. Until 1991, the soy growing industry of the country was constantly growing. The main soy cultivation region was Far East (Khabarovsk, Primorsky Krai and Amur Oblast). The total seed harvesting amounted to nearly 520.0K tons, the average yield was 0.8 t/ha [1].

In the conditions of the market economy, the land of soy cultivation decreased almost two times due to scarcity of herbicides, machines, soil acidification, price disparity and absence of state subsidies. The yield decreased down to 0.5 t/ha [6, 9].

Due to the measures taken, the soy cultivation land area exceeded the level of 1990 1.4 times, the yield increased 1.9 times, the total yield increased almost 3 times.

Also, the establishment of enterprises for soy processing into food and fodder products was planned, as well as the creation of the infrastructure for realization of soy cultivation products.

In Russia, 106 breeds are zoned in 34 selection institutions of the country.

It is well known that not a single cultivated crop can be compared with soy in terms of chemical composigion of seeds and its quality. The total content of protein and fats in the seeds of some breeds reaches 70 %. Soy fat complies with the standard of FAO/WHO, while the protein content exceeds it in terms of aminoacid composition and content of irreplaceable aminoacids. In addition, the gathering of protein from 1 ha of soy is 3.0 times larger than that of wheat.

The presence of microelements in the seeds and 12 vitamins allows widely using soy in medicine. Fibre, pectin, phospholipids of soy are used as food supplements.

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A unique composition of organic, mineral, biologically active substances, their functional properties conditions the versatility of the crop application: assortment of fodder produced from soy, food products, pharmaceuticals, technical aids amounts to dozens of thousands of titles.

The agrotechnical importance of the crop is colossal, which can provide itself with nitrogen by 70% through symbiotic nitrogen bonding [8].

The presence in soy seeds of anitnutrients (inhibitors protease, lectins, urease, glycosides, etc.) does not allow using it in raw conditions and complicates the technologies of its processing; however, they can be inactivated by thermal treatment.

The state policy of Russia on healthy food envisages wide adoption of soy processing technologies and introduction of its products into diet of the population.

The history of cultivated soy is the history of the crop adaptation to the conditions of different day length, temperature, moisture of soil and air and other climatic parameters. Owing to versatile ecological flexibility, soy is cultivated from the 46th parallel in the southern hemisphere to the 56th parallel in the northern one. It was only several decades ago, that soy cultivation boundary was believed to be at the 53rd parallel of the north latitude. Even now, many believe the zone of 52…54° to be that of experimental cultivation. Nevertheless, there are breeds that ripen at the sum of active temperatures of 1700 °C, which appreciably widens the sphere of industrial cultivation of the crop.

The main limiting factor of soy advancement further to north is early ripening. The genetics of this factor is complex, since soy is a short-day crop and the early ripening factor is regulated by the genes of sensitivity to the photoperiod. The creation of breed surpassing the parent breeds in early ripening became possible with the use of radiation mutagenicity.

We have refined the periods of sowing providing optimal density of cenosis in soy crops and, finally, its maximum productivity.

Currently, our experts study the possibility of advancement of soy sowing areas by introduction to new regions, in particular into the European part of Russia: Central Black Earth Region, Nonblack Soil Zone and North-Caucasian region, including Chechen Republic.

In this connection, the study of the elements of breed agricultural technology, which basis are breeds, and sowing periods became the foundation that determined the urgency of our investigation.

The urgency of the study: an important role in the increased production of vegetable protein belongs to grain bean crops, primarily to soy. An important conditions of soy introduction in Chechen Republic is the selection of high-yield breeds adaptive to growing conditions and development of cultivation technologies maximizing its genetic potential. The most important role is played by the sowing period.

2. Goal and Tasks

The goal of the study is to identify the effect of sowing period on the main indicators of photosynthetic activity of soy breeds.

The tasks of the studies is to study the influence of sowing periods on the dynamics of dry matter accumulation by the soy breeds.

To study the influence of the sowing periods in the main indicators of the photosynthetic activity of the soy breeds: leaf area, dry biomass accumulation, photosynthetic potential, net photosynthesis productivity, seed yield, coefficient of business efficacy.

3. Scientific Novelty

The scientific novelty of the studies is the justification of optimal terms of soy sowing in the conditions of Fore-Caucasus for breeds Zernogradskaya 2, Selekta 201 and Renta, which provide the most favorable conditions for the photosynthetic activity of soy crops. It was established that for the studied breeds, the optimal period of sowing is the first period (15.04).

4. Location, Methods, Conditions and Materials

The studies were performed on arable rotation of SUE Goskhoz ``Zakan-Yurt'', in Achkhoy-Martanovsk region of Chechen Republic, on common chernozem without irrigation.

The objects of study were early ripening breeds Zernogradskaya 2 and Selekta 201, and middle-early ripening breed Renta.

The phenological observation over the groth and developemnt of plants over the whole years of investigation were performed by the method of Gossortispytaniya (State breed testing). The following dates were noted: full sprouting, third ternate leaf, flowering, bean formation, full filling of seeds, full ripening.

The density was estimated at the phase of full sprouting and before harvesting on fixed plots, which involved allocation of two fields of 0.5 m^2 on each plot. The conversion

Table 1: Experimental scheme.

Breeds	**Sowing period**
Zernogradskaya 2	first -- 15.04
	second -- 01.05
	third -- 15.05
Selekta 201	first -- 15.04
	second -- 01.05
	third -- 15.05
Renta	first -- 15.04
	second -- 01.05
	third -- 15.05

of the biometric data of plant samples over 1 ha used the density of plants before harvesting.

We also studied the dynamics of photosynthetic activity of sow crops: the leaf area was determined at the phases of the third ternate leaf, flowering, bean formation, full filling of seed by the method of cutting. With the mass and area of the cuts, and total mass of leaves, the area of leaves was determined.

The area of leaves on 1 ha was calculated with due consideration of sowing density and number of sampled plants.

The photosynthetical potential and net photosynthesis productivity of the crops over the vegetation period was calculated by equation of Kidd, Vest and Brigs [7].

The yield was accounted by the method of sub-plot harvesting with reduction to the standard moisture.

5. Investigation Results

The characteristic of the indicators of phytosynthetic activity of crops requires the study of dry biomass accumulation dynamics during the ontogenesis [2].

The amount of dry biomass and its dynamic during vegetation depends on not only the development phase, but also on the environmental factors (temperature, water availability, soil fertility, quantity of plants on unit area, etc.) [10].

In our experiment, in the initial vegetation period from sprouting to flowering, the accumulation of vegetation biomass by soy plants is marginally more intense for late sowing periods, as compared to early ones. At the stages of bean formation and full filling of seeds, the earlier-sowed crops better accumulate dry matter (Table 1).

At the phase of full filling of seeds, we noted maximum accumulation of dry matter for all breeds an all sowing periods. By this phase, Zernogradskaya 2 breed had generated 6.85 t/ha in the first sowing period, 6.58 t/ha in the second one and 5.52 t/ha in the third one. In other words, in the first sowing period, more dry biomass was accumulated as compared to the second and third periods, by 5 and 25 %, correspondingly. The same regularity was established for the rest of the breeds. Indeed, over the first sowing period Renta breed had accumulated biomass of 8.55 t/ha, which is by 3 and 22 % more than that during the second and third sowing periods.

Over the years of investigation, the maximum accumulation of dry matter was in 2011.

Dry biomass accumulation by soy breeds was minimum in 2013, which was conditioned by the absence of precipitation during the critical phases of plants' growth and development and by relatively small amount of them over the vegetation period in general.

Table 2: Influence of sowing period on the dynamics of dry matter accumulation by soy breeds (t/ha) on average in 2011--2013.

Breed	Sowing period	Development phase				
		Third ternate leaf	Flowering	formation of beans	full filling of seeds	full ripening
Zernogradskaya 2	first	0.60	2.44	4.34	6.85	4.21
	second	0.65	2.40	4.23	6.58	4.14
	third	0.65	2.33	3.55	5.52	3.20
Selekta 201	first	0.56	2.53	4.85	7.77	4.86
	second	0.56	2.55	4.73	7.50	4.71
	third	0.56	2.50	4.14	6.30	3.76
Renta	first	0.48	2.67	5.55	8.55	5.58
	second	0.50	2.70	5.48	8.38	5.44
	third	0.51	2.65	4.73	6.94	4.37

In terms of dry mass accumulation, year 2012 was intermediate. As compared to non-favorable 2013 in terms of precipitation amount, a lot more dry biomass was accumulated.

During the analysis of dry biomass accumulation, it was established that in the initial phases of soy growth and development (from sprouting to flowering) the surplus of dry biomass occurred generally by means of stems and leaves. In the phase of bean formation, the mass of beans largely increases; over the phase of full filling of seeds, their fraction in total accumulation of dry biomass becomes equal to the fraction of leaves and stems.

At the end of seed filling stage, the rate of dry biomass accumulation decelerates, the formation of aoy grain continues owing to already synthesized macronutrients in leaves and stems.

Renta is the most advantageous breed in terms of dry biomass accumulation among the studied breed for all sowing periods. Indeed, this breed accumulated more dry biomass by 14--15 % versus Zernogradskaya 2, and by 6--7 % versus Selekta 201, regardless of the sowing period (Table 2).

For all breeds, the largest leaf area was formed over the first sowing period (38.6K m^2/ha for Zernogradskaya 2, 39.9K m^2/ha for Selekta 201 and 43.0K m^2/ha for Renta).

The highest biological yield of dry biomass was accumulated by the breeds after the first sowing period (6.92 t/ha for Zernogradskaya 2, 7.55 t/ha for Selekta 201 and 8.16 t/ha for Renta).

The first sowing period was established to be advantageous in terms of the indicators of photosynthetic potential. Indeed, for Zernogradskaya 2 breed, the indicator of photosynthetic potential amounted to 1937K m^2/ha·day; over the second and third sowing periods this indicator amounted, respectively, 1833K and 1670K m^2/ha·day. The same regularities in this indicator was identified for Selekta 201 and Renta breeds.

The breeds have the highest net photosynthesis productivity was noted for the first two sowing periods. The third sowing period falls behind for this indicator by 5--6 %.

Renta breed in terms of the quantity of dry biomass generated during one day calculated for the area of leaves of one square meter had a significant advantage. For instance, the net photosynthesis productivity of Renta breed averaged over three years amounted to 4.5 g/m^2x day, while that for Selekta 201 and Zernogradskaya 2 breeds were less by 7 and 18%, respectively.

The highest crop productivity of studied breed was noted after the first sowing period. The productivity of the seeds was as follows: 1.93 t/ha for Zernogradskaya 2, 2.14 t/ha for Selekta 201 and 2.39 t/ha for Renta.

The third sowing period in terms of this indicator was lower by 18--22 %.

In terms of the coefficient of the business efficacy of soy, the first sowing period is the best one.

TABLE 3: Main indicators of photosynthetic activity of soy breeds over sowing periods on average in 2011--2013.

Sowing period	Maximum leaf area [ths. m^2/ha]	Biological yield of dry biomass [t/ha]	Photosynthetic potential [ths. m^2/ha a day]	Net photo-synthetic productivity [g/m^2xday]	Seed yield capacity [t/ha]	Coefficient of business efficacy
Zernogradskaya 2						
First	38.6	6.92	1937	3.8	1.93	0.279
Second	38.0	6.77	1833	3.8	1.89	0.279
Third	35.2	6.18	1670	3.7	1.49	0.241
Selekta 201						
First	39.9	7.55	2244	4.1	2.14	0.283
Second	39.5	7.35	2146	4.2	2.05	0.279
Third	35.6	6.70	1990	4.0	1.75	0.261
Renta						
First	43.0	8.16	2685	4.5	2.39	0.293
Second	42.8	8.01	2578	4.6	2.34	0.292
Third	38.5	7.15	2341	4.4	1.96	0.274

6. Summary

As a result of the study the following **conclusions** were made:

1. the highest biological yield of dry biomass was accumulated by the breeds after the first sowing period (6.92 t/ha for Zernogradskaya-2, 7.55 t/ha for Selekta 201 and 8.16 t/ha for Renta).

2. the breeds have the highest net photosynthesis productivity was noted for the first two sowing periods. The third sowing period falls behind for this indicator by 5--6 %. Renta breed in terms of the quantity of dry biomass generated during one day calculated for the area of leaves of one square meter had a significant advantage.

3. the highest crop productivity of studied breeds was noted after the first sowing period. The productivity of the seeds was as follows: 1.93 t/ha for Zernogradskaya 2, 2.14 t/ha for Selekta 201 and 2.39 t/ha for Renta.

4. in terms of the coefficient of the business efficacy of soy, the first sowing period is the best one.

7. Conclusions

The reaction of the breeds on the sowing periods was differentiated and considerably depended on weather conditions and on the water availability in the first place.

The best indicators of photosynthetic activity the studied breed demonstrated during the first and second sowing periods. The optimality of the first and second period and their effect on the main indicators of photosynthetic activity depended on the precipitation amount over the vegetation period and their occurrence during the phenological phases of soy plants.

The third sowing period in terms of all main indicators of photosynthetic activity of soy crops was inferior to the first two sowing periods.

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