Current Status, State Support and Role of Agricultural Education for Greenhouse Industry in Russia

F16N504J

Mikhail Dorzhiev

Doctoral Program of Environmental Science and Technology

Graduate School of Science and Technology

Niigata University, Japan

2019

Table of contents

List of Tables

List of Figures

Chapter 2

Chapter 3

Chapter 4

Abstract

The economic sanctions imposed by the United States and the European Union on March 17, 2014, were aimed at many key sectors of the Russian economy. The most vulnerable industry experts estimated vegetable production. Russia was not ready to meet the demand of the population with fresh greenhouse vegetables. The retaliatory sanctions of Russia were introduced on August 7, 2014, an embargo on the importation of food products from the EU countries and a number of other countries as anti-sanctions. After political movements, the Russian greenhouse industry received a new impulse to new development.

This study first overviewed the history and development of higher education in the Republic of Buryatia, Russian in order to identify key roles in agriculture education development of the higher in Siberia and the Far East. Secondly, the study determined the gap by distinguishing five stages of greenhouse farming from its evolution in the 1930s in the USSR to modern Russia. Thirdly, the study analyzed the current situation in the industry and systemized technological features of exploited greenhouse constructions. Next, overviewed state support policies for the greenhouse industry, analyzed greenhouse production data, and surveyed the agricultural education system in Russia focused on higher education for the greenhouse industry. The main objective of the study was proposed that the influence of agricultural education in the development of the greenhouse industry in Russia had a significant role in the country's greenhouse development. The study proved that the development of new educational programs, as well as greenhouse industry support will have a rapid future development. Based on the analysis of data in the study was also found how to solve the current lack of qualified personnel needed for developing greenhouse industry.

Chapter 1. Introduction

The rapid development of Russian greenhouse industry has become a well-known fact in the last few years. According to the Ministry of Agriculture of Russia, 2017 was one of the most successful years for the industry, since governmental support has started various state programs for the greenhouse industry (Ministry of Agriculture of Russia, 2018). Thus in 2017 more than 250 hectares of new commercial greenhouses began to exist with a new production line, and by 2019 the current total greenhouse area becomes close to 3,000 hectares.

This rapid increase resulted mainly after national policy to make the country self-sufficient in fresh vegetable products and provide a year-round provision of high-quality products without the need to import from the US, EU, and other countries.

However, the greenhouse industry in Russia has overcome a dramatic decline in the 1990-s during the reforms period. According to expert estimation, the production rates decreased by several times, and the damage caused to the industry has not been restored completely. At present, Russian greenhouse production is gathering momentum and becomes more stable every year. However, the industry faces various challenges and issues, one of which is a severe lack of qualified professionals. Furthermore, literature reconsidering the development of the industry and historical transition of technology from the USSR[1] to modern Russia is limited.

Nowadays, there is a technological gap between new developed greenhouse complexes and old greenhouse complexes, which are still existed from the Soviet Union period. Thus, there is the same situation with a lack of qualified professionals needed for new developed

---

[1] Union of Soviet Socialist Republics

greenhouse complexes. Moreover, there is an issue with the agricultural education system in Russia focuses on higher education for the greenhouse industry needs.

The purpose of this Ph.D. study is to outline the historical transition of technology from the USSR to modern Russia, analyze current problems and issues in modern greenhouse industry, clarify the characteristics of the agricultural education system focused on higher education for the Russian greenhouse industry, and find a solution to solve a current lack of qualified professionals. Therefore, the purpose of Chapter 2 is to devote to the history and development of higher education in the Republic of Buryatia, Russian Federation since the higher education in Siberia and the Far East plays one of the important roles in agriculture development. Further, the purpose of Chapter 3 is to determine the gap by distinguishing five stages of greenhouse farming from its evolution in the 1930s in the USSR to modern Russia. Finally, the purpose of Chapter 4 is to analyze the current situation in the industry and systemize technological features of exploited greenhouse constructions.

Chapter 2. Analysis of the current status and perspectives of education for agricultural mechanization in the Republic of Buryatia, Russia

2.1 Introduction

Higher education in Siberia and the Far East occupies an important place in the Russian education system, because the quality and effectiveness of the services provided to the population depends on the training and professional competence of specialists. Various public and private institutions of higher education, such as universities, institutes and academies, are located in the Republic of Buryatia. Republic of Buryatia has large research and production capacity, ramified infrastructure and agricultural development. Agricultural science has historically been an essential part of Russian science, closely related to the practical side of the economy, aimed at the study of agricultural production. Natural climatic and geographical conditions of the Republic of Buryatia defined livestock and crop production as the priority sector of agriculture. Thus, agricultural science was aimed at the development of the animal husbandry and crop cultivation, to provide practical assistance to agricultural enterprises in the effective management of agricultural production (Igumnov, 2000). Higher agricultural education in Eastern Siberia began its development in 1931, with an opening of an Agricultural Pedagogical Institute in the Buryat-Mongol Autonomous Soviet Socialist Republic (ASSR), which was renamed to Buryat Agricultural Institute in 1960. In 1961 Faculty of Agricultural Mechanization was opened in the Institute (Balkhaeva, 2011; Zangeeva, 2012). Higher education in the USSR was fully funded by the government. Close connection between enterprises and specialized educational institutions were established. This meant that the company participated in the financing, and the graduates were required to work in these enterprises the first three years after graduation. Thereby, company had planned in advance, what kind of specialists they need (Vinokourov, 2012). The system provides the possibility of social success of the least prosperous sections of society. However, the post-perestroika period and then the crisis came. Funding has decreased dramatically, universities have received some autonomy and a quota on places with tuition fees. Students who received the highest marks in the entrance exams studied free of charge. The rest of the students were trained at their own expense. Enterprises ceased to finance higher education, however the state again assumed the role of Russia in the beginning of the twenty-first century. Since 1992, the higher education system has been restructured on the principles of university autonomy and academic freedom (Zaitseva and Yakovlev, 2012).

Higher vocational education in Russia is growing rapidly. The educational system depends on the current state and development of the government universities at the regional and local levels. Therefore, the purpose of this study is to clarify the history of the formation and development of agricultural science in the Republic of Buryatia in the Soviet and post-Soviet period, as well as to consider ways of solving problems.

2.2 Materials and Methods

Research papers in the sphere of agricultural education were used as a theoretical and methodological basis of the study. The analysis of the educational system specifics in the area of agricultural mechanization was conducted based on the 1995 State Educational Standard "Mechanization of agriculture" of Buryat State Academy of Agriculture named after Filippov V.R and on the study of curriculums of the years 1955 and 2016 presented in (Appendix I Table 1).

2.3 Results and Discussion

After signing the Bologna declaration Russia received an opportunity to educate and graduate experts according to the European requirements and standards, based on the demand of the world labor market (Novikova, 2009). Education is one of the major systems which enable a person to acquire knowledge and skills to use them effectively in professional activity.

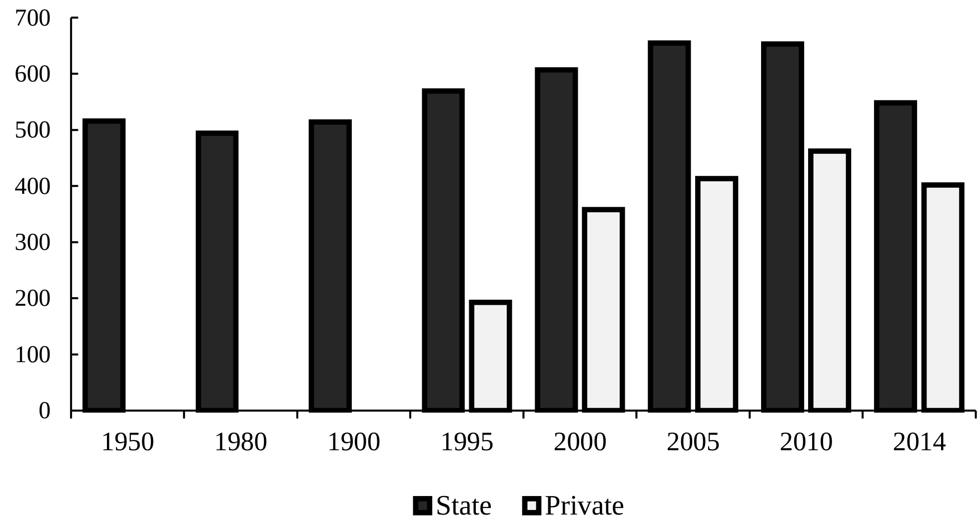


Figure 1. The number of higher institutions in the USSR and Russian Federation in 1950-2014.

(Source: Federal State Statistic Service, 2015).

According to the Russian Federal Service of State Statistics, the number of higher education institutions varied annually (Fig. 1). In 1950, only 516 higher education institutions were functioning, the main increase occurred in 1995, by increasing private institutions opening. In 2010, state higher educational institutions were opened 653, and private higher education institutions 462 that could not affect the quality of Russian education as a whole.

It results in reduction of the number of applicants entering agrarian universities, leading to the decrease in the engineer faculty students (Table 1). According to the Russian Federal Service of State Statistics in 1990, the output of specialists was 401100 people, and the output of agricultural specialists was 297000 people. In 1998, the total number of graduated students was 395500 people and the number of released agricultural profile was 20600 people. In 2006, the total number of graduates was 860200 people, and the graduates of the agricultural profile amounted to 30200 people.

Table 1. Graduation of specialists of state higher educational institutions in agricultural specialties until 2006 in the USSR and in Russia.

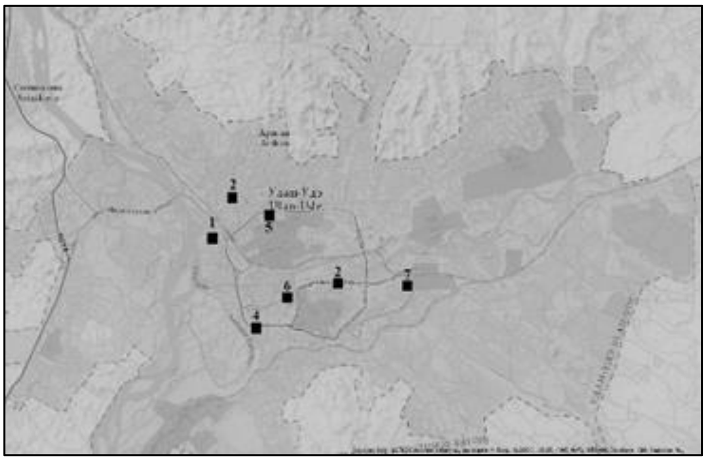
Years	1990	1998	2000	2003	2006
Graduation of students, total	401100	395500	436200	578900	860200
Of which agricultural specialties	29700	20600	21800	24800	30200

(Source: Federal State Statistic Service, 2008).

Another problem is reduction of the domestic demand in agricultural mechanization experts, which is followed by the low level of employment of graduates. Insufficient involvement of students in decision-making and designing of the educational environment, use of outdated methods, and the inability of existing educational programs to meet the requirements of employers negatively contribute to the quality of education (Abakumova, 2007).

To address the given problems, it is necessary to apply modern and effective approaches which will allow creating new working places for university graduates and will increase their interest in getting higher education without departing to other regions. It is necessary to strengthen the practical side of the educational process, by introducing more practical disciplines in the educational programs and applying experience of practicing professors. It is also beneficial to set up workshops and seminars by experts and company representatives. The curriculum needs to be based on the relevant requirements of employers. The education system of the Republic of Buryatia exists in accordance with the requirements for specialists. Thus, there is a considerable number of higher educational institutions in the capital of the republic - Ulan-Ude (Fig. 2). One of the best and modern educational centers in the agrarian field is Federal State Educational Institution of the Higher Education the "Buryat State Academy of Agriculture named by V. R. Filippov" (Zangeeva, 2009).

a)



b)

Figure 2. Location of higher educational institutions of Ulan-Ude the Republic of Buryatia

a) Map the Republic of Buryatia, Russia; b) Location of higher educational institutions of Ulan-Ude, Republic of Buryatia: (1. Buryat State University, 2. East-Siberian State University of Technology and Management, 3. Buryat State Agricultural Academy named after Filippov V.R, 4. East-Siberian State Institute of Culture, 5. Irkutsk State University of Railway Transport, 6. Siberian State University of Telecommunications and Informatics, 7. Russian State Humanitarian University).

The Ministry of Agriculture of the Russian Federation regulates activities of the Academy, and develops educational programs for bachelor and master's degrees, and postgraduate studies. Educational standards contain timetables and curricula (Nehlanova, 2006).

The historical analysis of curricula since 1955 and to the present shows that the educational programs underwent considerable changes (Appendix I Table 1). According to the data in the Table I the number of studied disciplines in 1955 amounted to 30 subjects. The majority of disciplines in the curriculum was aimed at general vocational training of the specialists and consisted of 18 professional subjects. It is necessary to note that humanitarian block of disciplines in the curricula of that time was practically absent. The humanities section of the in the curricula was mainly focused on the ideological education of the future specialists, and included subjects such as, for example, "Fundamentals of Marskizm and Leninism" and "Political Economy".

Moreover, students obtained skills in economics and accounting in the agricultural organizations. The number of natural science disciplines in the curricula of 1955 was negligible.

After the collapse of the USSR the Russian Federation introduced state educational standards, which aimed to preserve a common educational space within the country and to simplify the content of educational programs in all higher educational institutions of the Russian Federation (Dyukarev and Karavaeva, 2013).

The first generation of state educational standards (SES-1) were introduced in the late 1990s and left little freedom for higher educational institutions to design their educational programs. The second generation of state educational standard (SES-2) was adopted in 2000. SES-1 and SES-2 established requirements to the minimum content of the education programs, defined a number of compulsory subjects, and specified the number of hours for mastering the disciplines. In 2011 the Russian Federation developed and adopted a new generation of standards - federal state educational standards (FSES), which were fundamentally different from SES-1 and SES-2.

The list of subjects of the state educational standard 1995 with a degree in Agricultural Engineering, presented in Table 2. The list of studied disciplines was distributed over several cycles. The first cycle included social sciences - 1800 hours. Second cycle - mathematical sciences, which amounted to the 1850 hours. Specialized science accounted for 2000 hours of the total educational time.

Table 2. State educational standard of 1995 to specialty 311300 – "Mechanization of agriculture".

	Number of disciplines	Hours
1	Social sciences	1800
2	Mathematical sciences	1850
3	Specialized science	2000
4	Special subjects	2220
5	Facultative subjects	500

(Source: State educational standard, Moscow of April 9. 1995).

Professional disciplines included engineering graphics, technology of structural materials, materials science, theory of mechanisms and machines, strength of materials, machine components, lifting and transport machinery, metrology, standardization, electrical engineering, and automation. Special subjects comprised of crop production technology, mechanization and technology of animal husbandry, electric drive and electrical equipment, tractors and machinery, fuel and lubricants, and others. Optional disciplines occupied 500 hours in the plan. An analysis of 1995 state standard on "Mechanization of agriculture" reveals that in comparison with the curriculum of 1955 the number of hours allocated for the training sessions increased almost by two times. However, the amount of forms of control dramatically decreased.

At present, the state educational program in "Agricultural Mechanization" has the following characteristics: the whole theoretical course amounts to 8370 hours, and it is designed for 155 weeks of training. Educational and industrial practice is designed for 25 weeks, 22 weeks are allocated for examination period and the holidays last 54 weeks. Therefore, the whole course of training in the specialty "Mechanization of agriculture" amounts to a total of 256 weeks.

General analysis of the curricula and the state educational standard illustrates the most significant changes agricultural specialists training took place in the beginning of the 21 centuries. These changes are presumably connected to the transition of Russia to a two-tier education system, since Russia became a full member of the Bologna process in 2003 (Dyukarev and Karavaeva, 2013).

Geographic remoteness of the Buryat Republic from the largest of universities located in the western part of the Russian Federation entails both positive and negative effects. Nowadays, the imbalance between the major universities in the European part of Russia is clearly evident. While the higher education institutions of the "center" operate effectively and are included in various international ratings, universities of the farthest Russian regions are significantly lagging behind in terms of education quality. Thus, for instance, the Buryat State Agricultural Academy is the oldest university in the Republic of Buryatia and has the largest scientific potential in the whole Baikal region. However, since the Academy is the major, and usually the only institution preparing specialists for the regional economy, its research activities have become more and more isolated and concentrate mainly on the needs of the region. Scientific achievements of the Academy often cannot be applied outside the region, and it is scientific and research activity does not fully correspond with the tendencies of the modern science. Therefore, to solve this problem the Academy needs to integrate into the system of international programs and focus more on the requirements and demand of the national and global economy, rather than necessities of one region.

2.4 Conclusion

In conclusion, further development of the Russian higher education system is possible only the state addresses a number of challenges and domestic problems. In the Soviet period government undertook unprecedented steps to boost industrial development, therefore the years 1930-1940 were associated with a mass construction of industrial enterprises, which were in need of qualified engineering personnel (Hoshimova, 2013). Thus, the state made a significant effort to eliminate illiteracy and create secondary and higher education institutions, in order to provide qualified specialists. Educational establishments were equipped with necessary laboratory equipment, of academic and scientific literature. In the post-Soviet period, the quality of education decreased slightly, as a result of restrained political situation and socio-economic challenges. At the beginning of the 2000, when Russia became the member of the Bologna Process, Russian government has revised the classification of areas and specialties of higher professional education to meet European education standards. A new generation of educational standards was created, applying the credit system. Bologna education system in Russia suggests that bachelor is an operative engineer and master is a researcher engineer, a design engineer is for technical industries of economy. To address complex problems of education system in the region it is necessary to strengthen interuniversity cooperation in curriculum development, to design and adopt joint education programs, conduct joint research projects and internships. With regards to enhancing international activities it is necessary to promote exchange of students and academic staff with the foreign universities. It will contribute to the flow of new knowledge and experience to the universities and, therefore, improve quality of education and research activities.

Chapter 3. Review on stages of formation and development of greenhouse industry in the USSR and Russia

3.1 Introduction

In Russia, 33%–37% of the population’s demand for vegetable products is covered by imports. In the winter-spring period, this number increases to as high as 90%–95% for certain types of products (Toropilova, 2013). At the present stage, ensuring food security and providing the Russian market with vegetable products is one of the main tasks facing agricultural producers.

From 1960 to 1988, large socialist state and cooperative agricultural enterprises operated effectively in the USSR. State and collective farms were the main producers of agricultural products. Agriculture was gradually transforming from outdated, manual production to a large technically equipped industry, which played a significant role in the global economy. In 1980, the USSR ranked first in the world production of wheat, rye, barley, sugar beet, potatoes, cucumbers, sunflower, cotton and milk, second in sheep livestock, and third in the overall volume of agricultural production, livestock and grain harvest. The USSR was also a major exporter of various agricultural products such as grain, cotton, vegetables, vegetable and animal oils and fur (Tulenkova, 1980; Aliev, 1985; Bakuras, 1989; Ponomarev, 1989). As for the protected cultivation industry, in 1985, the total area of winter greenhouses reached more than 4700 ha, and the profitability of vegetable growing in greenhouse farms increased from 70% to 200% (Bakuras, 1989).

Today, the infrastructure of the greenhouse vegetable cultivation sector in Russia is represented by winter and spring greenhouses, as well as of vegetables produced by protected cultivation in Russia are harvested in winter greenhouses. According to Rosstat

(The Federal Service for State Statistics), the total area under greenhouse vegetable production in agricultural organizations in 2014 was 2120 ha, and the overall volume of harvested vegetables was 1.303 million tons, which is 10% more than that in 2013.

As a result of the introduction of the agricultural development program in Russia, the total harvest of vegetables grown by protected cultivation is predicted to reach 1.7 million tons by 2020 (Chekmarev, 2015).

This chapter aims to examine stages of formation of greenhouse production in the USSR, analyze main technologies used in greenhouse farming, and to determine the current state of greenhouses in Russia.

3.2 Stages of formation of greenhouse farming in Russia and the USSR

Development of greenhouse production in the USSR can be divided into several stages, which are characterized by specific features and challenges as follows:

Stage 1 (1930–1960):

The first large industrial greenhouses appeared in the country during this period. In 1930, construction of the first greenhouse complexes started in Moscow, Leningrad, Simferopol, Kislovodsk and the North Caucasus. By 1939, the total area of greenhouses in the USSR was 82.3 ha (Voronin and Bazarumbetov, 2013). Complexes located in the south of the country achieved the best results since operating costs were 40%–50% lower in the southern parts of the USSR than in the north (Ponomarev, 1989).

Greenhouse production capacity increased until 1941. In the years of the Great Patriotic War in 1941–1945, all agriculture in the USSR was severely damaged and greenhouse vegetable horticulture was practically destroyed. After the war ended, the USSR faced enormous challenges in the recovery and development of the national economy. First, in

1946, the government determined the pathways towards achieving the pre-war level of industrial and agricultural development (Voronin, 2012). The state adopted measures to strengthen potato, vegetable and livestock complexes around major cities and industrial centers, and to develop greenhouse production to supply the population with early vegetables and greens in the winter-spring period (Tulenkova, 1980). Consequently, the USSR managed to eliminate damage caused by the war to the national economy and agriculture and recover its greenhouse production within 5 years (Reimers, 1955).

Stage 2 (1960–1993):

In this stage, extensive restoration of greenhouse farms began across the country. The government developed and launched projects to determine standards for construction of block and arch type greenhouses using polyethylene and polyamide films and provide automatic regulation of microclimate, irrigation, and fertilization of plants (Tarakanov, Borisov and Klimov, 1982). Construction of greenhouses reached its peak in 1972–1986. Greenhouse complexes with areas of 12–54 ha was built in almost all regional centers and large cities all over the USSR, even in the northern areas such as Karelia, Chukotka and Taimir (Tulenkova, 1980; Ponomarev, 1989). In 1985–1991, several years prior to the collapse of the USSR, the largest greenhouse complexes included Yuzhniy, Moskovskiy, Leto and Belaya dacha with areas of 144, 115, 54 and 48 ha, respectively. In 1991, due to the unstable situation in the country, increased energy prices and change of ownership of agricultural organizations, 1400 ha of greenhouses ceased to exist (Bunin, Mukhortov and Rodionov, 2008). Thus, at the beginning of 1992, approximately 3200 ha of glass winter greenhouses were present in Russia (Ryzhkova, 2015).

Stage 3 (1993–2000):

This period was marked by the collapse of the USSR and the national economy. The unstable political and economic situation in the country led to a sharp deterioration of the financial and technological state of greenhouse complexes. A substantial part of the areas under the greenhouse production was disassembled or left abandoned. The volume of greenhouse agricultural production dramatically decreased and slowed down relative to foreign countries (Tarakanov, Mukhin and Shuin, 2003). Thus, depreciation of fixed assets of greenhouse complexes reached 80% in 1993 and production reached its record minimum in 1996 at 459 thousand tons of greenhouse products (Voronin and Bazarumbetov, 2013).

Stage 4 (2000–2010):

Further development of greenhouse vegetable cultivation was concentrated on the reconstruction of the remaining greenhouses with the aim to reduce energy costs for heating and microclimate; however, these attempts did not have any effect on the increase in the production of vegetables (Litvinov, Nurmetov and Devochkina, 2011).

Since 2006, Russian energy prices have been increasing annually, which has adversely affected the financial performance of greenhouse enterprises and led to a reduction of greenhouse area to 1870 ha (Detkov, 2016). At the same time, demand for flower production began to increase. Prior to this period, the flower market was 80% filled by foreign suppliers from Holland, Latin America, Ecuador, and Colombia, because the Russian flower manufacturers were unable to compete with other countries. However, the situation began to change with the formation of new flower farms, concentrated mainly in the central part of Russia (Litvinov and Shatilov, 2015).

In 2010, there was a certain revival of investment activity in the greenhouse business. Many large companies started to consider greenhouse vegetable growing as the best option for diversification of production, and as a promising area for investment. This interest was caused by the implementation of the state program aimed at support greenhouse farming (Syrov, 2017).

Stage 5 (2010–2016):

In 2014, the volume of land under greenhouse production remained low at 1880 ha. The following year, the government took measures to increase production by granting state subsidies to carry out construction and modernization of greenhouse complexes

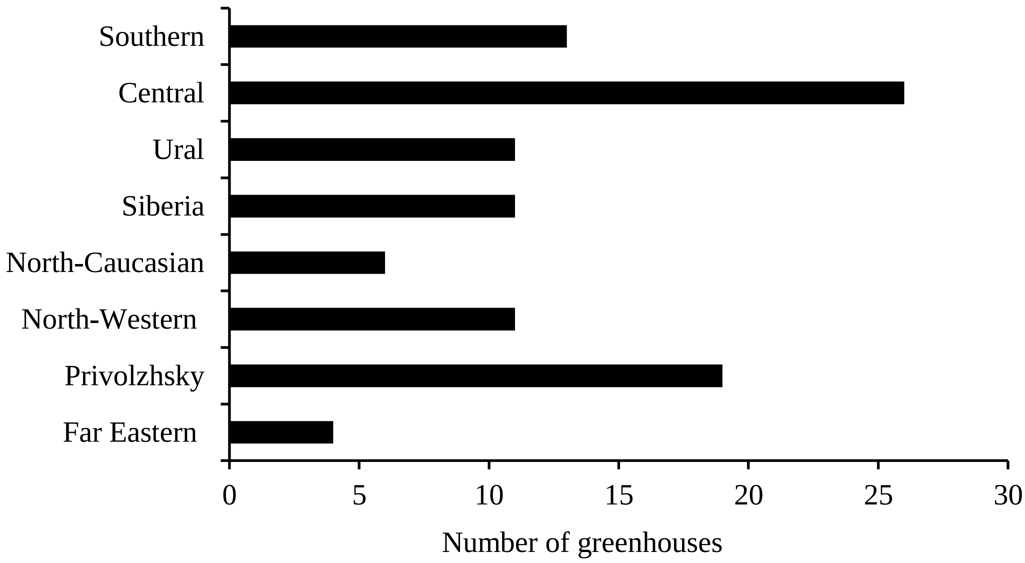


Figure 3. Greenhouse farms in the regions of Russia based on members of the Association Greenhouses of Russia in 2016.

(Source: Association "Greenhouses of Russia" 2017).

These measures increased the area of winter greenhouses to 2017 ha, and by 2016 this number reached 2376 ha. There are more than 25 greenhouse farms in the Central Federal District, about 13 farms in the Southern Federal District, and 19 greenhouses in the

Privolzhsky Federal District (Fig. 3).

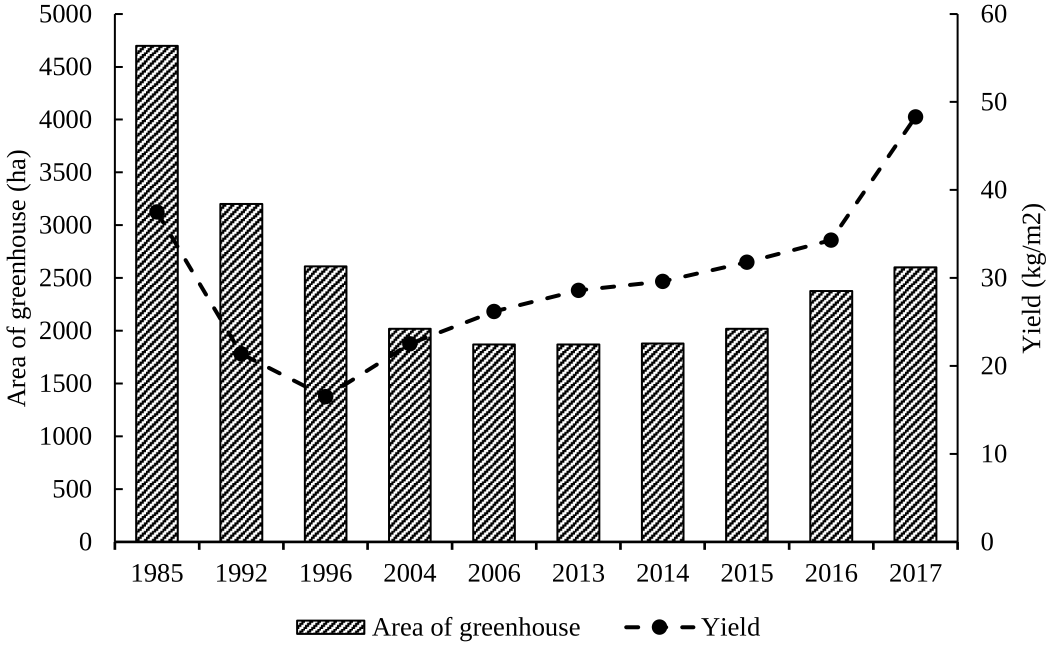


Figure 4. Volume of glazed winter greenhouses in Russia and the USSR. (Source: The Federal Service for State Statistics 2016, Association "Greenhouses of Russia" 2017, Alecon, 2016).

The volume of glazed winter greenhouses changed considerably in different years (Fig. 4). Expansion of the area of winter greenhouses is expected to continue, and the government plans to increase the extent of winter greenhouses to 4000 ha to cover the national requirement for fresh quality vegetables all year round. The total volume of greenhouse vegetable production is also planned to be increased by 1 million tons to achieve 1.7–1.8 million tons by 2020.

3.3 Application of progressive heating technology in greenhouses in the USSR

In the Soviet period, heating of greenhouses was one of the critical factors for improving vegetable production. Heating allowed extension of the period of greenhouse use in the winter season, and also created the necessary thermal regime, which ensured a larger and earlier harvest. Profitability of greenhouse vegetable cultivation depended directly on the reduction of the heating costs. The prices for the heating, in turn, depended on the type of fuel and the type of heating system. In 1961, the most common types of winter greenhouses heating were heat waste from industrial enterprises, condensing thermal power plants, nuclear power plants, and gas compressor stations. Technology involving heating with hot water obtained from industrial thermal power plants was applied in various ways. In some cases, after the hot water was used to heat the cultivation areas, it was returned to the enterprises partly cooled. In other cases, the entire potential of hot water was used to heat the greenhouses and then discharged into water basins or sewers (Bryzgalov, 1995). The greenhouses with water heating were set to a depth of 50 cm. Steel pipes with a diameter of 50–75 mm was mounted on brick or concrete pads at the bottom of the greenhouse with a slope for air removal and water drainage. Hot water from the boiler room or industrial enterprises was circulated through the pipes, thus heating the greenhouse (Edelstein, 1983). Since the soil on the edges of the greenhouse cooled more intensively, additional heating devices were placed around its perimeter. Lateral glazing was strengthened with plastic film (Markov, 1974).

Mixed heating of soil and air was considered to be a more effective method. A favorable temperature regime was created in the greenhouse, and air and soil were evenly heated, which enabled earlier planting of seedlings (Shefel, 1971).

Another heating technique came into practice in 1962, with the development of an electrical heating system of greenhouses, which included use of an uninsulated steel wire fed with a current of safe voltage (Ivanishin, 1963). Heating occurred when a voltage (50 V) was passed through the uninsulated steel wire (6–7 mm in diameter), which was covered with heat-resistant varnish. The wire was placed under the soil layer, thereby providing heating of the soil and air (Fig. 5). The use of the uninsulated steel wire in greenhouses also carried out partial sterilization of the ground, which in turn disinfected the soil (Ivanishin, 1964).

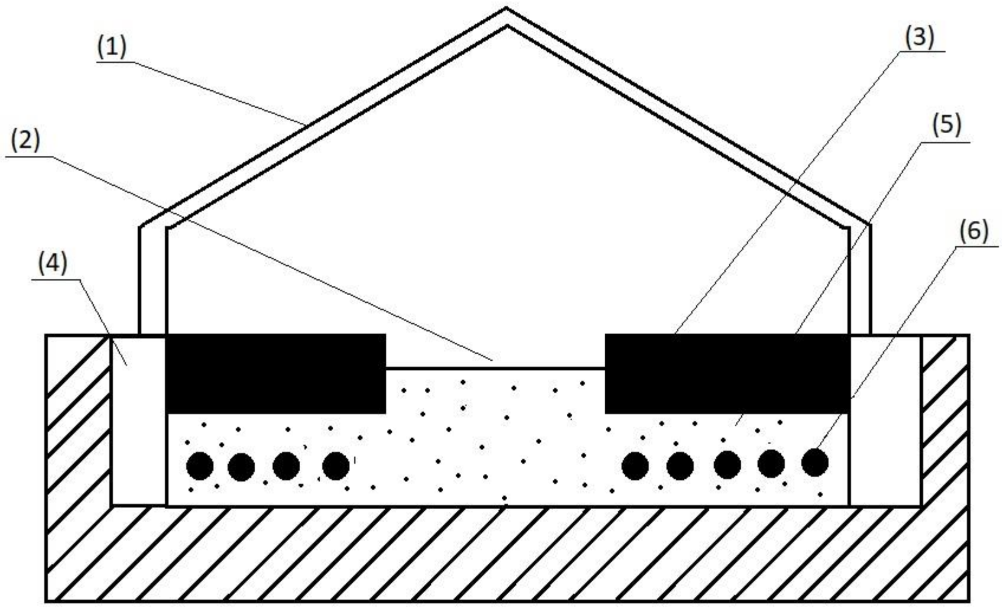


Figure 5. Schematic of the greenhouse with electric heating using an uninsulated steel wire: (1) roof, (2) passage, (3) layer of fertile soil, (4) foundation, (5) sand layer, (6) steel uninsulated wire with a diameter 5–6 mm.

(Source: Vegetable Growing In Pre-Baikal Region, Ivanishin, 1960).

The steel wire electric heating method was applied in the construction of greenhouses in the Angarsk and Kitoy collective farms of the Irkutsk region, Kenonsky state farm in the Chita region and a number of other agricultural organizations (Ivanishin, 1960). The main disadvantages of this method were as follows: the need to use a step-down transformer, the rapid corrosion of the steel wire and the difficulty of replacing the heated material, as well as the danger of conducting maintenance while the device was switched on.

A zinc-coated wire with a cross section of 2.5–3 mm was used to make the repair process of the soil heating system convenient. The wire was twisted into a spiral and placed in asbestos cement pipes with a diameter of 50–100 mm, which were put into a layer of sand at a depth of 40–50 cm. The mains voltage amounted to 220 V. The disadvantage of this method was the laborious process of manufacturing the asphalt-concrete gutter base under the asbestos cement pipes to prevent heat loss and the absence of air heating in the greenhouse (Markov, 1974).

3.4 Air heating of winter greenhouses in the USSR

In the Soviet period, various methods were used for heating greenhouses, e.g., thermal generators, gas burners and electric and gas air calorifiers. In the calorifiers, copper tubes were heated with electricity or hot water. The tubes quickly transmitted heat to the air, which was blown through the tubes by the fan, thus maintaining the microclimate inside the greenhouse (Bryzgalov, Sovetkina and Savinova, 1983). In thermal generators, gas combustion occurred directly within the greenhouse with subsequent conditioning and dispersal of warm air throughout the entire greenhouse volume using a fan. Due to the excessive amount of carbon dioxide and other products of combustion expelled directly into the greenhouse, this method required intermittent air infiltration and ventilation.

Fuel combustion in boilers was one of the most widespread air heating methods in the USSR. Hot water with a temperature of up to 100–130°C was passed through the pipes of the greenhouse. The hot water method also required adequate control of the carbon dioxide levels, which is vital for the photosynthesis of plants. In contrast to the direct-fired heating, the shortage of carbon dioxide needed to be addressed. Fresh animal manure was added to the soil with a layer of 8–12 cm to 30–50 kg/m2, or carbon dioxide was dispensed directly into the air (Markov, 1974).

3.5 The use of geothermal water as a source of heating in the USSR

The presence of a large number of geothermal sources in the USSR allowed the use of thermal energy reserves in the construction of greenhouse complexes. The largest thermal springs were concentrated in the North Caucasus, the Kamchatka and Magadan regions, in the area surrounding Lake Baikal, and in Western Siberia.

Geothermal water was used for heating greenhouses for the first time in 1969 in the Kamchatka region at the "Thermalniy" state farm. Water from the Sredneparatunskoye hot springs was utilized at a temperature of 780°C for greenhouse heating (Fig. 6). In these greenhouses, a boiler room was used for heat exchange. A pump pushed geothermal water into large diameter pipes within the boiler. Inside the large pipes there were tubes of smaller diameter filled with fresh water. The heated fresh water went through the pipes to heat the greenhouse and then returned, while the used geothermal water was reinjected back to the ground. The heat consumption in such greenhouses and hotbeds was determined by the engineering characteristics and the quality of the heating and ventilation systems (Bryzgalov, Sovetkina and Savinova, 1983).

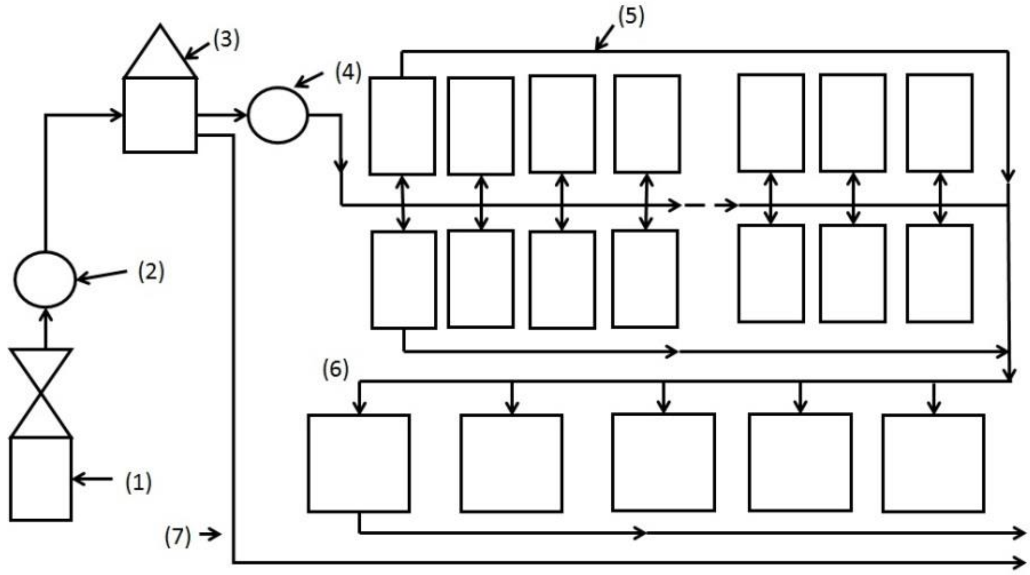


Figure 6. Schematic of greenhouse heating with geothermal water:

(1) well, (2) conveying pump, (3) boiler installation, (4) distribution pump, (5) winter greenhouses, (6) spring greenhouses, (7) discharge of the used geothermal water.

(Source: The vegetable growing of protected soil,

Bryzgalov, Sovetkina and Savinova, 1983).

Currently, Russia plans to build a modern greenhouse complex with an area of 5 ha in the Kamchatka region, which will be heated by underground thermal water (Kamchatsky Krai Invest Portal).

3.6 Application of additional lighting in greenhouses in the USSR

In the middle of the last century, artificial lighting in greenhouses was a widespread practice in the USSR (Prikupets, 2012). The low intensity of natural light in the greenhouses during the winter period was not sufficient for the normal vital activity of plants. In winter, artificial lighting was a crucial factor in obtaining early vegetable seedlings of good quality (Shuin and Efimov, 1960). For many years, the main type of lighting used in the greenhouse cultivation was incandescent lamps, which were inefficient and had a radiation spectrum that did not meet the needs of plants. In some cases, neon, mercury and sodium lamps of low power were used (Leman, 1952).

Another type of lamp used during the Soviet times was fluorescent lamps that were closed on top with a screen. The power of these lamps was 40–80 W and they could be heated only up to 40–45°C. Therefore, the lamps were located close to plants at just 3–5 cm distance. Moreover, due to the low power of the fluorescent lamps, it was necessary to place up to 10–15 lamps on each frame (Markov, 1974). As the plants grew, the frames on which the lamps were mounted were raised upwards (Fig. 7). As a source of additional illumination, fluorescent lamps resulted in an increased rate of photosynthesis, which accelerated fruiting and increased yield. The main disadvantages of fluorescent lamps were the large dimensions of the built structures, and that the seedlings were shaded from natural daylight (Lhamazhapov, 1974).

Figure 7. Plant irradiation with fluorescent lamps.

(Source: Vegetable growing, Markov, 1974).

In 1972, the first greenhouse irradiators in the country with an internal mirror surface (OT-400) were manufactured at an electrical plant in the city of Saransk. They produced a downward-directed luminous flux of about 30 lm (Fig. 8). The main advantage of the OT-400 irradiator compared with the previously used fluorescent lamps was the absence of shading of the seedlings, and the shading surface of the lamps was no more than 2%–4% of the illuminated area (Popov, 1986).

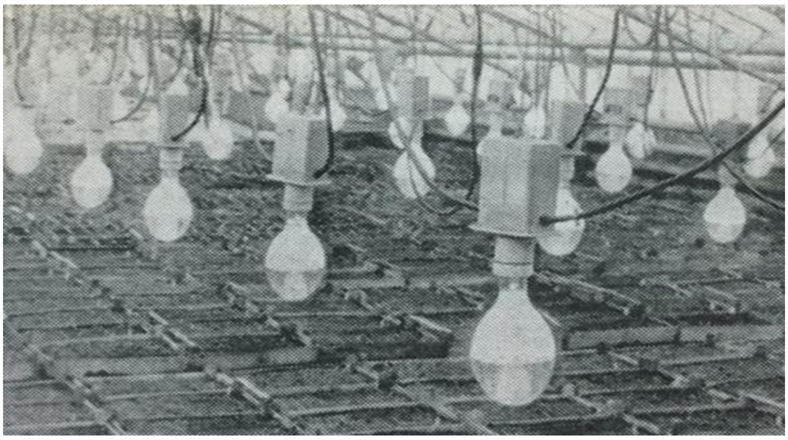


Figure 8. Irradiators OT-400, 1972

(Source: Vegetable growing, Markov, 1974).

The OT - 400 lamps were therefore used for additional irradiation of plants in greenhouses in all cold areas of the USSR. However, they also were not completely efficient and had a small luminous flux (Prikupets, 2012).

3.7 Plant irrigation technologies in the USSR

Soviet agricultural irrigation techniques included various methods: overhead sprinkling, hand watering, subsoil irrigation and impulse irrigation. The most common method of irrigation during the Soviet period was overhead sprinkling, which was used to moisten soil and air. In this method, mobile pipelines were placed at the height of 2 m from the soil surface along the perimeter of the greenhouse. Water pressure in the pipes was 1.5–2 atmospheres (Fig. 9). The irrigation process was adjusted to imitate the rains occurring in the summer. The sprinkling method was alternated with hose irrigation (Markov, 1974).

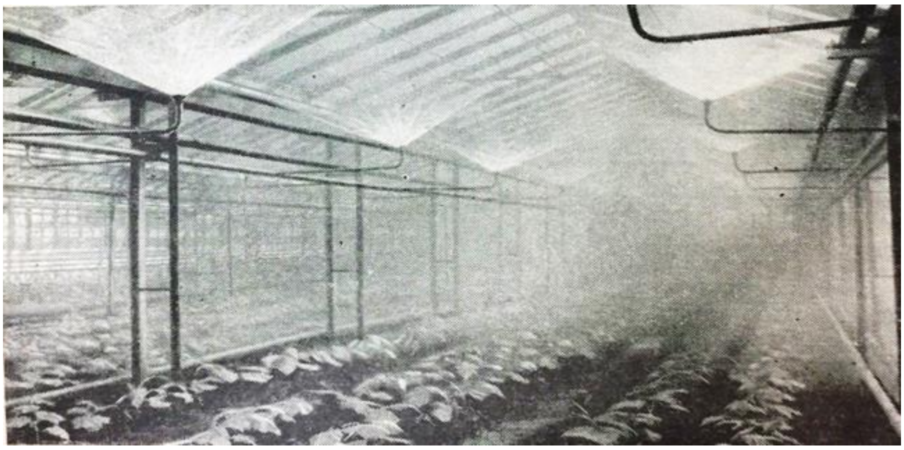


Figure 9. Overhead sprinkling irrigation

(Source: Vegetable growing, Markov, 1974).

Subsoil watering of plants was applied in the cultivation of certain varieties of melons and beans with a lowered relative humidity. This type of irrigation included installation of asbestos-cement troughs that were placed at a depth of 30 cm at a slope and at a distance of 70–100 cm from each other. Perforated pipes were installed in the troughs. However, this method of plant irrigation did not find wide distribution because of the need for an annual installation of a watering system and the large water consumption (Markov, 1974).

3.8 Application of hydroponics in the USSR

The development of industrial hydroponics is associated with the name of W. Gericke, a professor of the University of California. In 1929, he applied the method of aquatic culture and called the new technology "hydroponics". Professor W. Gericke managed to obtain a record harvest of 60 kg of tomatoes with one square meter. Results of his work served as the basis for improving the hydroponic method for industrial use in vegetable cultivation. Hydroponic technologies became widely used in the USA, England, Germany, France, Italy and especially in Japan, where the world largest hydroponics area of 22 ha was built near Tokyo in 1946.

Soilless plant cultivation had been studied in Russia before the USSR was created. In 1886, K.A. Timiryazev – a scientist known worldwide – organized a demonstration of experiments on soilless plant growing at the Nizhny Novgorod Fair to popularize the hydroponic method. However, the first attempt to use the hydroponic method for industrial purposes in the USSR occurred in 1959 at the Moscow winter hothouses of the Teplichny state farm (Bryzgalov, Sovetkina and Savinova, 1983). By 1970, greenhouses covering about 1 million m2 of land were built to use hydroponic technology. Large hydroponic plants appeared near the Moscow state farms Marfino and Belaya Dacha, near the Saint-Petersburg (then Leningrad) Leningradskiy state farm, and the Sverdlovsk state farm named after G. Ordzhonikidze. The hydroponic method was most widespread in Ukraine.

The hydroponic method was particularly effective in the far north regions, desert and mountain areas with no fertile land, and in large greenhouse farms located near large cities, where harvesting and delivery of soil were labor-intensive processes. Growing plants using artificial nutrient solutions enabled achievement of high and stable yields at low production costs (Aliev, 1985).

Waterproof tanks or concrete pools were used as water containers connected into a single unit by a channel that ran along the walls of the greenhouses and provided nutrient solution from a reservoir through the main pipeline. Containers for making and storing the nutrient solution were placed below the floor level of the greenhouse directly in the cultivation facility. The volume of the reservoir was calculated to contain 40–50 L of solution per 1 m^2 of area.

The tanks or pools had a small slope towards the reservoir, so that the solution would flow down to the reservoir. Nutrient solution was automatically fed to the plants by a flooding method using a pressure switch. When the contacts of the pressure switch were closed, a magnetic starter activated the electric motor of the centrifugal pump. When the level of the nutrients increased to 17–18 cm, the float switch became automatically activated (Fig. 10).

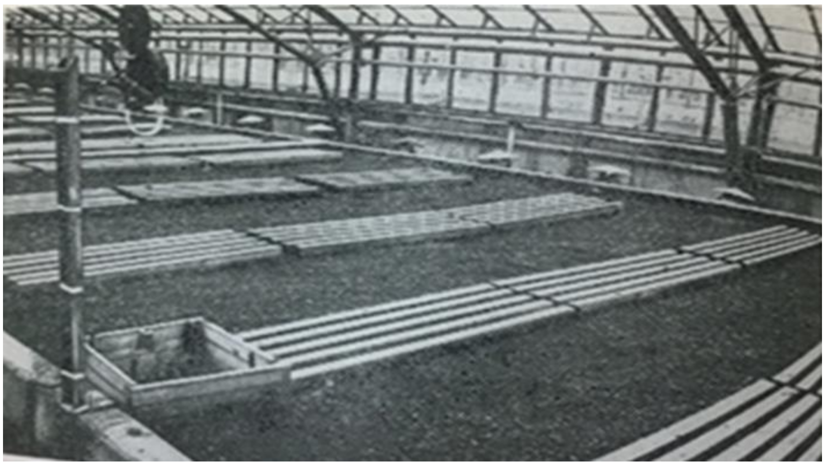


Figure 10. A pool for placing substrate in a hydroponic greenhouse

(Source: The vegetable growing of protected soil,

Bryzgalov, Sovetkina and Savinova, 1983).

The solution supply would stop, and the discharge started (Bryzgalov, Sovetkina and Savinova, 1983). At the same time, the solution acidity and its electrical conductivity were strictly controlled. The higher the concentration of the nutrient solution, the greater its electrical conductivity. When the electrical conductivity decreased to a certain value, adjustment of the solution was carried out. The advantage of this method was that it provided optimal conditions for root system growth by ensuring that plants always had sufficient moisture, nutrients and oxygen (Aliev, 1985).

Today, hydroponic methods of vegetable cultivation remain ubiquitous throughout the country. Although the basic principles of innovative hydroponics have not changed, scientifically approved well-balanced nutritious solution and modern computer-controlled feeding methods are being developed. In addition, new plastic materials covered with epoxy resin have made it possible to dispose of expensive and inconvenient metal trays, channels, and pumps. Use of durable and harmless plastic materials is safe for roots (Toropilova, 2013).

3.9 Conclusions on greenhouse industry in the USSR

The socio-political problems that arose in the last century undoubtedly influenced the development of the greenhouse industry in the USSR. The use of technological processes, such as heating of winter greenhouses with industrial waste, hot water from geothermal power plants, natural gas and artificial heating, ensured higher vegetable production and an earlier harvest. Geothermally heated greenhouses specifically designed for the wintertime constituted a unique technological method in vegetable cultivation. Finally, the hydroponic system made it possible to grow vegetables without using soil. All these important factors played an important role in the development of the greenhouse economy in the USSR (Moiseychenko, Zaveryukha and Trifonova, 1994).

Russian greenhouse complexes have not yet managed to reach the high area and production levels of the USSR. In 1985 in the USSR, the area of greenhouses was more than 4700 ha, whereas in Russia in 2017, the total area of greenhouses was 2600 ha (Agroarchive, 2017).

3.10 The present situation

In 2014, economic sanctions were imposed on Russia by the United States, the European Union, and some other countries to exert pressure with a view to changing the position of Russia in the international arena. One of the areas affected by the sanctions was the supply of imported vegetable products. In response, in August 2014, Russia imposed embargoed import of products from a number of Western countries. The sanctions imposed against Russia had a negative impact on various branches of trade and industry. However, they stimulated development of the national agriculture because of the lack of foreign producers on the domestic agricultural market and urgent need to fill the gap in provision of food products. Since then, the greenhouse industry has also been undergoing significant changes (Mamedov, 2014).

Because greenhouse production carries many risks, state support is crucial for an effective development of the industry. The Russian Ministry of Agriculture has developed a plan for construction or modernization of greenhouses for the period 2015–2020. According to the plan, new greenhouse areas will annually increase up to 400 ha (Chekmarev, 2015).

In order to stimulate construction of new greenhouses, the Government of Russia adopted Resolution No. 624 dated July 24, 2015 ("On Approving the Rules for Granting and Distributing Subsidies from the Federal Budget to Subjects of Russia for Reimbursing Direct Costs of Development or Modernization of Projects related to the Agro-Industrial Complex") as an additional measure of support for investment projects. The resolution includes the following measures of state support:

- subsidizing 20% of the direct costs incurred for the construction and modernization of greenhouses and subsidizing part of the interest rate on investment loans for construction, reconstruction of greenhouse complexes and small energy facilities;
- subsidizing part of the interest rate on loans that are concluded for a period up to 1 year for purchase of fuels and lubricants; means of plant protection, mineral fertilizers and seeds (except for the elite seeds); spare parts and materials for the repair of agricultural machinery, equipment, trucks and tractors; and materials used for drip irrigation (Ministry of Agriculture of Russia, 2016).

3.11 Conclusion

Greenhouse production reached its highest level during the Soviet period using technological methods that increased the volume of production by several times. A considerable contribution to the development of the greenhouse production was made by cultivation methods, such as electric soil heating, use of geothermal water, additional artificial lighting and the hydroponic growing system.

One of the primary objectives for increasing greenhouse production in modern Russia is the introduction of innovative production technologies, as well as the development of modern resource-saving technologies that can improve the quality and quantity of greenhouse products.

Every year, new greenhouses are put into operation. In 2016, the gross harvest of vegetables grown in greenhouses reached 813.6 thousand tons. To ensure the population of Russia has access to fresh greenhouse vegetables during the winter-spring seasons, up to 1.9–2.0 million tons of vegetables is needed annually. Producers of greenhouse products will have to face many challenges on the way to achieving an effective greenhouse economy. However, notably, the area of greenhouses in Russia has been steadily growing in recent years, which suggests that it is possible for Russian greenhouse production to prosper in the future.

Chapter 4. Current status, Industry support and Agricultural education for the Greenhouse industry in Russia

4.1 Introduction

4.1.1 Development of greenhouse industry in Russia

The greenhouse horticulture sector in Russia mainly developed during the Soviet Union period (Union of Soviet Socialist Republics; USSR) with the peak in construction of facilities from the 1970s to 1986. During this period, greenhouses were built in all regional centers and near major cities with populations of more than 100,000 people. During the Soviet Union period, the greenhouse industry (protected cultivation) was a productive industry that was able to supply vegetables to the population during the off-season period. The devastating reforms of the 1990s negatively affected Russian agriculture in general, but especially greenhouse production, which has still not recovered to its pre-reform position (Muravyev, 2011).

Greenhouse production in Russia has several specific features. At present, there are modern greenhouses that were built using foreign technologies and adapted for Russian climate conditions. The Netherlands is the main supplier of greenhouses; drip irrigation systems are made in Israel, and boilers for greenhouse heating are produced in Germany. The share of domestically produced raw materials and technological solutions for greenhouse construction has increased gradually up to 30% in recent years (Agricultural platform "Agroinvestor", 2019).

According to the Greenhouses of Russia Association, which was founded in 1994, the pace of greenhouse construction has doubled since 2013, with 200–300 ha of greenhouses being built every year. State support for agricultural producers has played a significant role in the development of the greenhouse industry in Russia. Nowadays, the association plays a significant role in supporting domestic producers. The association represents and protects the interests of greenhouse enterprises, monitors modern technological achievements and helps to implement them in the greenhouse industry, and promotes cooperation between Russian and international greenhouse producers. More than 189 enterprises from all over Russia have joined this association. The largest proportions of greenhouse producers are from the Krasnodar and Stavropol regions, and the Republics of Bashkortostan, Karachay-Cherkessia, and Tatarstan (Federal Service for State Statistics, 2019; Greenhouses of Russia Association, 2019).

4.1.2 Current challenges in Russian greenhouse industry

There are several main issues faced by the Russian greenhouse industry. High production costs continue to challenge the industry. Depreciation of fixed assets is approaching 80% (Chekmarev, 2015). Due to the long service life (20–35 years) of greenhouses, the obsolete design of older models prohibits the introduction of modern technologies, which in turn restricts increases in production because the greenhouse itself is the main component of production efficiency. Simultaneously, obsolete technologies entail significant costs resulting in low profitability of greenhouse production. The average profitability of only 10%–12% prevents agricultural producers from investing in business development and technological improvement and remains one of the primary factors hindering industrial development (Greenhouses of Russia Association, 2019).

Another problem that has remained unresolved for decades is the significant lack of qualified personnel with higher education in all agricultural spheres including agronomy and engineering. Agriculture is developing every year, and new diversified, technologically sophisticated agricultural farms are being created. However, according to the All-Russia Agricultural Census conducted in 2016–2017, 47.9% of male and 27.6% of female employees in the sector are aged above 30, and many specialists are approaching retirement age Fig 11.

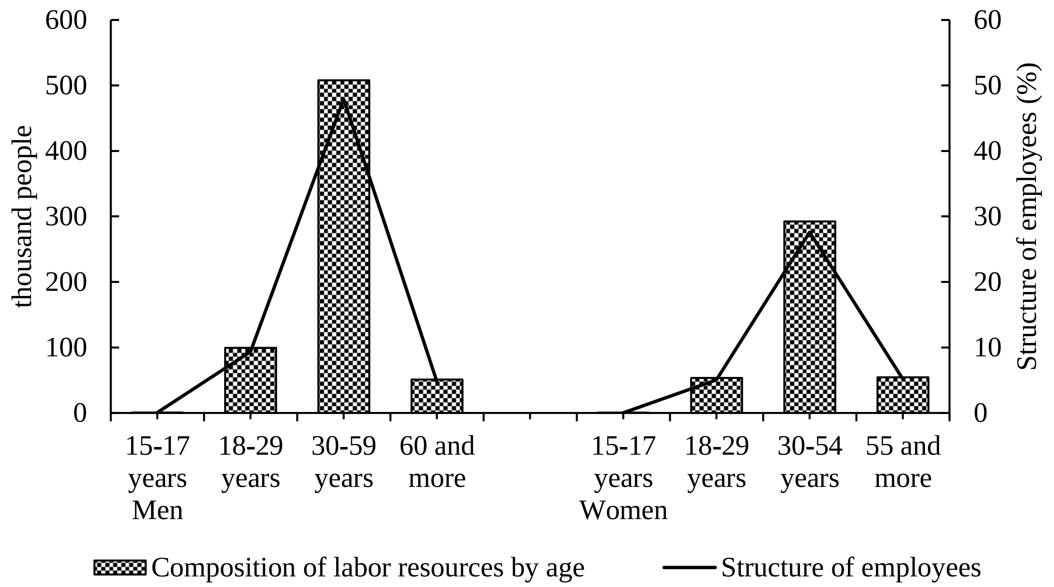


Figure 11. Distribution of population employed in agriculture by age groups. (Source: All-Russia Agricultural Census, 2018).

In terms of educational attainment, a large proportion (38.17%) of employees in agriculture has basic general or secondary general education. Agricultural employees with basic vocational education amount to 22.84%. Of the 21.22% of agricultural employees with secondary vocational education, almost half (9.8%) have specific agricultural qualifications. Only 12.38% of all employees in agriculture have attained higher education, and only 6.7% have professional agricultural degrees (All-Russia Agricultural Census, 2018; Fig 12).

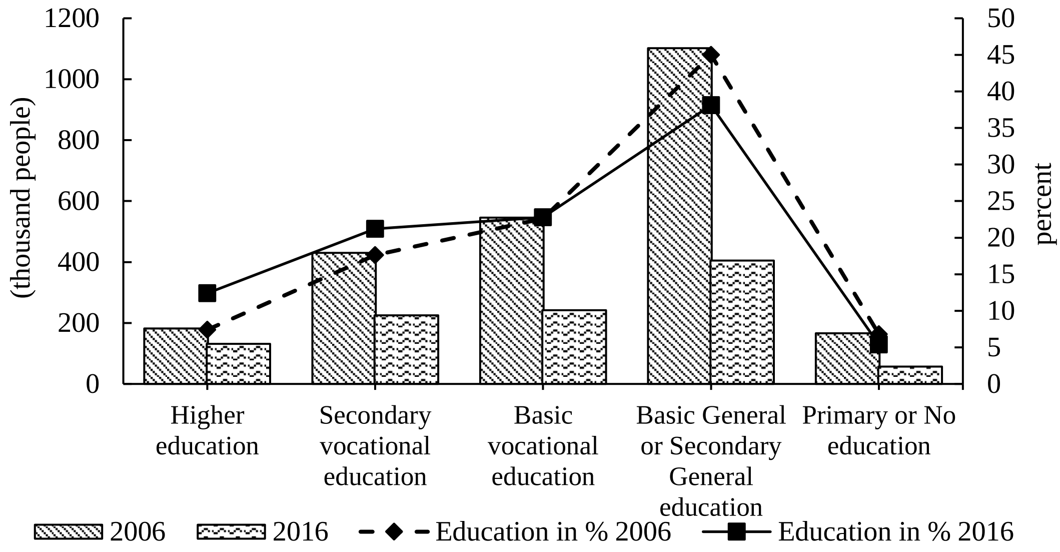


Figure 12. Educational Attainment of Population Employed in Agriculture.

(Source: All-Russia Agricultural Census, 2018).

Because the modern greenhouse industry is one of the most innovation-driven, technology-dependent industries, the disparity between technological progress and educational obsolescence is particularly large. This means that a lack of qualified personnel is another severe issue restricting the progress of the industry. In the program for the maintenance and development of greenhouses, the Ministry of Agriculture set an ambitious target of 4,700 ha of greenhouses by 2020, producing about 1.5 million tons of vegetables to meet 80% of the total demand of the population provided that the yield of vegetable crops is no less than 50 kg/m^2 (Greenhouses of Russia Association 2019; Ministry of Agriculture of Russia 2019). For sustainable greenhouse production to develop to that extent, there must be comprehensive state support and a new system of education and training to produce highly qualified personnel

4.1.3 Study purposes

Therefore, the primary aim of this chapter is to clarify the characteristics of the agricultural education system focused on higher education for the greenhouse industry in Russia. To do so, I overview current state and challenges of the industry paying attention to the state support policies. I clarify different technological types of greenhouses requiring different qualifications of the personnel working there. Despite both the greenhouse industry and related sectors and system of agricultural education in Russia undergoing significant changes, relevant literature in English on these topics is scarce. Research on the educational programs for specifically the greenhouse professionals has never been done so far.

4.2 Materials and Methods

To gather information for this study, we examined official data of the Federal State Statistics Service, Ministry of Agriculture, and the Ministry of Science and Higher Education of the Russian Federation. To overview curriculums related to the greenhouse industry, we obtained state educational standards and relevant legal regulations, and checked official sites and publications of agricultural educational institutions. We also studied relevant literature and information from the Greenhouses of Russia Association.

4.2.1 Technological types of greenhouses utilized in Russia

Greenhouse production includes engineering techniques such as construction technology, plant growth, environmental protection, and vegetable production. For this study, we gathered information on the technological types of greenhouses, and on the qualifications required for personnel to manage such facilities.

Greenhouse production in Russia began with primitive lean-to structures and has since developed to include modern high-tech facilities. The greenhouse industry stagnated for a long time after the collapse of the USSR, and consequently, many Russian greenhouses are outdated and inefficient (Bryzgalov, 1995). In 2018, out of the 2,600 ha of land occupied by operational greenhouses, 1,750 ha had old complexes with a service life of 30–40 years, and up to 50 ha of outdated greenhouses were being removed annually (Agricultural platform "Agroinvestor," 2019). Currently, we can define five different types (generations) of greenhouses in Russia.

The 1st generation of greenhouses is characterized mainly by one-slope construction with wooden frames and floors. The slope of the ramp faces the sun to intercept maximum solar radiation. These greenhouses are ventilated by vents on the ramp and are stove-heated.

The 2nd generation greenhouses have a gable roof and are more progressive with water and air heating for year-round use. These greenhouses have metal or wooden frames and support posts arranged in two rows in the center, connected to the upper part by metal girders. They are double ventilated at the top and sides.

The 3rd generation greenhouses are the large-scale hangar-type greenhouse that are used year-round and have hot water and electric heating. Compared with earlier generation greenhouses, the 3rd generation greenhouses have better operational and environmental indicators due to the ability to control the microclimate, their effective space utilization, and their simplified installation process. In particular, these greenhouses have better illumination and increased ventilation capacity, stable thermal conditions of the soil and air, and the ability to accommodate vehicles and tillage machines. In these greenhouses, it is easy to mechanize or automate ventilation, sprinkling, and other procedures (Ryzhenko, 2007; Mamedov, 2015; Dorzhiev *et al.*, 2018).

The 4th and 5th generation greenhouses are the most commonly used type in Russia nowadays. Modern 4th generation greenhouses are suited to high-tech production. Those produced by Venlo, for example, are tall, well-sealed, highly automated, and range in size from 1,000 to 10,000–30,000 m^2. Multi-span greenhouses are a combination of 2–3 or more double-sloped greenhouse modules adjacent to each other and joined along the longitudinal sides. The roof sides of adjacent modules are connected by gutters, which discharge water as well as functioning as load-bearing elements of the roof. All modules of multi-span greenhouses are interconnected and make up a structure with a glass roof, in which it is possible to move freely from one block to another. (Litvinov and Shatilov, 2015). The main advantages of multi-span greenhouses are the lower costs of construction per unit, and reduced heat consumption (lower heating costs). The disadvantage of this type of greenhouse is that it is unable to sustain an optimum microclimate during the warm period of the year. Because there is no system to reduce the internal temperature, the risk of over-heating is high Fig 13.

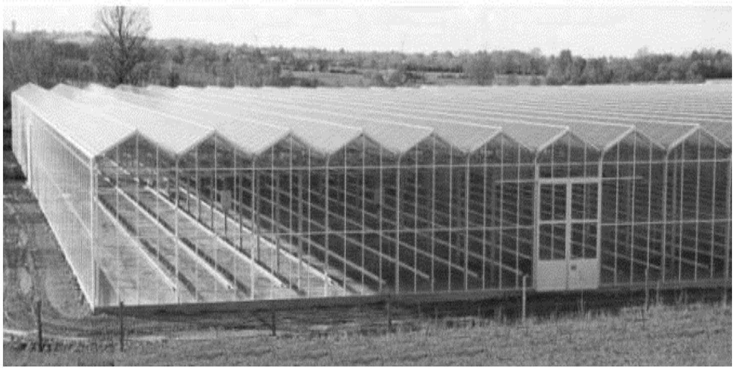


Figure 13. The 4th generation greenhouse (multi-span greenhouse).

The 5th generation greenhouses are represented by innovative Dutch companies and include the Ultra Clima type by the KUBO company; SuprimAir by CERTHOM, and ModualAIR by Vander Hoeven Fig 14. These greenhouses have several advantages: they can maintain an optimum level of CO_2 and an ideal microclimate any time of the year and have low energy costs because of thermal energy re-use. In the Ultra Clima greenhouses, the rising warm air is directed by fans to plastic hoses located under each row of plants for another heating cycle. Whereas the heat from the lamps (approximately 90% of the lamp power) disappears in an ordinary greenhouse, the heat in an Ultra Clima greenhouse is almost fully re-used and there is very little heat loss. In addition, the positive pressure inside the greenhouse acts as a shield to prevent insects from entering (Sokolov, 2015; Gish and Karpenko, 2016).

Figure 14. The 5th generation Ultra Clima greenhouse.

In 2015, the first 32-ha 5th generation greenhouse complex was built using KUBO technologies in Dankov city, Lipezk region. This project was achieved as a cooperation between the Russian manufacturer of automation systems for industrial greenhouses

“NPF FITO” and the “Greenhouse technologies” company (Gish and Karpenko 2016; Sokolov, 2015). By November 2018, “NPF FITO” constructed almost 100 ha (six complexes in several regions of Russia) of 5^{th} generation Ultra Clima greenhouses, representing one-third of the world’s total of 300 ha (Semykin, 2018).

Contemporary greenhouse technologies are changing and developing every 2–4 years. At the same time, older greenhouses with obsolete technologies are still used in Russia. All greenhouse complexes should be staffed by highly qualified personnel who are able to adapt to technological changes easily, or even lead these transformations. Ideally, greenhouse managers should be able to quickly implement new technologies for modern high-tech production, analyze complex situations, and make responsible decisions.

Table 3 illustrates Russian greenhouse data from 1992 to the current state 2018, such as the gross harvest of vegetables, total area of greenhouse land and harvested yield.

Table 3. Russian greenhouse data from 1992 to 2018.

Year	Area of Greenhouse (ha)	Yield kg/m^2	Gross harvest of vegetables (thousand tons)
1992	3200	21	684
1996	2610	17	459
2004	2020	23	630
2006	1870	26	500
2013	1870	29	613
2014	1880	30	728
2015	2018	32	710
2016	2376	34	814
2017	2600	48	922
2018*	2900	60	930

Note: * as of 25 December. 2018.

(Source: Association Greenhouses of Russia, 2018;

Federal Service for State Statistics, 2018).

4.2.2 State policies supporting greenhouse industry

The further development of greenhouse production in Russia is impossible without government support. Although there are various state programs for agricultural support in Russia, the industry still needs a more profound approach to address its problems. For instance, while new greenhouse enterprises receive financial support from the Government, there are no state support programs for the repair and reconstruction of existing greenhouse complexes (Muravyev, 2011; Aleksashkina, 2016).

To encourage the construction of new greenhouse complexes with investor support, the Russian Government adopted the following resolution dated 24 July 2015: № 624 "On approval of rules for provision and distribution of subsidies from the federal budgets of the Russian Federation for reimbursement of the direct costs on creation and modernization of projects in of the Agro-industrial complex". In the period from 2015 to 2017, the Commission of the Ministry of Agriculture of Russia selected and approved 47 investment projects with a total investment of 892 577 US dollars. The projects received subsidies of 179 000 dollars that covered part of the direct costs incurred in the construction and modernization of greenhouse complexes with a total area of 366.5 ha. An analysis of greenhouse construction and development from 2015 to 2018 and beyond is summarized in Fig 15. According to the Russian regional authorities responsible for Agro-industrial complex management, the state plan for the construction and modernization of greenhouse complexes in 2015–2017 was not completed due to insufficient funding Fig 15.

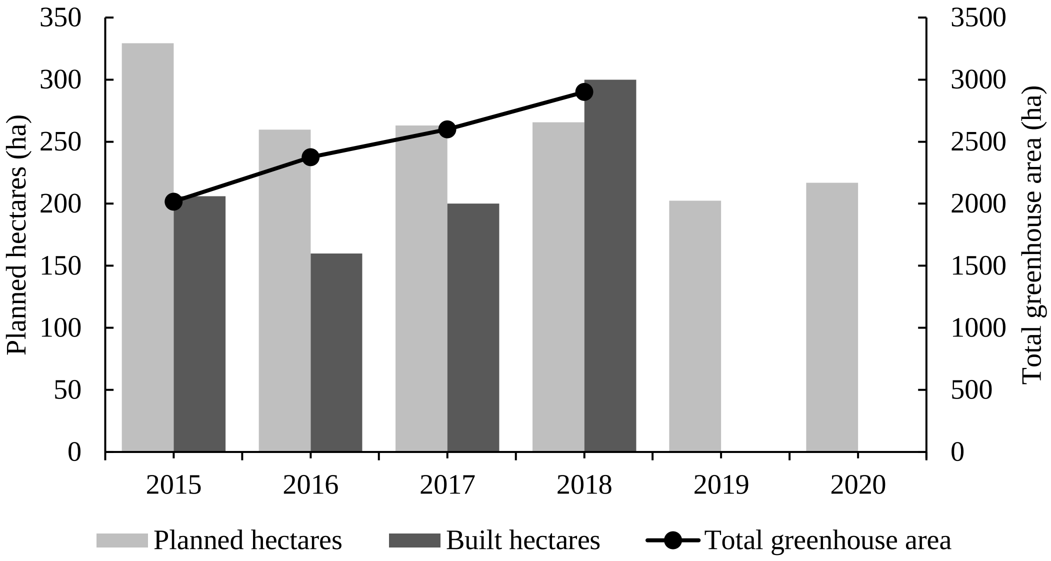


Figure 15. Greenhouses construction development supported by the state program (Source: Ministry of Agriculture of Russia, 2018; Federal Service for State Statistics 2019).

Thus, out of 329.4 ha planned greenhouses, only 206 ha of greenhouses were built. In 2016, the area of new greenhouses amounted to 160 ha out of the planned 259.8 ha. In 2017 about 200 ha of greenhouse construction was completed. In 2018, the industry finally built 300 ha of winter modern greenhouses, creating more than 6,000 new jobs. So far, the total greenhouse area in Russia is 2,900 ha (Ministry of Agriculture of Russia 2019; Greenhouses of Russia Association 2019).

Unfortunately, the statistical data on the area and volume of greenhouse production is unreliable because the industry is continually changing and evolving, and because there is no official information on the volume of vegetables produced annually in greenhouse complexes owned by private investors. Thus, a considerable amount of greenhouse production remains unaccounted for.

There are two state policies that provide the legal basis for agricultural education: The Workforce Training and Skills Development in the Russian Federation for the period up to 2020; and the Federal State Target Program of Education Development for 2016–2020 (approved by RF government on May 23, 2015, № 497). The development of a new strategy for agricultural education in the Russian Federation has been debated since 2014. These policies state that the roadmap for the development of educational strategies must be well planned and adequately prepared with cooperation among industries, educational and scientific institutions, and the government.

4.2.3 Agricultural education system in Russia

Nearly half of the total workforce employed in agriculture in Russia has a basic and/or secondary level education. Vocational schools and lyceums provide the basic level of vocational education and training for agricultural workers. The secondary level of vocational education is provided by vocational technical schools or colleges and leads to a qualification as a specialist. Students can start vocational training after 9–11 years of general education. Those who start vocational training from year 9 also study general subjects, allowing them to take standardized state examinations and continue to university. Agricultural universities have established vocational educational institutions that provide methodological and research training to produce middle-ranking specialists. There are 253 of these vocational educational institutions located in 73 regions of Russia (Volkov *et al.,* 2017). The higher agricultural education system subordinate to the Ministry of Agriculture of Russia encompasses 55 educational institutions located in 58 regions of Russia Fig 16. They include one agricultural institute, 17 agricultural academies, and 37 agricultural universities, 22 of which have 43 branch campuses (Agrovuz, 2019).

Figure 16. Map of agricultural educational organizations.

Note: information is from www.agrovuz.ru.

(Source: Agrovuz, 2019).

Across Russia, 29 universities have faculties of agriculture that provide educational training in several agricultural majors. The leading majors are Mechanization of Agriculture, Agronomy, and Food Processing Technology. Higher education in Russia consists of two main degrees: Bachelor's and Master's degrees. Bachelor's courses are 4 years long, and Master's courses are 2 years long. Many agricultural universities also offer Ph.D. courses (3–4 years).

The agricultural education system in Russia has implemented the principle of "lifelong education" through a network of continuing educational institutions. Advanced training and professional requalification of employees is provided by specialized educational establishments and qualification centers, while continuing education programs are provided by all higher educational institutions subordinate to the Ministry of Agriculture (Volkov *et al.,* 2017).

We reviewed the curriculums of higher education programs in Russian agricultural educational organizations, focusing on educational programs for the greenhouse industry and relevant sector qualifications.

4.3 Results and Discussion

4.3.1 Analysis of Russian greenhouse data

According to table 3 data, we can note that there is data which was collected not systematically by each year (from 1992 to 2018 yrs.) of the Russian greenhouse industry. This relates to the data published by the Russian Statistics Office. Due to the unsatisfactory data collection in the Russian Federation by Statistics centers, unfortunately, annual statistical reports lack important needed data for more detailed analysis.

I examined official data, which is available on statistical annual reports, (2013-2017; Table 3), accessible at Federal Service for State Statistics and data presented by Association Greenhouses of Russia, (2004-2006; Table 3), as well as our own collected data, (1992, 1996, 2018; Table 3), by observation on-site within Russia. The results of the analysis estimated by a linear function from Table 3 are given in Fig. 1-3, in (Appendix III).

Appendix III Fig. 1 shows the weak negative linear relationship between the area of greenhouse and greenhouse developing years, with significant value R^2 = 0.12. This relationship is connected with the post-Soviet Union period, when the area of greenhouse started to decrease from 1996 due to lack of financial support for renovation of Soviet Union greenhouses facilities and developing new greenhouse complexes. However, current state shows us the rapidly increasing of greenhouse area, that starts from 2013.

Appendix III Figure 2 shows the positive linear relationship between the gross harvest and greenhouse developing years, with significant value $R^2 = 0.45$. This relates with developing levels of greenhouse production by expanding of greenhouse area and implementation of new technologies as it is mentioned in materials part of the chapter (4-th and 5-th generations of greenhouses; Antonova, 2015). It can be said that the gross vegetables harvest increases as year by year increases the level of greenhouse developing. Refer to Table 3, we can see the current state of gross harvest of vegetables up to 2018, e.g. in 2017 amounted to 922 thousand tons, which is 17% more than the previous year; in 2016 the gross harvest (813.6 thousand tons) also increased by 34.2% compared to the 2015 level of 709.8 thousand, etc. The Russian Government plans an annual increase in vegetable production by 20-30% by 2020 and growth of the total volume of greenhouse vegetable production up to 1720 thousand tons per year.

Appendix III Fig. 3 shows the positive linear relationship between the yield of greenhouse production and greenhouse developing years, with significant value $R^2 = 0.56$. This relates with the previous facts (analysis of Appendix III Fig. 1-3), area of greenhouse increases, as well increases the gross vegetables harvest and yield from 1 m^2 by the result of greenhouse developing efficiency level.

4.3.2 Higher education for greenhouse industry

4.3.2.1 General information

We reviewed and analyzed curriculums related to the greenhouse industry in the last 5 years, from 2014 to 2019. We selected this period because the international sanctions imposed on Russia in 2014 had a massive impact to increase domestic greenhouse production and increasing competitiveness in the world market. The embargo on the import of vegetables forced the Russian government to include greenhouse production in the state program to support agriculture (Mamedov, 2014). Thus, the Russian Ministry of Agriculture has developed a plan for the construction (modernization) of greenhouses for 2015–2020.

Analyses of the curriculums focused on qualifications for greenhouse production showed that, before 2015, there were no specific study programs to prepare qualified personnel for the industry. However, two main agricultural majors were directly connected to the greenhouse industry Fig 17.

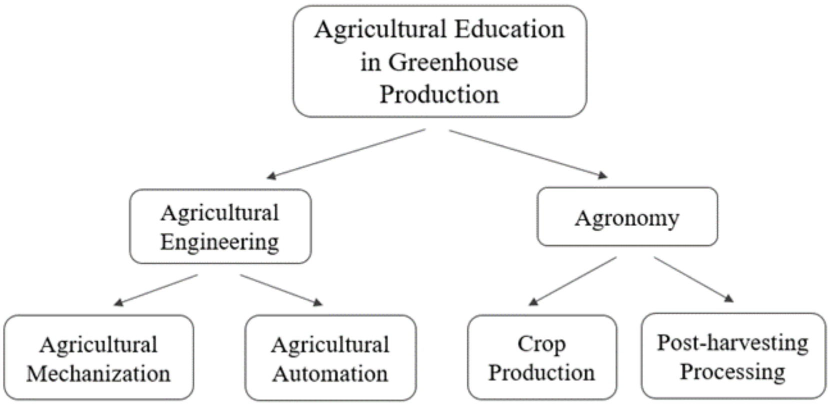


Figure 17. Agricultural education chart for greenhouse production.

Note: Agricultural majors providing specialists for greenhouse production.

Fig. 17 shows two agricultural majors, known as "specializations", in Russia. These two majors produce specialist agricultural engineers and agronomists.

An agricultural engineer is a specialist who can mechanize, electrify, and automate production processes; ensure the efficient use of agricultural machinery; calculate modes of operating agricultural machinery in accordance with specified conditions; and organize the storage, repair, and maintenance of agricultural equipment. An agronomist deals with soil management practices; improves agricultural production lines in terms of crop production, and develops operations that include farmers, gardeners, agricultural machine operators, and post-harvest processors.

Agricultural engineering and agronomy courses have two sub-majors (Fig. 17, third line) that are studied in detail. When we analyzed the curriculums of both specializations, we found that agricultural engineering and agronomy share many common subjects (e.g., agricultural engineers study the principles of crop growth, and agronomists learn the principles of agricultural machinery and mechanization). However, only the agronomy curriculums, mostly at the Master's level, have subjects related to greenhouse production. Producers have reported that almost every educated person employed recently lacks the practical knowledge to work to the required standard immediately after taking a position (Semykin, 2018). As discussed above, the 4th and 5th generation greenhouses represented by foreign and domestic modern operating technologies require highly qualified personnel to manage sophisticated technological production lines. Thus, producers want well-qualified personnel with suitable job experience for particular positions. To overcome the disparity between the knowledge of new university graduates and that required for the actual job, producers provide new employees with substantial additional training or sometimes even full requalification (Gavrish and Korol, 2014).

According to the estimates of the director of the Scientific Research Institute of the Protected Ground Vegetable Growing, to maintain 2,130 ha of winter greenhouses in Russia in 2015, the industry needed 500–600 specialists (3–4 specialists per ha). Most of the agronomists with specializations in technology, agrochemistry, plant protection, and automation engineering are already working, so the majority of specialists in the industry need to undergo retraining. Several dozen new graduates each year should be educated according to updated educational standards. The creation of a national training center for industry specialists has been debated since 2013. While the question of the financial burden remains open, a smaller training center is already operating at the Belgorod greenhouse complex (Gavrish and Korol, 2014; Semykin, 2018).

4.3.2.2 New educational standard

Meanwhile, Ph.D. (35.06.01), Master's (35.04.05), and Bachelor's (35.03.05) educational programs with the specialization "Horticulture" were approved by orders №1017, №1049, and №1165 of the Ministry of Science and Higher Education of the Russian Federation on 18 August 2014, 23 September 2015, and 20 October 2015, respectively. Bachelor's degree programs were launched at 17 agricultural universities on Sept. 1st, 2016. I summarized in at the (Appendix II Table 2) part data, on agricultural universities with educational programs for the greenhouse industry.

Since portions of the new curriculums directly relate to greenhouse production, Master's and Bachelor's students in horticulture programs will graduate as specialists for this industry. For instance, a major in the Bachelor of Horticulture (35.03.05) includes papers on fruit growing, viticulture and winemaking, vegetable growing, the production and processing of medicinal crops and essential oil raw materials, ornamental gardening and floristics, selection, genetics, and biotechnology of garden crops, and greenhouse gardening. The Master's program (35.04.05) includes courses on the development of production lines, and implementation of the cultivation of vegetables, fruits, medicinal crops, and grapes using modern, environmentally safe, intensive, resource-saving technologies that are adapted to certain technological and soil-climatic conditions.

The Ph.D. programs will prepare scientists and experts with the highest level of knowledge in those areas. To ensure a certain number of future graduates, the Russian State Agrarian University - Moscow Timiryazev Agricultural Academy provides 20 state-funded places for greenhouse-related specializations annually (Agrovuz, 2019).

The first Bachelor of Horticulture students are expected to graduate in 2020. Some of those students will continue to the Master's program (2 more years). Thus, the lack of qualified personnel in the greenhouse industry is expected to ease only by 2020, and by 2022 the industry will have more highly educated specialists.

4.3.2.3 Concept to solve a current lack of qualified personnel

According to our collected data and observations, we have illustrated the concept to solve the current issue of a lack of qualified personnel in the greenhouse industry. The fundamental principle is given in Fig. 18.

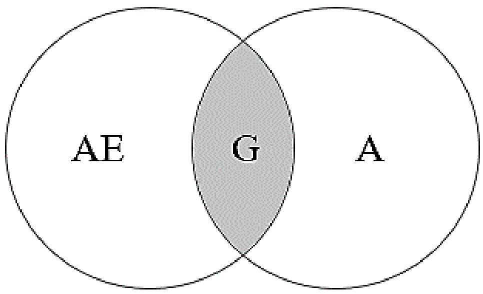


Figure 18. Concept to supply qualified personnel for the Russian greenhouse industry: AE – Agricultural Engineer; G – Greenhouse specialist; A – Agronomist.

As noted above, the first qualified personnel for the greenhouse industry will graduate by 2020–2022, and there are common subjects in the curriculums of agricultural engineers and agronomists who graduated before 2016. Only agronomy majors have studied subjects related to the greenhouse production industry. Fig. 18 illustrates that greenhouse specialists represent the crossover between agronomists and agricultural engineers. This figure highlights that all specialists with agricultural education and basic knowledge (e.g., agricultural engineers and agronomists) are able to requalify for greenhouse production in a short time. The G section represents specialists for the greenhouse industry. Producers should employ qualified personnel from those two main agricultural areas (AE and A) and supply further training to address current lack of qualified personnel.

Although higher educational institutions are expected to develop new educational programs and majors for the greenhouse industry, they should not act only as a provider of workers for the economy. Universities are expected to serve as innovation centers, ensuring interconnections among science, education, business, and the state, which is necessary for the development of the industry (Volkov *et al.,* 2017).

4.4 Conclusion

Currently, the situation of the greenhouse production industry in Russia is complex and contradictory. On the one hand, substantial state support means that the greenhouse industry is a substantial contributor to the Russian economy that has reached a new stage of development. Modern greenhouse complexes are made up of innovative 4^{th} and 5^{th} generation greenhouses. On the other hand, several problems remain unresolved. Modern greenhouse technologies are changing and developing every 2–4 years, and the industry lacks highly qualified personnel. The issue of a shortage of qualified personnel is being addressed by employing the specialists from closely related spheres, such as agricultural engineering and agronomy, followed by further education and requalification. In accordance with the new state educational strategy and the demands of the greenhouse industry, an updated educational standard was developed in 2015, with relevant programs starting at universities in 2016. Therefore, new graduates that are qualified for the greenhouse industry will be available from 2020–2022 onwards.

The State Program for the Development of the Agro-Industrial Complex is projected to enable Russian greenhouse producers to fully satisfy the domestic demand for fresh vegetables by the end of 2020. This plan assumes that there will be further intensive development of the industry. To cope with the industry's needs and state strategies, all stakeholders in the industry, educational/scientific institutions, and the government should cooperate in the development of new educational programs and qualifications.

At present, there is a lack of statistical data and in-depth studies reflecting the actual situation with abandoned and newly constructed greenhouses, and there are rapidly evolving trends in education and retraining for the greenhouse industry. Given these uncertainties, it is important to conduct further research to fully understand the current state and the future directions of the greenhouse industry in Russia

Chapter 5. General conclusions

This research aimed to identify and outline the historical transition of technology from the USSR to modern Russia, investigate present problems and issues which influence on greenhouse industry development. To clarify the characteristics of the agricultural education system focused on higher education for the Russian greenhouse industry, in addition, find a solution to solve a current lack of qualified professional.

By analyzing all the findings of this study, this Ph.D. research can be concluded as follows: In the USSR period government undertook unprecedented steps to boost industrial development. Thus, the state made a significant effort to eliminate illiteracy and create secondary and higher education institutions, in order to provide qualified professional. Educational establishments were equipped with necessary laboratory equipment, of academic and scientific literature. In the post-Soviet period, the quality of education decreased slightly, as a result of the restrained political situation and socio-economic challenges. At the beginning of 2003, when Russia became a member of the Bologna Process, the Russian government has revised the classification of areas and specialties of higher professional education to meet European education standards. New generation programs of educational standards were created, however, during that time was formed a lack of qualified professional.

Greenhouse industry reached its highest level during the Soviet period using technological methods that increased the volume of production by several times. A considerable contribution to the development of the greenhouse production was made by cultivation methods, such as electric soil heating, use of geothermal water, additional artificial lighting and the hydroponic growing system. However, current technological type of greenhouses utilized in Russia shows the gradual growth of vegetable production year by year. In addition, vegetable production in greenhouses has almost doubled since 2014 and the rates continue to increase.

Currently, the greenhouse industry demonstrates a contradictory situation. By using the momentum of substantial state support, it turned out to a prospective sphere of the Russian economy which has reached a new stage of development. However, several problems remain unsolved. Modern greenhouse technologies are changing and developing every 2-4 years and the industry badly lacks highly qualified personnel. Prevalent shortage in qualified personnel for the industry shortage is being solved by employing the specialists from closely related spheres, such as agricultural engineering and agronomy, with following continuing education and requalification. Answering the new state educational strategy and the greenhouse industry demands, in 2015 the updated educational standard was developed; in 2016, relevant programs were started at the universities. Thus, the lack of qualified personnel in the greenhouse industry is expected to ease only by 2020, and by 2022 the industry will receive even deeper educated specialists. Further additional observation of educational programs is needed to prove their positive influence on the greenhouse industry development.

Dedication

This thesis is dedicated to my wife.

For her endless love, support and encouragement

My wife, Alima Dorzhieva has been a source of positive emotions, motivation, and strength during moments of despair and discouragement. Her wifely care and support have been shown always in incredible ways. She dearly supported me over the years for my education and intellectual development.

Acknowledgements

I would like to express my gratitude to several people and institutions:

First, I express my heartiest gratitude to my supervisor of my Ph.D. thesis Associate Professor Hideo Hasegawa, for his useful advice and comments that he has provided throughout my Ph.D. study. I also would like to gratefully thank my committee members: Prof. Hideo Miguchi and Prof. Makoto Nakata. I extend thanks to Professor Konstantin Luzbaev, from Buryat State Academy of Agriculture named after Filippov V.R, which provided me needed material for conducting this Ph.D. project. I also thank my all coauthors Assistant Professors Anna Lyude and Elizaveta Kolesnikova, Mr. Iaroslav Patuk and Mrs. Alima Dorzhieva for their important contributions in this Ph.D. project.

Also, I gratitude to Associate Prof. Andrew Whitaker, Mr. Boris Boiarskii for their excellent practical help.

I am grateful to The Ministry of Education, Culture, Sports, Science, and Technology of Japan (MEXT) for the financial support and opportunity to be a student of the Higher Agricultural Specialist Program for the Russian Federation the Far East.

References

Abakumova N.A. 2007. The main directions of the transformation of the content of the training of specialists for agriculture in the 21st. Bulletin of Kostroma State University. 13 (1), 12-16. [in Russian]

Agricultural platform "Agroinvestor". Available at: www.argoinvestor.ru, accessed 16 March 2019.

Agroarchive. 2016. Available at: http://agro-archive.ru/, accessed 24 July 2017.

Agrovuz. 2019. Available at: www.agrovuz.ru, accessed on 23 April 2019.

Alecon. 2016. Available at: http://alecon.co.il/article/greenhouse-russia/, accessed 20 July 2017.

Aleksashkina O.V. 2016. The prospects of greenhouse business development in Russia. Bulletin " Rural development and social policy". 4 (12), 54-57 [in Russian]

Aliev E.A. 1985. Cultivation of vegetables in hydroponic greenhouses. Kiev. Harvest. 2, 160 p.

Altbach P.G., Salmi J. 2011. The Road to Academic Excellence. The Making of World Class Research Universities. The World Bank. 394 p.

Andreev Y.M. 1975. Influence of the light mode on the formation of elevated and root system of a greenhouse cucumber. Abstract of the thesis. Moscow. 17 p. [in Russian]

Andreev Y.M. 2003. Vegetable growing. Academy. 256 p. [in Russian]

Association "Greenhouses of Russia" 2018. Available at: http://rusteplica.ru, accessed 15 April 2019.

Bakuras N.C. 1989. The cultivation of seedlings and vegetables in greenhouses. Tashkent. 144 p.

Balkhaeva I.K. 2011.The training for agriculture in the Buryat-Mongolian autonomous Soviet Socialist Republic 1920-1930. Bulletin of the Buryat State University. 7, 75-82. [in Russian]

Bryzgalov V.A. 1995. Vegetable growing of the protected soil. 2 edition with additions. Moscow. 78–84. [in Russian]

Bryzgalov V.A. 1995. Vegetable growing of the protected soil. Moscow. Kolos. 351 p. [in Russian]

Bryzgalov V.A., Sovetkina V.I. and Savinova E.N. 1983. Vegetable growing of the protected soil. Moscow. 45–48. [in Russian]

Bunin M.S., Mukhortov S.Y. and Rodionov V.K. 2008. Vegetable growing in the Central Black Earth of Russia. Voronezh State Agricultural University of K.D. Glinka. 312 p. [in Russian]

Chekmarev P.A. 2015. On the problems of horticulture in the Russian Federation. Bulletin "Development of vegetable growing in the Russian Federation". 275-285. [in Russian]

Chekmarev P.A. 2015. About problems of development of vegetable growing in the Russian Federation. 276–282. [in Russian]

Dedov N.I., Isutkina V.N. 2013. Prospects for the development of vocational training of engineers in modern conditions. News of Volgograd State Technical University. 10 (6), 42-44. [in Russian]

Detkov N.S. 2016. Potatoes and Vegetables. Available at: http://potatoveg.ru/, accessed 22 June 2017.

Dorzhiev M., Hasegawa H., Dorzhieva A., and Lyude A. 2018. Analysis of Technologies and Equipment in Greenhouses of the USSR. Proceedings of the 9th International

Symposium on Machinery and Mechatronics for Agriculture and Biosystems (ISMAB). 28-30 May 2018, Jeju, Korea.

Dyukarev I., Karavaeva E. 2013. Towards a comparability of programmer of higher education. Newsletter, Deusto University Press. 172 p.

Edelstein V. I. 1983. Vegetable of growing. 175 p. [in Russian].

Federal Service for State Statistics. 2019. Available at: http://www.gks.ru, accessed 26 April 2019.

Federal State Budget Educational Institution of Higher Education. 2016 "The Buryat State Agricultural Academy by name Filippov V.R." Calendar instructional graph on 2016-2017. Direction preparation of bachelors 35.03.06. [in Russian]

Federal State Statistics Service. 2008. Russia in figures. Moscow. Rosstat. 143 p. [in Russian]

Federal State Statistics Service. 2015. Russia in figures. Moscow. Rosstat. 248 p. [in Russian]

Gavrish S.F., Korol V.G. 2014. Personnel Training-is of Vital Importance. Scientific-informative journal for greenhouse industry "Gavrish". 1, 34-39. [in Russian]

Gil L.S., Pashkovsky A.I. and Sulima L.T. 2012. The modern vegetable growing of the protected and open ground. Zhytomyr. Rue. 468 p.

Gish R.A., Karpenko E.N. 2016. Modernization and improvement of microclimate parameters management-the basis of the 5-th generation greenhouses. Scientific Journal of KubSAU. 123,1-23.

Hoshimova S F. 2013. History of technical training for agriculture Tajik SSR. Scientific notes of Khujand State University, Academician B. Gafurov, Humanitarian sciences. 35 (2), 162-171.

Igumnov E. V. 2000. Formation of Buryatia scientific institutions and their activities in the field of historical science (19 th-20 st). Bulletin of the Buryat State University. 7, 22 p. [in Russian]

Investment portal of Kamchatka Krai. 2017. Available at: http://investkamchatka.ru/, accessed 24 July 2017.

Ivanishin A.I. 1960. Experience of electric heating of the protected soil. Messenger of Agricultural Science. 6, 17–19. [in Russian]

Ivanishin A.I. 1963. A nonisolated wire for heating of greenhouse. Potatoes and Vegetables. 2, 32–37. [in Russian]

Ivanishin A.I. 1964. "Vegetable Predbaikalie" Moscow. 18-19. [in Russian]

Leman V.M. 1952. Use of fluorescent lamps for cultivation of plants in greenhouses. Agricultural Academy by name Timiryazev K.A. 26–32. [in Russian]

Lhamazhapov A.S. 1974. The vegetable growing in the protected soil. Ulan-Ude. 31–33. [in Russian]

Litvinov S.S., Nurmetov R.J. and Devochkina N.L. 2011. Protected soil of Russia: condition, problems, introduction of new technologies. 2, 5-8. [in Russian]

Litvinov S.S and Shatilov M.V. 2015. The efficiency of vegetable growing of Russia (analysis, strategy, forecast). All-Russian Research Institute of vegetable growing. 6 (17), 140 p. [in Russian]

Mamedov M.I. 2014. Prospects of the protected ground in Russia. Scientific practical journal. Vegetables of Russia. 4 (25), 4-9. [in Russian]

Mamedov M.I. 2015. The structure and the total area under protected cultivation production in the world, and global greenhouse technology. Vegetables of Russia. 3 (28), 64-69. [in Russian]

Mamedov M.I. 2014. Prospects of the protected ground in Russia. Scientific practical journal. Vegetables of Russia. 4 (25), 4-9. [in Russian]

Markov V.M. 1974. Vegetable growing. Moscow. 129 p. [in Russian]

Ministry Agriculture of Russia. 2019. Available at: http://mcx.ru/ministry, accessed 25 April 2019.

Moiseychenko V.F., Zaveryukha A.H. and Trifonova M.F. 1994. Bases of scientific research vegetable growing. Moscow. Ear. 383 p. [in Russian].

Muravyev A.Yu. 2011. Protected soil of the Russian Federation: State, problems, prospects, ways and possibilities of financing. Greenhouses of Russia 1, 5-7. [in Russian]

Nehlanova A.M. 2006. Prospects for the development of agriculture of the Republic of Buryatia. Reading of name Nikonov. 11, 273-285. [in Russian]

Novikova V.M. 2012. Problems and prospects of higher education in Russia. Moscow State Institute of International Relations. 6, 282-285. [in Russian]

Nurmetov R.D. and Devochkina N.L. 2011. A condition of the protected soil of Russia and the current trends of its development. 55-57. [in Russian]

Ponomarev P.F. 1989. Progressive technologies of cultivation, storage, and realization of green vegetables. 152 p. [in Russian]

Popov G.F. 1986. Greenhouse facilities. Rosselkhoz Publishing House. [in Russian]

Prikupets L.B. 2012. 40 years to the hothouse lamp in Russia. Greenhouses of Russia. 4, 55-56. [in Russian]

Reimers F.E. 1955. Cultivation of vegetables in greenhouses of Eastern Siberia. Irkutsk book publishing house. 168 p. [in Russian]

Results of the All-Russia Agricultural Census 2016: In 8 volumes. 2018. Volume 2. The number of objects of All-Russia 2016 agricultural census. Labor resources and their characteristics.

The Federal State Service IIC "Statistics of Russia" Available at: http://www.vshp2016.ru, accessed 28 April 2019.

Ryzhkova S.M. 2015. Production and realization of vegetable production of the closed soil. Bulletin of the Belogorodsky University. 4, 392-401. [in Russian]

Semykin M. 2018. The main indicator of successful work is high yields in our greenhouses. Perfect Agriculture. Special Issue- Protected Soil of Russia, November, 26-31. [in Russian] Available at: http://www.perfectagro.ru/, accessed 19 April 2019.

Shefel S.D. 1971. Economic efficiency of vegetable growing of the protected soil and way of its increase in specialized state farms. Thesis 08.594. 3–18. [in Russian]

Shuin K.A. and Efimov M.V. 1960. Features of body height of vegetable plants in the conditions of Buryat the ASSR. Circulation. Buryat agricultural institute. 15, 47–54. [in Russian]

Sokolov I.S. 2015. Technologies of the 5th generation industrial greenhouses. Agricultural Business. Greenhouses of Russia. 1, 22-23. [in Russian]

State educational standard of higher professional education. 1995. State requirements for the minimum content and level of training of engineers in the specialty 311300 - Agricultural mechanization. [in Russian]

Tarakanov G.I., Borisov N.V. and Klimov V.V. 1982. Vegetable growing of the protected soil. Moscow. 303 p. [in Russian]

Tarakanov G.I., Mukhin V.D. and Shuin K.A. 2003. The current state of vegetable growing in the protected soil of Russia. Vegetable growing. 1, 6–9. [in Russian]

The Federal Service for State Statistics. 2016. Available at: http://www.gks.ru/, accessed 26 May 2017.

The Federal State Target Program of Education Development for 2016-2020 (approved by the RF government on May 23, 2015, № 497).

The Ministry of Higher Education of the USSR. 1995. The academic plan specialty "Mechanization of agricultural production" Qualifications – engineer. Institutes and faculties of agriculture mechanization. 31 p. [in Russian]

The Strategy for Agricultural Education in the Russian Federation up to 2030 (Project) Available at: http://www.ssaa.ru/svedeniya/document/, accessed 26 April 2019.

Toropilova E.N. 2013. Increase in economic efficiency of vegetable growing of the protected soil based on resource-saving technologies. Thesis. VAK 08.00.05. Saratov. 45–56. [in Russian]

Tulenkova A.G. 1980. How to grow up vegetables all the year round. Moscow. 3, 88 p. [in Russian]

Vinokourov M.A. 2012. Higher Education and Science in Russia: problems and prospects. Proceedings of the ISEA. 84 (4), 5-9. [in Russian]

Volkov S.N., Shirokorad I.I. and Pafnutova E.G. 2017. Main Lines of Strategy of Agricultural Education Development in the Russian Federation, International Agricultural Journal. 1-9. [in Russian]

Voronin V.V. 2012. Greenhouse facility in the system of agro-industrial complex in Russia. Problems of regional ecology. Moscow. 5, 79-84. [in Russian]

Voronin V.V. and Bazarumbetov S.Z. 2013. Problems of the territorial organization of greenhouse facility in the Russian Federation. Problems of regional ecology. Moscow. 6, 57-64. [in Russian]

Zaitseva L.A., Yakovlev A.L. 2012. The Formation and Development of the Higher Agricultural Education in the Eastern Siberia (1931-1980). Bulletin of the Buryat State University. 6, 70-73. [in Russian]

Zangeeva L.R. 2009. Filippov V.R. states man and scientist. Buryat State University. 7, 148-149. [in Russian]

Zangeeva L.R. 2012. The history of formation and development of agricultural science in the republic of Buryatia (1923-1991). Doctoral dissertation:07.00.02: defended 19.05.2011. Buryat State University Press. 7, 70-74. [in Russian]

Appendix I. Table 1. Analysis of curricula, educational programs, training of engineers for agriculture in 1955 and 2016.

Form	Subject	1955 year Agricultural mechanization Speciality (5 years)	2016 year Agroengineering Bachelor (4 years)	2016 year Agroengineering Master (2 years)
Disciplines	Natural science	6	8	-
	Humanitarian sciences	2	8	1
	Specialized subjects	19	45	18
	Social Sciences	3	3	1
	Total items	30	64	20
Control forms	Exam	99	79	20
	Course projects	9	6	4
	Test	-	13	6
	Total control	108	98	30
Type of lessons	Lectures	2340	1338	134
	Laboratory	920	1464	220
	Practical	1260	910	24
	Independent work	130	3150	1888
	Control	120	1026	110
	Total hours	4770	7888	2376
Practices	Training practice	4	4	-
	Industrial practice	28	16	36
	Total weeks	32	20	36
	Holidays (week)	33	17	17
	State final examination (week)		6	6

(Source: Comparative analysis of the curricula of August 10, 1955

and the curriculum 2016-2017).

Appendix II. Table 2. List of universities with educational programs for greenhouse industry.

№	Name of the University	Bachelor course	Master course	Ph.D. course	Location (City name)
1	Russian State Agrarian University - Moscow Timiryazev Agricultural Academy	35.03.05	35.04.05	35.06.01	Moscow
2	The Academy of Social Relations	35.03.05	-	35.06.01	Moscow
3	Saint-Petersburg State Agrarian University	35.03.05	35.04.05	35.06.01	Pushkin
4	Kazan State Agricultural University	35.03.05	35.04.09	35.06.01	Kazan
5	Ural State Forestry University	35.03.05	-	35.06.01	Yekaterinburg
6	Ural State Agrarian University	35.03.05	35.04.05	35.06.01	Yekaterinburg
7	South Ural State Agrarian University	35.03.05	35.04.05	35.06.01	Troitsk
8	Omsk State Agrarian University named after P.A. Stolypin	35.03.05	35.04.05	35.06.01	Omsk
9	Samara State Agricultural Academy	35.03.05	-	35.06.01	Ust-Kinelsky
10	Don State Agrarian University	35.03.05	35.04.05	35.06.01	Rostov
11	Kuban State Agrarian University	35.03.05	35.04.05	35.06.01	Krasnodar
12	Voronezh State Agrarian University named of Emperor Peter I	35.03.05	35.04.05	35.06.01	Voronezh
13	Volgograd State Agrarian University	35.03.05	35.04.05	-	Volgograd
14	State Agricultural University Northern Trans-Urals	35.03.05	35.04.05	35.06.01	Tyumen
15	Altai State Agricultural University	35.03.05	35.04.05	-	Barnaul
16	Dagestan State Agrarian University named after M.M. Dzhambulatova	35.03.05	35.04.05	35.06.01	Makhachkala
17	Smolensk State Agricultural Academy	35.03.05	35.04.05	35.06.01	Smolensk

Note: dash (-) shows that information was not found, Ph.D. course on agriculture; Master and Bachelor courses (majors of study) on Horticulture.

(Source: Agrovuz, 2019, based on websites of each university).

Appendix III.

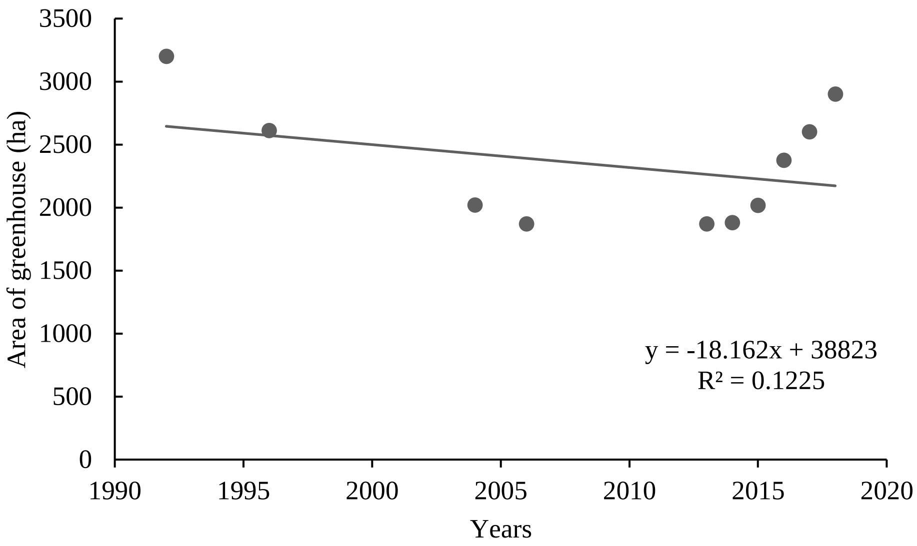


Figure 1. Relationship between area of greenhouse and greenhouse developing years

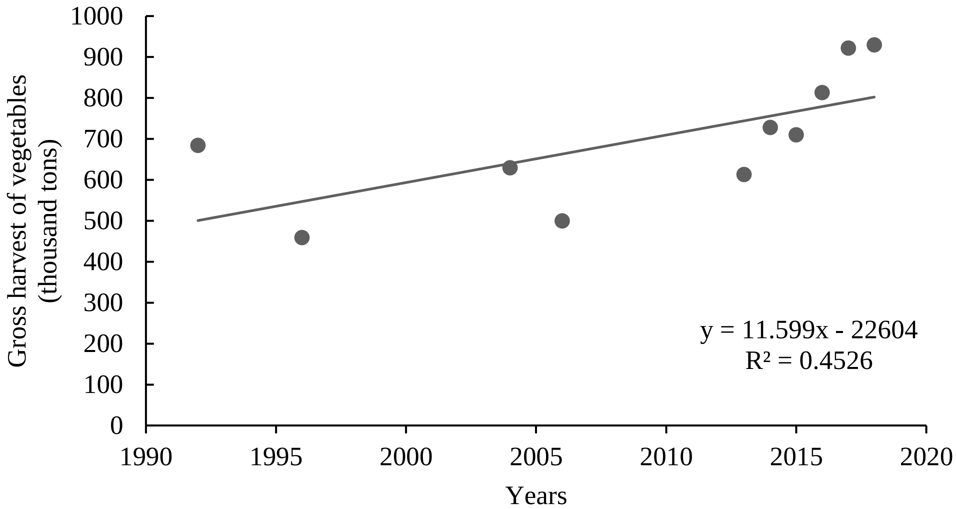


Figure 2. Relationship between gross vegetables harvest and greenhouse developing years.

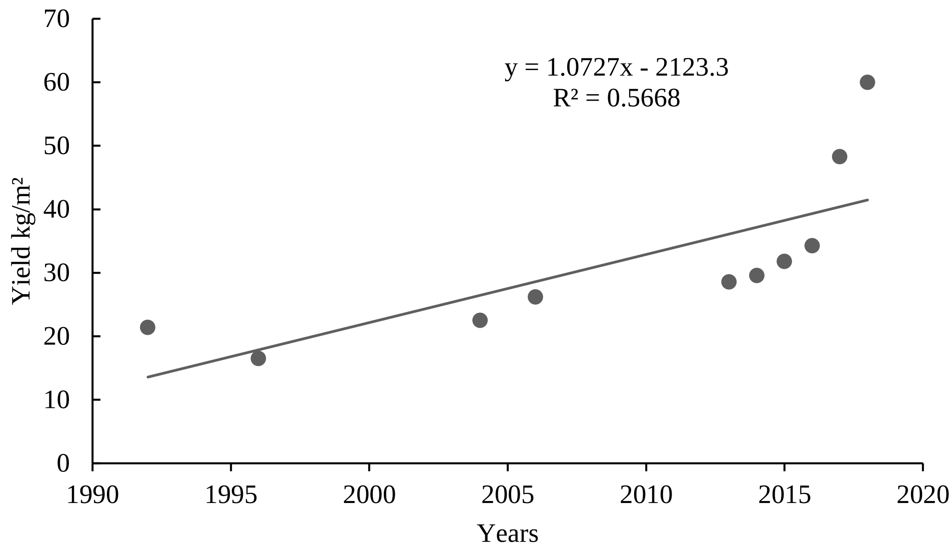


Figure 3. Relationship between yield of greenhouse production and greenhouse developing years.