

# **Management of Agrophysical Soil Properties, Plant Growth and the Formation of a Potato Yield with Early and Double-yielding Culture by Optimizing Row Spacing and Maintenance Measures in Southern UZBEKISTAN**

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## **ABSTRACT**

This article presents the results of effect of different row spacing and planting care methods on the water-physical properties of the soil, on plant growth and development, on the formation of aboveground and underground parts, and on potato productivity. It was revealed that when cultivating medium-early potato varieties in early and double-yielding crops in southern Uzbekistan, to obtain 25-30 t/ha and higher marketable yield, it is advisable to plant tubers according to a 90x15 cm scheme and to care for planting during the growing season, performing loosening and hilling once to a depth of 18 cm and 2 times at 23 cm with a protective zone of 8-10 cm with an “Amak” milling cultivator or a “KRN-2.8A” cultivator with additional devices installed.

## **Keywords**

Mid-early varieties, spring (early) and double-yielding crops, row spacing, methods of care, volumetric mass (density) of soil, growth stimulants, cultivation, productivity.

## **Introduction**

Natural and climatic conditions of the southern regions of Uzbekistan, including the Surkhandarya region, favour the production of early potatoes. Important cultivation considerations include the correct selection of highly productive and adapted varieties, the organization of local primary and elite seed production and the improvement of existing agricultural technology.

Scientific research on the cultivation of potato varieties with different row spacing and care measures has been carried out by scientists from countries with developed potato production, such as R. Peters in the USA [2012], A. Specher, B. Scholz in Germany [1991], W. Zerulla [1992], P. Schukmani [1998] in Holland, J. – M. Lee, G. – W. Choi, J. Janick in Korea [2008], I. N. Romanova, S. E. Terenteva, M. I. Perepichai, K. V. Martynova in Russia [2019], and N. V. Kononuchenko in Belarus [2009]; these research results are published in scientific publications.

The influence on the yield of commercial tubers with various care measures and row spacing widths was studied by D.T.Abdukarimov, T.E.Ostonakulov et al [1998], T.E.Ostonakulov [1991; 2013; 2017;2018; 2020], T.E.Ostonakulov, A.Kh.Khamzaev [2008; 2015], A.Kh.Khamzaev [2016], A.Kh.Khamzaev, T.E. Ostonakulov [2013], C .X. Ishimov [2012].

In these regions, to obtain high-quality early and seed potato crops in an early and double-yielding crop, it is necessary to optimize a system of care measures aimed at maintaining plantings that are free of weeds, soil in a loose state (cultivating rows, cultivating, hoeing, hilling, etc.).

However, insufficient studies have been carried out on this system of agrotechnical measures for the cultivation of potatoes as an early and double-yielding crop with different row spacing and care measures in the context of varieties while taking into account existing and modern technology.

The aim of the present study is to develop a system of measures to ensure a high-yielding, high-quality and inexpensive crop by studying the influence on the growth, plant development, and physical and water properties of the soil when growing medium-early potato varieties as an early and double-yielding crop with different row spacing and care measures.

## **Materials andMethods**

Field experiments were carried out in 2015-2018 in irrigated light grey-earth soils of the “ShodibekSunnatbekSurkhan” farm in the Angor district of the Surkhandarya region.

According to the mechanical composition of the soil, it is mainly homogeneous, heavy and medium loamy; the groundwater is non-saline and is at a depth of 8-10 metres.

For agrochemical soil analysis, samples were taken from arable (0-30 cm) and subsurface (31-50 cm) horizons. For these arable and subsurface horizon samples, it was established that the humus content was 1.08-0.73; the total nitrogen content was 0.11 and 0.07, respectively; the phosphorus content was 0.20 and 0.13; the potassium content was 2.04 and 1.65%; the mobile phosphorus content was 18.6 and 14.1; and the exchangeable potassium content was 203 and 176 mg/kg. The soil solution was neutral or slightly alkaline, with pH=7.1-7.2.

The climate of the region is sharply continental, very hot and dry, characterized by a sharp change in temperature during the seasons, as well as throughout the day. The winter is quite mild and warm. The average air temperature in January ranges from +3 °C to +7 °C, and in July, it changes to 39-41 °C, and sometimes it rises to 48 °C.

According to long-term data, the average annual rainfall is 47.3 mm. Most of the rainfall occurs in autumn, winter and spring and is barely observed in summer. During the research period, the annual rainfall was 173.0–204.9 mm, that is, 25.7–57.6 mm more than the long-term average.

The object of research was the widespread medium-early potato varieties Sante (Netherlands) and Yaroqli-2010 (our selection), with a row spacing of 70 cm according to the scheme 70x20 cm and 90 cm according to the scheme 90x15 cm, and 3 options for planting care were studied: Option 1 – loosening and hilling 1 time at a depth of 16 cm and 2 times at a depth of 18 cm in the protective zone of 8-10 cm using a “KRN-2.8A” cultivator (control); Option 2 – loosening and hilling 1 time at a depth of 18 cm and 2 times at a depth of 23 cm in a protective zone of 8-10 cm

using an “Amak” milling cultivator; and Option 3 – loosening and hilling 1 time at a depth of 18 cm and 2 times at a depth of 23 cm in a protective zone of 8-10 cm using a cultivator KRN-2.8A with additional devices.

With early culture, the tubers were planted in the spring, February 9–10, and with double-yielding crops, freshly harvested tubers were manually planted in the summer, July 22–25. The plot area for cultivation is 504 m<sup>2</sup> (with a planting scheme of 70x20 cm) and 648 m<sup>2</sup> (with a scheme of 90x15 cm) and for varieties is 252-324 m<sup>2</sup>. The experiments are performed in quadruplicate.

With early culture, whole and cut seed tubers of Sante and Yaroqli 2010 potato varieties weighing 30-80 grams were germinated for 18-20 days before planting in 2-3 layers in bright rooms at a temperature of 12-15 °C.

In a double-yielding crop culture, in summer, freshly harvested tubers were treated before planting in a growth stimulator working solution consisting of 100 kg of water, 1 kg of thiourea, 1 kg of potassium thiocyanate, 0.5 grams of gibberellin, 2.0 grams of succinic acid and 5-10 litres of “Roslin” with exposure for 3-5 minutes.

Next, the seed tubers were maintained for 4-5 days in a moist (65-70%) dark room for germination. Then, before planting, seed tubers were stored for 2-3 days in bright rooms until the sprouts were green. Subsequently, the prepared seed potatoes were planted in the field.

Field experiments, planting, planting care, harvesting and recording of crops, observations, counts and analyses were carried out in accordance with generally accepted methods and recommendations [1967; 2018].

Statistical analysis of the results of field experiments was performed using the Microsoft Excel program and SPSS (Statistical Package for the Social Sciences) according to B.A. Dospekhov [1985].

## **Results and discussion**

It was established that when growing potatoes as an early and double-yielding crop according to the 90x15 cm planting scheme and applying care measures—loosening and cutting furrows using the “Amak” milling cultivator or “KRH-2.8A” cultivator with an additional device installed, with the first to a depth 18 cm and the second to 23 cm, leaving a protective zone of 8-10 cm, compared with the 70x20 cm planting scheme—it is possible to improve the physical properties of the soil, that is, volumetric mass and creep of soil. The “Amak” milling cultivator or “KRN-2.8A” cultivator with an additional device installed was used for loosening the soil and cutting furrows with different row spacings; when growing early and double-yielding crops, a decrease in soil bulk mass of 0.02-0.03 g/cm<sup>2</sup> was achieved, and the duty cycle increased by 0.4-0.7% compared with the control option (Table 1).

The dynamics of changes in soil temperature in the potato variety plots by years and decades in the arable horizon of 0-20 cm in May-June were revealed during the cultivation of an early crop of medium-early potato varieties with different row spacing and care measures. In May, the soil temperature for horizons of 0-10 and 10-20 cm ranged on average 21.8-24.2 and 21.9-23.1 °C, respectively; that is, an increase in temperature by an average of 2.6 and 2.4 °C was observed

over the horizons. These indicators for horizons of 0-10 and 10-20 cm in June averaged 26.4-27.9 and 26.9-27.50 °C, respectively; that is, a gradual increase in temperature of 1.5 and 1.40 °C was observed.

When growing potato varieties as a double-yielding crop with different row spacing (planting according to the schemes 70x20 and 90x15 cm) and applying care measures, the soil temperature at horizons 0-10 and 10-20 cm for years and decades in July-October varied on average as follows: in July, from 26.5-24.5 and 26.2-23.5, respectively; in August, from 24.6-23.9 and 23.4-23.3; in September, from 22.7-20.6 and 22.0-20.1; and in October, from 19.8-17.9 and 19.3-17.5 °C; or by months, the average decrease in soil temperature over the horizons was observed to be from 2.0-2.7 and 1.9-2.1 °C.

When planting potatoes according to the schemes 70x20 and 90x15 cm, it was noted that the soil moisture levels of the upper horizon (0-10 cm) and lower horizon (10-20 cm) were 0.2-0.5 and 0.2-0.3% higher when seedlings appeared, respectively, 0.1-0.5 and 0.4-1.1% higher with flowering, and 0.5-0.6 and 0.1-0.4% higher with yellowing tops than those of the control. These values were obtained when applying the following care measures: loosening and cutting furrows using the “Amak” milling cultivator or “KRN-2.8A” cultivator with an additional device installed, with the first to a depth of 18 cm and the second to a depth of 23 cm with a protective zone of 8-10 cm.

The research results showed that various care measures and row spacings have a significant impact on the growth and development of potato varieties, increasing the length of the vegetation period by 2-4 days at the beginning of plant vegetation, with the formation of tall, powerful, multi-stemmed and leafy potato bushes; the furrows were loosened and cut using the “Amak” milling cultivator or “KRN-2.8A” cultivator with an additional device installed, with the first to a depth of 18 cm the second to a depth of 23 cm, leaving a 8-10 cm protective zone. With an early culture and planting scheme of 70x20 cm for the potato varieties, the assimilation surface area of leaves per hectare was 46.9-53.3 thousand m<sup>2</sup>, which is 4.3 thousand m<sup>2</sup> more than that of the control. When planted according to the 90x15 cm scheme, the value range was 54.2-57.8 thousand m<sup>2</sup>, or 3.6-4.4 thousand m<sup>2</sup> more than that of the control. When cultivating potato varieties in a double-yielding culture and planting according to a 70x20 cm scheme, the assimilation surface area of leaves per hectare was 41.1-49.0 thousand m<sup>2</sup>, which is 7.0-6.4 thousand m<sup>2</sup> more than that of the control

**Table 1**  
**Change in soil bulk mass during the cultivation of potato varieties in an early double-yielding crop depending on the row spacing and care measures (2015-2017)**

№	Name of tool, number and depth of planting care measures	In early culture	In double-yielding culture
		Volumetric mass of soil in a 0-20 cm layer in different phases of development	

		before planting	budding flowering	yellowi ng tops	before plantin g	buddin g floweri ng	yellowin g tops
<b>In the medium-early variety Sante with a planting scheme of 70x20 cm</b>							
1	Loosening and hilling 1 time at a depth of 16 cm and 2 times at 18 cm in the protective zone of 8-10 cm using a “KRN-2.8 A” cultivator (control)	1,35	1,32	1,34	1,36	1,34	1,35
2	Loosening and hilling 1 time at a depth of 18 cm and 2 times at 23 cm in a protective zone of 8-10 cm using the "Amak" milling cultivator	1,32	1,31	1,31	1,33	1,31	1,32
3	Loosening and hilling 1 time at a depth of 18 cm and 2 times at 23 cm in a protective zone of 8-10 cm using the cultivator KRN-2.8 A with additional devices	1,32	1,31	1,31	1,33	1,31	1,32
<b>In the medium-early variety Yaroqli-2010 with a planting scheme of 70x20 cm</b>							
4	Loosening and hilling 1 time at a depth of 16 cm and 2 times and 18 cm in the protective zone of 8-10 cm using a “KRN-2.8 A” cultivator (control)	1,35	1,32	1,33	1,36	1,33	1,34
5	Loosening and hilling 1 time at a depth of 18 cm and 2 times and 23 cm in a protective zone of 8-10 cm using the "Amak" milling cultivator	1,32	1,30	1,31	1,33	1,31	1,32
6	Loosening and hilling 1 time at a depth of 18 cm and 2 times at 23 cm in a protective zone of 8-10 cm using the “KRN-2.8 A” cultivator with additional devices	1,32	1,30	1,31	1,33	1,31	1,32
<b>In the medium-early variety Sante with a planting scheme of 90x15 cm</b>							
7	Loosening and hilling 1 time at a depth of 16 cm and 2 times at 18 cm in the protective zone of 8-10 cm using a “KRN-2.8 A” cultivator (control)	1,33	1,30	1,31	1,34	1,32	1,33
8	Loosening and hilling 1 time at a depth of 18 cm and 2 times at 23 cm in a protective zone of 8-10 cm using the "Amak" milling cultivator	1,31	1,28	1,29	1,31	1,29	1,31
9	Loosening and hilling 1 time at a depth of 18	1,31	1,28	1,29	1,31	1,29	1,30

	cm and 2 times at 23 cm in a protective zone of 8-10 cm using the “KRN-2.8 A” cultivator with additional devices						
<b>In the middle early variety Yaroqli-2010 with a planting scheme of 90x15 cm</b>							
10	Loosening and hilling 1 time at a depth of 16 cm and 2 times at 18 cm in the protective zone of 8-10 cm using a “KRN-2.8 A” cultivator (control)	1,33	1,29	1,30	1,33	1,30	1,31
11	Loosening and hilling 1 time at a depth of 18 cm and 2 times at 23 cm in a protective zone of 8-10 cm using the "Amak" milling cultivator	1,30	1,28	1,28	1,30	1,29	1,29
12	Loosening and hilling 1 time at a depth of 18 cm and 2 times at 23 cm in a protective zone of 8-10 cm using the “KRN-2.8 A” cultivator with additional devices	1,31	1,27	1,28	1,30	1,28	1,29

variant when planting according to the 90x15 cm scheme. The value range was 43.9-51.5 thousand m<sup>2</sup>, or 4.4-4.7 thousand m<sup>2</sup> more than that of the control variant.

With an early and double-yielding culture, the crop formation and plant productivity differed for the potato varieties with various measures for care and row spacing. The highest plant productivity (619-660 g, 24-26 g more than that of the control) was obtained by planting according to the 90x15 cm scheme and applying care measures of loosening and cutting furrows using the “Amak” milling cultivator or “KRN-2.8A” cultivator with an additional device installed. For these options, when growing potato varieties, higher indices were obtained than those of the control. It was noted that the mass of tops from 1 bush was 416-463 g (3-15 g more than that of the control), the height of the plant was 92.1-105.4 cm (7.7-8.1 cm higher), the number of leaves was 112.9-120.0 pieces (13.6-6.6 pieces more), the number of tubers was 9.0-10.8 pieces (0.1-0.3 pieces more) and the average weight of one tuber was 57.9 -73.3 g (1.2-2.1 g more). When growing potatoes in a double-yielding crop, the highest productivity by variety (480-536 g, 28-42 g more than that of the control) was obtained by planting according to the 90x15 cm scheme and applying care measures of loosening and cutting furrows using the “Amak” milling cultivator or “KRN-2.8A” cultivator with additional devices installed.

The yield of potato varieties in early culture with different row spacing and care measures was 24.4-33.3 tons per hectare (Table 2). The highest yield per hectare by varieties was 29.8-33.3 tons, or 3.0-4.9 tons (11.2-17.3%) more than in the control version, which was obtained when planting according to the 90x15 cm scheme, loosening row-spacings and cutting furrows with the help of an “Amak” milling cultivator or a “KRN-2.8A” cultivator with an additional device installed. With an increase in the row spacing from 70 cm to 90 cm, an additional yield of 2.0-3.1 tons (7.0-10.3%) per hectare was obtained.

By applying different row spacings (70x20 and 90x15 cm planting schemes) and measures for caring for planting potatoes in a double-yielding crop, the yield of tested potato varieties was 20.8-29.1 tons per hectare, which is 2.8-6.2 tons more than that of the control options. The highest additional yield by variety (3.3-6.2 t/ha) was obtained when planting tubers according to the 90x15 cm scheme and applying care measures using the “Amak” milling cultivator or “KRN-2.8A” cultivator with an additional device installed.

When growing potato varieties in early culture, the highest marketable yield (28.7-32.7 t/ha), seed tuber crop (16.8-17.9 t/ha) and reproduction rate (4.7-5.0) were obtained during planting according to the 90x15 cm scheme and application of care measures: loosening and cutting furrows with the help of the “Amak” milling cultivator or the “KRN-2.8A” cultivator with an additional device installed. The same scheme was observed when growing potatoes in a double-yielding crop. At the same time, marketable yield per hectare amounted to 25.3-28.2 tons, and the seed tubers yielded 13.4-14.7 tons, with a breeding coefficient of 4.1-4.9.

**Table 2**  
**Productivity, marketable yield and seminal potatoes in early culture, depending on the width of the rowspacing and methods of care**

№	Tool name, number and depth of planting care measures (factor C)	productivity by years, t/ha			average productivity, t/ha	including marketable		seminal		Coe f. breeding
		2015	2016	2017		t/ha	%	t/ha	%	
	In the medium-early variety Sante (factor A) with a planting scheme of 70x20 cm (factor B)									
1	Loosening and hilling 1 time at a depth of 16 cm and 2 times at 18 cm in the protective zone of 8-10 cm using a “KRN-2.8 A” cultivator (control)	24,8	25,6	22,8	24,1	23,3	95,6	13,6	58,4	3,8
2	Loosening and hilling 1 time at a depth of 18 cm and 2 times at 23 cm in a protective zone of 8-10 cm using the "Amak" milling cultivator	28,1	30,5	27,2	28,6	27,6	96,4	16,6	60,1	4,6
3	Loosening and hilling 1 time at a depth of 18 cm and 2 times at 23 cm in a protective zone of 8-10 cm using the cultivator KRN-2.8 A with additional devices	28,0	29,1	26,3	27,8	26,7	96,2	16,0	60,0	4,4
	In the medium-early variety Yaroqli-2010 (factor A) with a planting scheme of 70x20 cm (factor B)									

4	Loosening and hilling 1 time at a depth of 16 cm and 2 times at 18 cm in the protective zone of 8-10 cm using a "KRN-2.8 A" cultivator (control)	26,5	25,0	26,8	26,1	25,3	97,1	13,9	55,0	3,9
5	Loosening and hilling 1 time at a depth of 18 cm and 2 times at 23 cm in a protective zone of 8-10 cm using the "Amak" milling cultivator	30,0	28,9	31,7	30,2	29,5	97,6	16,6	56,4	4,6
6	Loosening and hilling 1 time at a depth of 18 cm and 2 times at 23 cm in a protective zone of 8-10 cm using the cultivator KRN-2.8 A with additional devices	29,7	28,5	30,6	29,6	28,9	97,5	16,2	56,1	4,5
<b>In the medium-early variety Sante (factor A) with a planting scheme of 90x15 cm (factor B)</b>										
7	Loosening and hilling 1 time at a depth of 16 cm and 2 times at 18 cm in the protective zone of 8-10 cm using a "KRN-2.8 A" cultivator (control)	27,9	27,7	24,8	26,8	25,7	96,2	14,8	57,6	4,1
8	Loosening and hilling 1 time at a depth of 18 cm and 2 times at 23 cm in a protective zone of 8-10 cm using the "Amak" milling cultivator	32,1	31,6	28,1	30,6	29,5	96,5	17,2	58,5	4,8
9	Loosening and hilling 1 time at a depth of 18 cm and 2 times at 23 cm in a protective zone of 8-10 cm using the cultivator KRN-2.8 A with additional devices	31,6	30,9	26,9	29,8	28,7	96,4	16,8	58,6	4,7
<b>In the medium-early variety Yaroqli-2010 (factor A) with a planting scheme of 90x15 cm (factor B)</b>										
10	Loosening and hilling 1 time at a depth of 16 cm and 2 times at 18 cm in the protective zone of 8-10 cm using a "KRN-2.8 A" cultivator (control)	27,3	28,2	29,7	28,4	27,8	97,8	15,1	54,3	4,2
11	Loosening and hilling 1 time at a depth of 18 cm and 2 times at 23 cm in a protective zone of 8-10 cm using the "Amak" milling cultivator	31,6	34,5	33,8	33,3	32,7	98,1	17,9	54,8	5,0
12	Loosening and hilling 1 time at a depth of 18 cm and 2 times at 23 cm in a protective zone of 8-10 cm using the	30,7	33,1	32,2	32,0	31,4	98,0	17,1	54,6	4,8



cultivator KRN-2.8 A with additional devices										
LSD <sub>05</sub> (C)=	4,64	5,83	2,56							
LSD <sub>05</sub> (B)=	1,16	1,46	0,64							
LSD <sub>05</sub> (A, B, C)=	2,32	2,92	1,28							
S <sub>x</sub> % =	3,67	4,06	2,79							

## Conclusion

When cultivating medium-early potato varieties with early and double-yielding crops in irrigated light grey-earth soils of the southern regions of Uzbekistan, to obtain 25-30 t/ha and higher marketable yield, it is advisable to plant tubers according to a 90x15 cm scheme and care for planting during the growing season, performing loosening and hilling 1 time at a depth of 18 cm and 2 times at 23 cm with a protective zone of 8-10 cm with an “Amak” milling cultivator or “KRN-2.8A” cultivator with additional accessories installed.

Based on the results of this research, an application was filed for a patent “Adaptations of a cultivator to improve cultivating and hilling row spacing” (Intellectual Property Agency of the Republic of Uzbekistan).

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