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Investigations

Productivity of Lettuce Varieties in Conveyor Cultivation in the Open and Protected Soil of the Southeast of Kazakhstan

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Abstract: In the framework of diversification of vegetable production in Kazakhstan, special attention is paid to minor vegetable crops. Conveyor cultivation of green vegetables plays an important role in providing fresh vegetables to consumers year-round. In this regard, two types of lettuce have been studied: Leaf lettuce and heading lettuce. The studies were performed in 2014-2016 at the Kazakh Research Institute of Potato and Vegetables Growing and at the Kazakh National Agrarian University. It has been established that the conveyor cultivation of leaf and heading lettuce with the use of protected and open soil is an efficient method of uninterrupted supply of local green products to the population in the off-season period. In protected soil, lettuce should be cultivated in four periods with the use of rootstock, by sowing seeds from the first third of January until the second third of February. The age of rootstock is 23 to 26 days for leaf lettuce and 28-32 days for heading lettuce. For obtaining early lettuce in the open ground, it should be sown in four periods, starting from the first third of April until second third of May. During the first period, rootstock is to be used (18 days old) and in the other three periods, the method without rootstock is to be used. Varieties of Odessian Kucheryavets lettuce (leaf lettuce) and Krupnokochanny (heading lettuce) are recommended for vegetable farms.

Keywords: Leaf Lettuce, Heading Lettuce, Grade, Conveyor Cultivation, Time of Product Yield, Yield, Quality

Introduction

Lettuce is a precocious vegetable variety. Low content of fibers, high content of vitamins and mineral salts make salad an everyday food product for people in many countries of Europe, America and Asia. It contains a lot of ascorbic acid, thiamine, riboflavin, nicotinic acid, rutin and carotene. The laticifer of lettuce (lacticin) calms down the nervous system, improves sleeping (Markov, 1974; Lukyanets and Fedorenko, 2004). Three types of lettuce are known in the culture: Wood-lettuce, endive and leaved chicory (Ipatyev, 1966). They all belong to family Asteraseae (Compositea). Most widespread is *Lactuca sativa* L., which is represented by four species, which differ in their morphological characteristics: Asparagus lettuce (*L. Sativavar. angustana*), leaf lettuce (*L. Sativavar*. crispa), summer endive (*L. Sativavar*. longifolia) and heading lettuce (*L. Sativavar*. capitata) (Krug, 2000).

In Kazakhstan, leaf vegetables are mainly cultivated on private land, which does not meet the needs of the market. Therefore, they are mainly imported from distant countries (China) and from the CIS (Uzbekistan, Kyrgyzstan). In order to ensure uninterrupted year round supply of a wide range of high quality fresh vegetables to the population, cultivation of various species and varieties of vegetable crops is studied, including green crops, in the conditions of open and protected ground.

Today, when environmental load on the human body has sharply increased, healthy lifestyle and a balanced diet are becoming increasingly important. An important role is given to green and spicy crops, since even small amount of consumed green crops in the human diet has a positive effect. Lettuce promotes formation of

atherosclerotic substance - choline, stimulates excretion of cholesterol, thus preventing atherosclerosis. Systematic consumption of green vegetables contributes to preventing and treatment of many diseases. Scientists of the National Cancer Center of Japan have proven that regular consumption of fresh yellow-and-green vegetables (lettuce, parsley, mustard, dill, etc.) reduces the risk of cancer 2 times, even in case of regular smoking, drinking alcohol, highly caloric and fatty food (Gil *et al*., 2012). The main objective of vegetable production is continuous and sufficient supply of traditional vegetables, including green ones. It is the consumption of green crops that saves people from the "diseases of the civilization" caused by malnutrition (Girenko and Zvereva, 2007; Pivovarov, 2006).

Over the past 30 years, a considerable growth has been achieved in the diversity of green vegetables and their year-round production. The UK ranks first in the volume of green vegetables sales, followed by Italy, France, Spain, Germany, Holland and Portugal. In the world's vegetable growing, lettuce is the most widespread and popular green vegetable (Monaghan *et al*., 2008).

Lettuce is a depository of vitamins. It contains salts of potassium, calcium, iron, phosphorus, easily soluble carbohydrates and organic acids (oxalic, citric, nicotinic acids) and it is rich in manganese, cobalt, copper, iodine and zinc. Regular consumption of lettuce prevents hypertension, obesity and intestines weakness. Fresh juice helps for chronic gastritis (Tropina, 1978; Pantielev, 1978; Dotsenko, 1988).

The Americans eat 30 pounds of lettuce a year per capita, which is five times more than a hundred years ago (Bunning and Kendall, 2012). Leaves of lettuce are an excellent source of vitamins A and K and feature high content of vitamin C, vitamins of group B_1, B_2, B_6, PP, E, C, mineral salts of potassium, calcium, magnesium, iron, phosphorus and other phyto-nutrients (Ovoschniekultury, 1988). It is believed that dark-green and red leaves of some lettuce varieties provide more nutrition than other green vegetables (Belik, 1991).

Lettuce features early ripeness, cold resistance and is of high dietary value. Lettuce may be grown both in a greenhouse and in the open field (Mathew and Karikari, 1990; Filho, 2009). Lettuce is one of the first vegetable crops in the open soil to provide commercial vitamin-containing products in the early spring. By using a set of varieties, sowing dates and methods of growing lettuce, one can ensure continuous supply of fresh green vegetables. In choosing the method of cultivation and sowing dates, not only the duration of the vegetative period of lettuce varieties and cultivars is considered, but the changes of the interphase periods as well, which depend on the temperature conditions during the growing period. Thus, in case of late sowing dates, the plant development accelerates. The period between the emergence and consumer ripeness in the open soil, depending on the cultivar and weather conditions, is 25-40 days for leaf lettuce, 50-80 days for heading lettuce and 75-90 days for summer endive. The leaf varieties of wood-lettuce are fast ripening, but less productive than the heading varieties (Belik *et al*., 1981).

Lettuce is of great value for humans. Literature data about the technology of cultivating lettuce distinguishe the main conditions for high productivity of this crop, both in the open soil and in protected ground. Each variety of lettuce differs from the others in many economic and biological characteristics, same as each area has different soil and climate conditions. The soil and climatic conditions play an important role in placement and specialization of vegetable production. Heading and foliar lettuce varieties are widely cultivated worldwide, especially in zones with temperate climate. In order to obtain high quality yields, one should isolate the best varieties for cultivation at various times of sowing in a given area.

According to the research of Yudaeva (1980), Komarova (1980) and Archakova (1978), in the conditions of the Moscow, the Leningrad and the Murmansk regions, respectively, in case of spring and summer crop, the early ripening varieties of lettuce quickly passed to shoots and did not form the yield. In these regions, late-ripening varieties are fit for cultivation, such as Krupnokochanny, Round Green, Odessian Kucheryavets, Great Lakes and other varieties. Consequently, the varietal composition of lettuce changes depending on the time of planting and the cultivation zones.

In the southern subtropical areas of the Soviet Union, the time of sowing, varietal composition and the methods of cultivating lettuce are very different from those in the temperate zones. According to the research of Alborishvili (1968), it has been established that in the conditions of Sukhumi (Abh. ASSR) the best time for cultivating lettuce in the autumn and winter is entire September and in the spring - early March. In case of sowing on the first of September, the yield can be obtained, as needed, from the beginning of November until May 15; in case of sowing in March - from May 15 until June 10.

N. A. Nikonova devoted her studies to selecting varieties of headed lettuce for various dates of cultivation in winter unit greenhouses in the Moscow region. She tested 50 varieties of lettuce in 28 sowing periods (16 – in the winter-and-spring and spring-and-summer periods and 12 - in autumn-and-winter periods) (Pantielev, 1991).

In the Moscow region, to obtain lettuce in the open ground from mid-May to late October, Rumyantseva V. I. recommends to combine crops of winter foliar variety Moscovsky Parnikovy with varieties of headed lettuce of the mid-ripening and late-ripening groups – Berlin Yellow and Green Round, cultivating them under cover made of film and without cover. The late-ripening

variety Odessian Kucheryavets is recommended for sowing on July 20, while the mid-ripening Berlin yellow – on August 1, to be grown in October under cover (Rumyanceva, 1976).

The great importance of choosing varieties for specific periods of cultivation in a specific area is noted. This allows organizing conveyor supply of lettuce products.

Research Methods

The research was performed in 2014-2016 at the greenhouse of the Kazakh Research Institute of Potato and Vegetable Growing (Kaz RIPVG) located in the foothill zone in the southeast of Kazakhstan at the altitude of 1,050 m above sea level, at the latitude of 43°15'24" North and the longitude of 76°55'42" East. Here experiments in conveyor lettuce cultivation in greenhouses were laid and completed.

Field experiments in the open soil were laid out at the training and production farm "Agrouniversity" of the Kazakh National Agrarian University (1,080 m above sea level).

The soil of the experimental plot is dark brown, has loamy mechanical composition and silty-lumpy structure. The arable layer contains 2.1 to 3.8% of humus, 0.12 to 0.16% of total nitrogen, 0.17 to 0.20% of total phosphorus and 3.75% of total potassium. The content in soil of mobile forms of the main macro-nutrition was the following: Hydrolyzable nitrogen – 80 mg/kg, mobile phosphorus – 26-35 mg/kg, exchange potassium – 600 mg/kg. The soil absorbing complex is saturated with cations of calcium and magnesium, the amount of absorbed bases is 15-18 mg-equivalents per 100 g of soil. The bulk density of soil is 1.0 to 1.2 g/cm^3.

The object of the study was lettuce. During the experiments, varieties of lettuce were cultivated that had been approved for use in the southeast of Kazakhstan (the Almaty region), as well as those introduced from Russia.

In the experiments for studying the conveyor supply of products, two cultivars of lettuce were used – leaf and heading: Cultivars Odessian Kucheryavets and Krupnokochanny (respectively).

The size of the experimental plot was 12 m^2 in protected ground (a greenhouse) and 16 m^2 – in the open field; the experiment was repeated 3 times.

The research was performed according to the conventional classic methods of Dospekhov (1985) and Belik (1972). Phenological observations were made from the moment of sowing until the end of fruiting, the time of beginning and end of phenological stages was recorded (the phase of emergence of individual and mass sprouts, the beginning of the grocery body formation and last lettuce harvesting). The biometric studies to determine the vigor of plant development were performed in the phase of forming grocery bodies. Plant height, diameter of leaf bud, the number and the area of the leaves were determined. Chemical analyses of lettuce were performed at the biochemical laboratory of KazRIPVG. The biochemical substances were determined in the phase of plant commodity ripeness. An average sample was taken for three plants in each variant. The content of ascorbic acid was measured according to the method of S.M. Prokoshev, that of titrated acidity and total sugars were measured according to micromodification of the method of Bertrand, nitrates content was measured potentiometrically with the use of electrodes (GNDVP, 1986).

The content of micro- and macroelements in the leaf and heading lettuce was measured at the Research Institute of Crop Farming and Vegetable Growing (Serbia, Novi sad) using a device TA Ekolab, TA-LAB.

To confirm veracity of the obtained data on leaf and heading lettuce, they were statistically processed (Dospekhov, 1985).

Based on the climatic conditions of the region and on the biological characteristics of lettuce, a combination of methods of growing with rootstock and without rootstock was used in the experiments, with regard to the optimum sowing time. In choosing the method of cultivation and sowing dates, not only the duration of the vegetative period of lettuce varieties is considered, but the changes of the interphase periods as well, which depend on the temperature conditions during the growing period.

The seeds were sown in the greenhouse and in the open soil were with the interval of 10 days: Heading lettuce – four times, leaf lettuce – four times. The seeding depth was 0.5 to 1 cm. The seeding rate in the method with rootstock was 0.1 to 0.2 kg/m^2. The optimum temperature in the greenhouse 2-3 days after emergence was +22°C, humidity was 90%. Further, the day temperature in the greenhouse was +18...+22°C, the night temperature was +16...+17°C, air humidity was 75-80%.

During January and February, when illumination was below 1,000 Lux, the lettuce seedlings were additionally lighted round the clock for 15 days, followed by 14-16 h a day during the daylight hours.

Lamps with high-pressure sodium arc bulbs DNaT-400 with the illumination of 10,000 Lux were used. The microclimate control system in the greenhouse includes the systems of heating, humidification, ventilation, CO_2 supply, which operate in the manual and automatic modes.

Results and Discussion

Soil and climatic conditions determine growth, development and yield formation of any crop. Each zone is characterized by its own soil and climatic conditions.

The duration of lettuce rootstock growing depends on the time of sowing, the season and the temperature profile. In the studies performed in 2015-2016, the age of

seedlings changed depending on the time. The last factor plays an important role in the winter months. In protected soil, when the seeds were sown on January 10, the age of leaf lettuce rootstock was 26 days, of heading lettuce – 32 days, when the seeds were sown on January 20, it was 25 and 30 days, when sown on January 30, it was 23 and 30 days, when sown on February 10, it was 23 and 28 days, respectively. During this period, the plant forms 4 to 7 true leaves (Table 1).

The use of uneven-aged rootstock is due to the need of forming the harvest of lettuce at various times to ensure conveyor supply of products to the consumers, as well as to reduce the cost of rootstock cultivation.

In the open soil, rootstock was prepared only for the first sowing of lettuce, during the subsequent periods, the seeds were sown directly into the soil, since the temperature conditions (heat profile) allowed growing lettuce without rootstock. Growing rootstock requires certain costs, while the costs of direct sowing into the soil are considerably lower.

Thus, for conveyor lettuce growing in greenhouses, it is necessary to start sowing in the first third of January and sow during four periods; the age of the rootstock is 23 to 26 days. Sowing seeds into the open ground should start in the first third of April and continue during the four periods until the second third of May; the rootstock is only sown during the first period (18 days old), while in the remaining three periods it may be cultivated without rootstock. For conveyor growing of heading lettuce in greenhouses, seeds for obtaining rootstock are sown in four periods: For the first time - in the first third of January and every 10 days afterwards; the age of the rootstock is 28-32 days, which is more than that of leaf lettuce. Sowing of heading lettuce seeds into the open ground should start in the first third of April and continue during the four periods until the second third of May; the rootstock is only sown during the first period (25 days old), while in the remaining three periods it may be cultivated without rootstock.

To determine the intensity of growth and development of leaf and heading lettuce plants, formation of their vegetative biomass and grocery bodies, biometric studies were conducted, the diameter of the leaf bud, plant height, height of the head and the total leaf area of the bud were measured (Table 2).

Biometric measurements were taken in the phase of commodity ripeness for 12 plants in each variant. Leafiness of the plants and leaf area is of great importance in lettuce yield formation. The largest total area of leaf buds was noted in the third and the fourth phases and was 3,224-3,738 cm^2.

The numerous experiments in various conditions show that there is not always direct relationship between increased duration of lighting and accelerated lettuce development. Both the conditions of the experiment and the assortment involved in the experiment are important (Sase *et al*., 1998). That is, in fairly good lighting conditions, formation of lettuce leaves improves.

For headed lettuce, the largest total area of leaf buds was noted in plants of the fourth sowing time – 3,738 cm^2. The smallest value was observed in the first period – 2,885 cm^2 (Fig. 1).

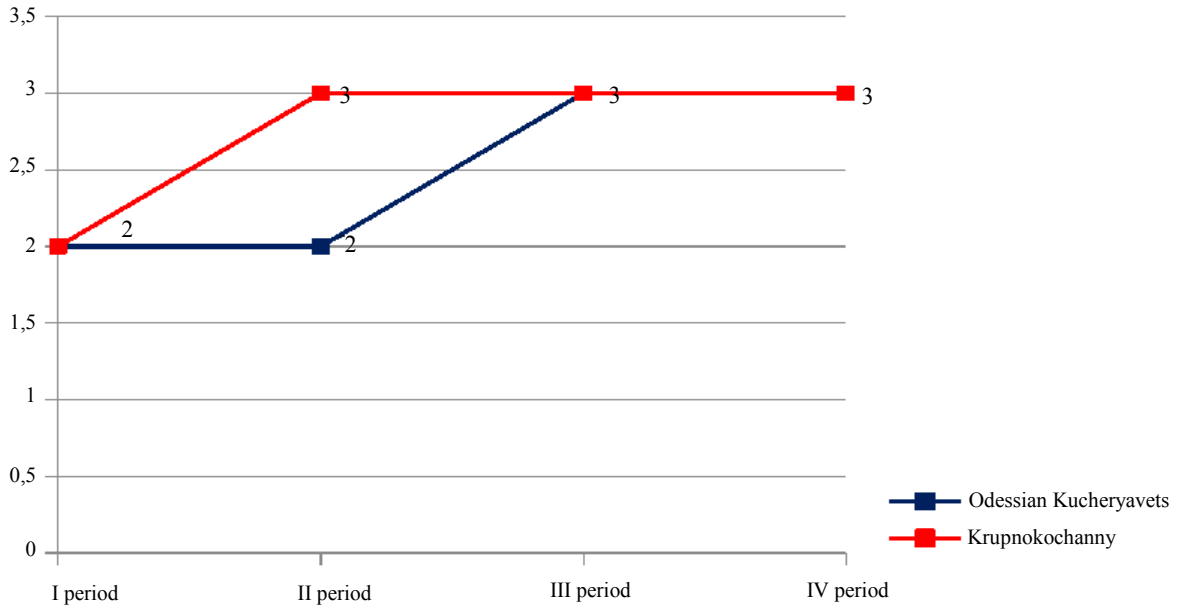

Fig. 1: The total area of leaves in the bud (cm^2) in varieties of Odessian Kucheryavets and Krupnokochannaya in a winter greenhouse

Table 1: The dates of sowing and age of lettuce rootstock in protected and in the open soil (2015-2016)

Leaf lettuce			Heading lettuce		
Periods of sowing	Sowing date	Age of rootstock (days)	Periods of sowing	Sowing date	Age of rootstock (days)
Protected soil (greenhouse)					
I period	10.01	26	I period	10.01	32
II period	20.01	25	II period	20.01	30
III period	30.01	23	III period	30.01	30
IV period	10.02	23	IV period	10.02	28
S stand. dev		2.3			2.7
Open soil					
I period	04.04	18	I period	04.04	25
II period	23.04	-	II period	23.04	-
III period	04.05	-	III period	04.05	-
IV period	15.05	-	IV period	15.05	-

Table 2: Biometric indicators of commercial ripeness of leaf and heading lettuce in greenhouses (2015-2016)

Lettuce Sowing leaf in the Periods	The diameter of the leaf bud, cm	Plant height, cm	Leaf			Head		The total area of leaf in the bud, cm^2
			Length, cm	Width, cm	Quantity	Height, cm	Diameter, cm	
Odessian Kucheryavets leaf lettuce								
I period	25.9	22.0	15.4	28.6	17.0	-	-	2,326
II period	28.0	22.7	16.0	28.1	16.0	-	-	2,499
III period	29.1	23.8	16.9	30.4	20.5	-	-	3,224
IV period	30.1	24.6	18.6	30.2	22.0	-	-	3,530
Sx,%	0.13							0.04
LSD_{05}	0.04							2.19
S stand. Dev	2							1,151
Head lettuce, the Krupnokochanny cultivar								
I period	29.0	24.1	17.0	20.7	19.5	13.4	12.7	2,885
II period	30.6	23.9	19.6	20.2	22.5	14.4	13.6	3,264
III period	30.9	25.2	19.5	21.0	21.5	16.0	13.9	3,266
IV period	32.0	25.0	21.0	21.3	24.0	17.8	14.1	3,738
Sx,%	0.13							0.05
LSD_{05}	0.13							5.14
S stand. dev	1.3							832

For leaf lettuce (The Odessian Kucheryavets cultivar) grown in the greenhouse, the biometric indicators of plants differed by the time of cultivation. The habit of plants was less developed during the first and second periods of sowing. This was the result of lack of heat and light in the greenhouse during this period. At later sowing dates, better development of plants was observed.

Thus, the diameter of leaf bud was 29.1 to 30.1 cm compared to the same indicator in more early periods of sowing, which was 25.9 to 28.0 cm. The same tendency was observed in other biometric indicators. This is due to better thermal and light profiles during the periods of cultivation.

Lettuce is a long-day plant. For the formation of vegetative mass of both the leaf bud and the head and thickened stem, the conditions of short light day are favorable. With high light intensity, the rate of leaves formation increases and the leaves length to width ratio decreases (Bensink, 1971). With low light intensity, the leaves elongate, the stem of the lettuce plant elongates, thus severely reducing the yield (Bondarenko and Tikhomirova, 1980).

For heading lettuce (the Krupnokochanny cultivar), the biometric indicators of plants also markedly differed in the periods of cultivation. Thus, at later sowing dates, better development of plants was observed. Thus, the diameter of leave buds was 29.0 to 30.6 cm in earlier periods and 30.9 to 32.0 cm in the later periods, the diameter of the head had the tendency to increase from 12.7 cm in the first period to 14.1 cm in the fourth period.

As far as leaf lettuce (the Odessian Kucheryavets cultivar) is concerned, the biometric indicators of plants in the open ground differed markedly in the time of sowing. The tendency to increase the diameter of the leave bud of the heading lettuce depending on the sowing date was noted to be the same as for the leaf lettuce. In the first period, the diameter of the leaf bud (an important indicator for leaf lettuce) was 31.2 cm,

while in the fourth period it was 35.9 cm. In field experiments with heading lettuce (the Krupnokochanny cultivar), the biometric indicators of plants also differed markedly according to the periods of cultivation (Table 3).

In early periods of sowing, plant height was 23.2 to 23.6 cm, in later periods – 25.7 and 27.1 cm, leaf length ranged between 19.5 and 20.8 cm and between 21.6 and 23.2 inches, head diameter (the grocery body of head lettuce) was 13.1 to 13.3 cm and 14.0 to 15.3 cm. Analyzing the obtained data, we should note that the biometric indicators of lettuce plants were better in the open soil, higher to the greenhouse.

While in open ground, the total area of lettuce leaf buds was in the fourth sowing period – 7,015 cm^2, in the first and the second periods, the area of leaf buds was about the same and for headed lettuce, the largest leaf bud area was found in the first and fourth periods and was 7,373-7,404 cm^2 (Fig. 2).

In vegetable production in the protected and open soil, special attention is paid to productivity of crops. This is because every square meter of greenhouse area and each hectare of arable land is of great value and should generate considerable income. Therefore, scientific research (breeding, processing) should be aimed at increasing productivity of vegetable plants. Crop productivity is the main efficiency indicator of agricultural technologies. It is known that the yield of a vegetable crop is one of the main and most significant indicators. In this respect, in our research we determined productivity of lettuce in various periods of sowing in conveyor production. In the conditions of greenhouse, the yield of leaf lettuce was 1.78 to 2.07 kg/m^2 (17.8 to 20.7 t/ha); the lowest result was noted during the first period of cultivation and the highest - in the fourth period of cultivation. 7.77 to 8.32 t/ha of leaf lettuce were obtained in the open soil (Table 4).

In the greenhouse, 2.24 to 2.76 kg of lettuce heads were obtained from 1 m^2 (22.4 to 27.6 t/ha). In the field experiment, the yield of heading lettuce ranged between 13.25 and 14.95 t/ha. With that, the highest yield was generated during the fourth period of cultivation (Table 5).

Table 3: Biometric indicators of commercial ripeness of leaf and heading lettuce in the open soil (2015 - 2016)

			Leaf			Head		
Variants	Bud diameter, cm	Plant height, cm	Length, cm	Width, cm	Quantity	Height, cm	Diameter, cm	The total area of leaf in the bud, cm^2
Odessian Kucheryavets leaf lettuce								
I period	31.2	32.4	18.3	30.7	27	-	-	6,157
II period	32.8	31.2	19.1	32.8	26	-	-	6,030
III period	33.8	33.9	20.6	32.0	28	-	-	6,622
IV period	35.9	34.4	21.4	33.1	32	-	-	7,105
Sx,%	0.19							0.13
LSD_{05}	0.44							5.43
S stand. dev	2.7							1,045
Head lettuce, the Krupnokochanny cultivar								
I period	29.7	23.2	19.5	21.8	27.5	14.5	13.1	7,373
II period	31.8	23.6	20.8	21.9	27	14.7	13.3	6,808
III period	32.3	25.7	21.6	23.5	28.5	15.1	14.0	6,992
IV period	31.6	27.1	23.2	25.7	29	16.8	15.3	7,404
Sx,%	0.15							0.03
LSD_{05}	0.34							5.76
S stand. dev	2.2							509

Table 4: Productivity of leaf lettuce in protected and open soil (2015-2016)

Protected soil				Open soil			
Periods of Sowing	Plant weight, g	Productivity, kg/m^2	Harvesting date	Periods of sowing g	Plant weight, g	Yield, t/ha	Harvesting date
I period	54.00	1.78	27.02	I period	176.00	8.16	20.05
II period	58.00	1.90	6.03	II period	167.00	7.77	10.06
III period	61.00	2.00	14.03	III period	174.00	8.09	18.06
IV period	63.00	2.07	24.03	IV period	180.00	8.32	28.06
Sx,%	3.00	1.09 to 2.6		Sx,%	1.04	0.64	
LSD_{05}	6.17	0.05		LSD_{05}	5.12	0.17	
S stand.dev	2.80	0.5		S stand. Dev	6.90	1.20	

Table 5: Productivity of heading lettuce in protected and open soil (2015 - 2016)

Protected soil				Open soil			
Periods of sowing	Head weight, g	Productivity, kg/m^2	Harvesting data	Periods of sowing	Head weight, g	Yield, t/ha	Harvesting data
I period	204.00	2.24	21.03	I period	309.00	14.35	12.06
II period	223.00	2.45	28.03	II period	286.00	13.25	28.06
III period	222.00	2.44	5.04	III period	292.00	13.55	11.07
IV period	251.00	2.76	14.04	IV period	322.00	14.95	19.07
Sx,%	0.42	3.43		Sx,%	0.26	0.11	
LSD_{05}	3.07	0.27		LSD_{05}	3.81	0.05	
S stand. dev	16	0.60		S stand. dev	13.90	1.30	

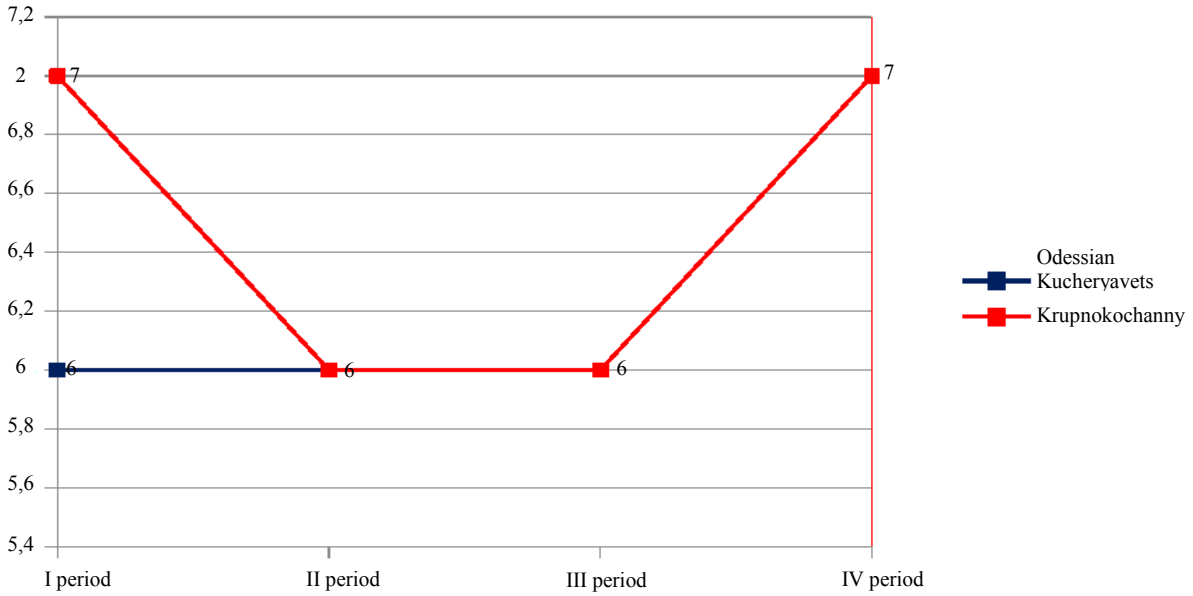

Fig. 2: The total area of leaves in the bud (cm^2) in varieties of Odessian Kucheryavets and Krupnokochannaya in the open soil

It should be noted that high levels of yield were obtained in all periods of cultivation. In vegetable production, product quality is important, since it is directly related to the health of the population. Vegetables, being a depository of vitamins, are a valuable part of the daily diet of humans. In this context, their quality and environmental safety require a special approach. Yields of vegetables should be clean, with high content of vitamins. This is especially true for lettuce, since lettuce products (leaves, heads) are used fresh. Given the importance of product quality, we performed biochemical analysis of lettuce harvest during the four periods of conveyor cultivation of the crop.

Lettuce has a high content of mineral salts. The lack of trace elements in food of women and children of the underschool age is mainly due to low consumption of micronutrients, especially iron and zinc (Bouis, 2003). Lettuce (*Lactuca sativa*) is the most commonly consumed vegetable lettuce in Colorado (Bunning *et al*., 2010); it is rich in microelements, including Fe and Zn (Pillay and Jonnalagadda., 2007). It is a valuable feature of lettuce, since lettuce is one of the main sources of micro- and macronutrients (Table 6). Therefore, the content of macro- and micronutrients in the product was determined.

Depending on the period of cultivation, leaf lettuce contained the following amount of elements (mg/kg): aluminum - 15.1 to 18.6; copper – 0.9 to 1.4; iron – 14.5 to 18.3; zinc – 7.1 to 8.1; manganese – 5.4 to 6.9; potassium – 1,789 to 2,110; calcium – 1,426 to 1,601; sodium – 1,459 to 1,734; magnesium – 479 to 531.

In headed lettuce, the number of macro- and microelements was higher (except sodium, ferrum (Fe), zincum (Zn)), compared to leaf lettuce. Depending on the periods of the conveyor cultivation production, the content of elements fluctuated within the following limits (mg/kg): Aluminum – 17.6 to 18.4; copper 1.5 to 2.0; iron – 17.2 to 20,0; zinc - 7.6 to 7.9; manganese – 6.3 to 7.9; potassium – 1,754 to 2,032; calcium – 1,639 to 1,816; sodium – 534 to 581; magnesium – 555 to 584.

Table 6: Content of macro- and micronutrients in leaf and headed lettuce cultivated in the open soil (2015-2016)

Periods of sowing	Al, mg/kg	Cu, mg/kg	Fe, mg/kg	Zn, mg/kg	Mn, mg/kg	K, mg/kg	Ca, mg/kg	Na, mg/kg	Mg, mg/kg
Leaf lettuce – the OdessianKucheryavets									
I period	15.7	1.2	18.3	7.1	5.4	1,789	1,426	1,709	531
II period	15.1	0.9	14.5	7.9	5.8	1,994	1,446	1,546	479
III period	17.9	1.4	18.0	7.9	5.0	2,110	1,560	1,459	488
IV period	18.6	1.4	17.9	8.1	6.9	1,948	1,601	1,734	495
Headed lettuce – Krupnokochanny									
I period	17.7	1.8	17.2	7.6	7.8	1,918	1,789	534	559
II period	17.6	1.5	19.4	7.6	7.7	1,754	1,639	544	555
III period	18.4	2.0	19.5	7.9	6.3	1,922	1,803	587	561
IV period	18.2	1.9	20.0	7.9	7.9	2,032	1,816	581	584

Mineral elements are not less important quality parameters of vegetables, including lettuce. The content of these elements in lettuce depends on the concentration of their mobile forms in soil, varieties and growing conditions. Depending on the climatic factors, concentration of mobile forms in soil and their uptake by plants changes.

Burdine (1975) noted that in the conditions of short day the potassium content was higher. Its content in leaves (4.4%) was lower than those in heads (7.7%) and roots (11.3%). In case of winter growing, lettuce plants are more demanding for potassium. The content of total nitrogen, phosphorus, potassium, calcium and magnesium increases at high temperature. In the conditions of long day, the content of total nitrogen, phosphorus and potassium decreases and the content of calcium and magnesium increases.

Burdine (1976) noted that increasing the dosages of phosphorus fertilizers increased the content of phosphorus and potassium in lettuce.

Lucas and Guzmann (1980) noted that with the introduction of high dosages of potash fertilizers, the uptake of magnesium by lettuce plants decreased.

Consequently, the roles of macro- and microelements are interdependent. However, it should be noted that while macroelements mostly affect the amount of the yield, microelements influence crop quality and plants resistance to adverse factors of the environment.

A higher content of boron, copper, zinc and iron is observed in the conditions of high-temperature and a short day. Copper, manganese, iron, boron, magnesium, nitrogen and phosphorus content in lettuce reduces and that of potassium increases during the second period of vegetation (Burdine, 1975).

To assess the relationship between the quality indicators and the periods of cultivation, the following indicators have been determined: Content of dry matter, sugars, vitamins and nitrates in the products. It has been established that the quality of leaf and heading lettuce in various harvesting periods in conveyor cultivation markedly varied. A considerable difference was also observed for types of lettuce. This should be considerable in lettuce cultivation in the protected and open soil in the southeast of Kazakhstan. In the experiments with lettuce, the biochemical analysis of the product showed the following results. In greenhouses, the content of dry matter in the leaves was 3.73% in the first period, 4.07% in the second period, 5.10% in the third period and 6.16% in the fourth period, the content of vitamin C was 3.35; 4.45; 6.15 and 6.79 mg/%, the total sugar content was 2.70; 2.35, 3.95 and 4.79%, respectively.

Acidity varied between 0.20 and 0.56%. The content of nitrates in the first period of cultivation was higher and amounted to 390-431 mg/kg; in the later periods it reduced to 300-315 mg/kg, which can be attributed to better illumination conditions.

In the experiments with headed lettuce performed in a greenhouse, the content of dry matter in heads was 3.52% during the first period, 4.65% during the second period, 5.79% during the third period and 6.71% during the fourth period; the content of vitamin C was 3.25; 5.35; 5.35 and 6.05 mg/%; the total sugar content was 2.90; 3.30; 3.70 and 4.85%, respectively (Table 7).

Acidity varied between 0.37 and 0.81%. The content of nitrates by the periods of sowing was 230, 393, 398 and 465 mg/kg, respectively.

In the open soil, the quality of lettuce was significantly higher than that in greenhouses. This is due to the natural conditions of lettuce plant growing and yield formation.

The harvest of leaf lettuce obtained in conveyor cultivation in the open soil contained 7.75 to 9.75% of dry substances, 11.90 to 15.47% of ascorbic acid (vitamin C) and 3.35 to 6.01% of total sugars. The harvest of heading lettuce contained 8.28 to 11.87% of dry substances, 12.68 to 14.61% of vitamin C and 4.67 to 6.79% of total sugars.

Depending on the cultivation period, the results of biochemical analysis were different. Thus, the content of dry matter for variety Odessian Kucheryavets in the greenhouse varied from 3.73 to 6.16% and in the open ground-from 7.5 to 9.75%; for variety Krupnokochannaya in the greenhouse varied from 3.52 to 671 mg%, in the open ground - from 9.08 to 11.87 mg%; the content of vitamin C for variety Odessian Kucheryavets in the greenhouse ranged from 3.35 to 6.79 mg% and in the open ground - from 11.9 to of 15.47 mg%; for variety Krupnokochannaya in the greenhouse varied from 3.25

to 6.05 mg%, in the open soil - from 12.68 to 14.61 mg%; total sugar content for variety Odessian Kucheryavets in the greenhouse was 2.7-4.97% and in the open soil - 3.35-6.01%; for variety Krupnokochannaya it was 2.90-4.85% in the greenhouse and 4.68-6.79% in the open soil. Analyzing these data, it should be noted that in case of growing during the fourth period, the indicators were higher both in the greenhouse and in the open soil.

Accumulation of nitrates in plants is a complex physiological process. The main reason for nitrates accumulation above the norm is intensive intake of mineral nitrogen in form of nitrates and its incomplete involvement in metabolism. Therefore, unused nitrates accumulate in the vegetative organs of the plant. The excess of nitrates in plants affects human health.

For the main products of plant origin, sanitary and hygiene standards have been established - the maximum permissible concentration (MPC) of nitrates that have been approved by the Ministry of Health of the USSR in 1988. MPC for the lettuce obtained in greenhouses is 3,000 mg/kg of wet weight.

In 1997, European standard for nitrates in lettuce plants has been approved. For summer cultivation, it is 3,500 mg per 1 kg of green mass and for winter growing, it is 4,500 mg per 1 kg of green mass (Amersfort, 1997).

The presence of nitrates in plants is a normal phenomenon. After all, nitrogen, along with phosphorus and potassium, is the basis of plant nutrition. The information about the effect of mineral nutrition on nitrates accumulation in lettuce plants is very controversial. Since lettuce has short vegetation season, the use of nitrogen fertilizers may result in accumulation of large quantities of nitrates.

The content of nitrates in products is an important environmental indicator of quality. When grown in the field, lettuce accumulated 529-739 mg of nitrate per 1 kg of wet weight, heading lettuce – 647-745 mg/kg, with the maximum allowable concentration for green vegetables (including lettuce) equal to 2,000 mg/kg (Table 7).

Table 7: Quality indicators of leaf and heading lettuce harvest (2015-2016)

Protected soil (greenhouse)					
Experiment variants	Dry matter, %	Vitamin C, mg%	Total sugars, %	Total acidity, %	Nitrates, mg/kg
Leaf lettuce – the Odessian Kucheryavets					
I period	3.730	3.350	2.70	0.44	390
II period	4.070	4.450	2.35	0.27	431
III period	5.100	6.150	3.95	0.20	315
IV period	6.160	6.790	4.79	0.56	300
Sx,%	0.660	0.260			
LSD_{05}	0.100	0.040			
S stand. dev	1.300	1.600			
Headed lettuce – Krupnokochanny					
I period	3.520	3.250	2.90	0.81	230
II period	4.650	5.350	3.30	0.37	393
III period	5.790	5.350	3.70	0.54	465
IV period	6.710	6.050	4.85	0.59	398
Sx,%	0.300	0.180			
LSD_{05}	0.050	0.030			
S stand. dev	1.400	1.400			
Open soil					
Leaf lettuce – the Odessian Kucheryavets					
I period	7.750	11.90	3.35	0.59	694
II period	8.180	13.60	4.43	0.57	529
III period	9.090	14.65	5.03	0.27	739
IV period	9.750	15.47	6.01	0.77	731
Sx,%	0.150	0.420			
LSD_{05}	0.040	0.190			
S stand. dev	1.100	1.800			
Headed lettuce – Krupnokochanny					
I period	9.080	12.68	4.68	0.39	689
II period	11.06	13.04	4.67	0.57	647
III period	8.280	13.25	5.09	0.48	724
IV period	11.87	14.61	6.79	0.67	745
Sx,%	0.130	0.130			
LSD_{05}	0.040	0.050			
S stand. dev	1.700	1.500			

Conclusion

Conveyor cultivation of foliar and headed lettuce in a combination of greenhouses and open soil is an efficient way for prolonging the period of uninterrupted supply of fresh local green products to population during the off-season.

As a result of the studies in the greenhouses of the Southeast of Kazakhstan, it is recommended to cultivate lettuce in 4 periods via seedlings, by sowing seeds from the 1st decade of January until the 2d week of February.

The age of seedlings should be 23 to 26 days for foliar and 28-32 days for headed lettuce.

In the soil-climatic conditions of open ground in the Almaty region, for obtaining early products, it is recommended to sow lettuce in 4 periods, starting from the 1st decade of April, until the 2d decade of May. However, foliar lettuce (18 days of age) and headed lettuce (the age of seedlings is 25 days) should be grown via seedlings only during the first period, in the remaining three periods, seeds are to be sown directly into soil (the method without seedlings).

During the cultivation of lettuce in various periods, the nitrates content in foliar lettuce in the greenhouse was 10.5 to 15 times lower than the maximum permissible value and in headed lettuce, this figure was 9.7 to 19.6 times lower.

During the cultivation of lettuce in the open soil in various periods, the nitrates content in foliar lettuce was 4.7 to 6.6 times lower than the maximum permissible value and in headed lettuce, this figure was 4.7 to 5.4 times lower.

Lettuce varieties Kucheryavets Odessa (foliar) and Krupnokochannaya (headed) are recommended for vegetable-growing farms where green crops are cultivated.

The practical significance of the paper lies in the fact that the research allows to organize cultivation in the greenhouse along with cultivation in the open soil, for ensuring conveyor cultivation of lettuce (January through July).

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Authors Contributions

All authors equally contributed in this work.

Ethics

This article is original and contains unpublished material. The corresponding author confirms that all of the other authors have read and approved the manuscript and there are no ethical issues involved.

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