PROAGRO LECTORIUM

Efficacy of silicon-containing agrochemical application for cereals and potatoes

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Stages in the study of silicon in plants

Alexander von Humbolt (1769–1859): Detection of silica (SiO_2) in plants.
Sir Humphry Davy (1778–1829): "The silicon-containing epidermis of plants provides protection for plants against insect pests." "The Elements of Structural Chemistry" (1813).
Justus von Liebig (1803–1873): proved that plants need silicon for complete mineral nutrition like P, K, N. "Organic Chemistry in Its Application to Agriculture and Physiology" (1840).
Jöns Jakob Berzelius (1779–1848): identified Si as an element and studied silicon-organic interactions in soil (1842).

Dmitry Mendeleev (1834–1907): proposed the use of amorphous silicon dioxide as a silicon fertilizer (1870).
Vladimir Vernadsky (1863–1945): "Beyond doubt, no living organism can exist without silicon." "Silicon emerges in the universe as an element of exceptional importance" (1921).

Global silicon fertilizer turnover is 2,800,000 t/year

Silicon-containing agrochemicals and amorphous silicon sources

Si use: soil application, foliar applications and seed treatment.

Natural: diatomites, zeolites, ash (6,000–24,000 RUB/t)
Synthetic: liquid glass, aerosil, silica gel, monosilicic acid (40,000–400,000 RUB/t)
Waste: granulated slag, silica gels, metallurgical waste (600–4,000 RUB/t)

ApaSil *separation*

$$H_2SiF_{6\ (p\text{-}p)} + 6OH^{-}_{\ (p\text{-}p)} \rightarrow SiO_2 \times 2H_2O_{\ (TB)} + 2H_2O + 6F^{-}_{\ (TB)}$$

Material	Aerosil A-300 (amorphous SiO_2)	Diatomite (Australia)	Diatomite (Inza deposit)	Zeolite (Khotynets deposit)	Si-Mg	ApaSil agrochemical Apatit JSC
Active silicon, mg/kg	6,170	2,550	2,590	2,730	5,920–6,340	4,560–5,330

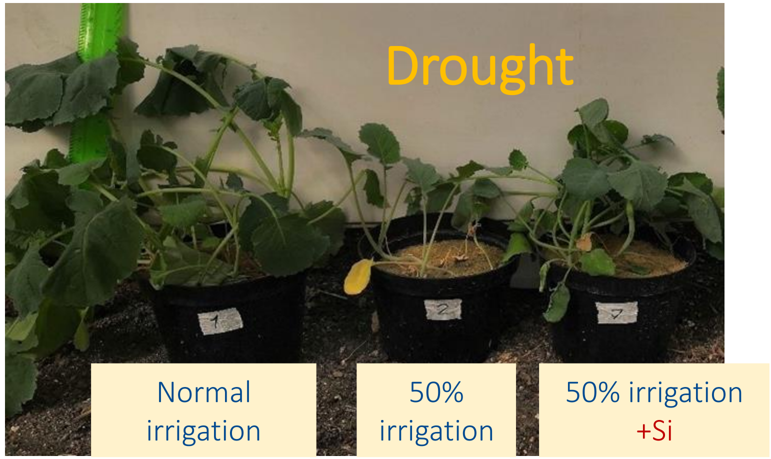
Silicon is an anti-stressant for plants

- ✓ IMPROVES SEED GERMINATION
- ✓ STIMULATES IMMUNITY
- ✓ ACCELERATES PLANT GROWTH
- ✓ IMPROVES STRESS RESISTANCE
- ✓ STIMULATES ROOT DEVELOPMENT

Silicon (Si) helps plants resist stress:

- drought;
- salinization;
- diseases.

Si increases photosynthetic activity of leaves by enhancing plant metabolism, strengthens stems and increases resistance to drowning. Si strengthens the absorption of nutrient elements and increases the growth rate of plants.



Spring rapeseed

Amaranth

Photo: Institute of Basic Biological Problems RAS, 2021

ApaSil agrochemical

Agrochemical mainly composed of an amorphous (biologically active) form of silica and water.

One of the products obtained by processing of apatite concentrate following the reaction of neutralization of hydrofluoric acid.

On January 18, 2022, the pesticide and agrochemical (ApaSil) was certified for state registration.


МИНСЕЛЬХОЗ РОССИИ

СВИДЕТЕЛЬСТВО

О ГОСУДАРСТВЕННОЙ РЕГИСТРАЦИИ ПЕСТИЦИДА ИЛИ АГРОХИМИКАТА

№ 3473 от «18» января 2022 г.

Настоящее свидетельство выдано

АО «АПАТИТ», ОГРН 1025100561012

В соответствии с Федеральным законом от 19 июля 1997 г. № 109-ФЗ «О безопасном обращении с пестицидами и агрохимикатами»

агрохимикат АпаСил

получил государственную регистрацию за № 445-10-3473-1

на срок до «17» января 2032 г. и допускается к обороту на территории Российской Федерации со следующими регламентами применения:

Директор Департамента растениеводства, механизации, химизации и защиты растений Р.В. Некрасов

М. П.

№003899

Tests at the All-Russian Research Institute of Phytopathology

In July 2019, the first vegetation trial was set up on wheat and potatoes to determine guidelines for the use of the **ApaSil agrochemical** and its impact on the environment.

Increase in above-ground biomass of wheat was significant. Ears were formed earlier when the optimal dose of **ApaSil agrochemical** was applied.

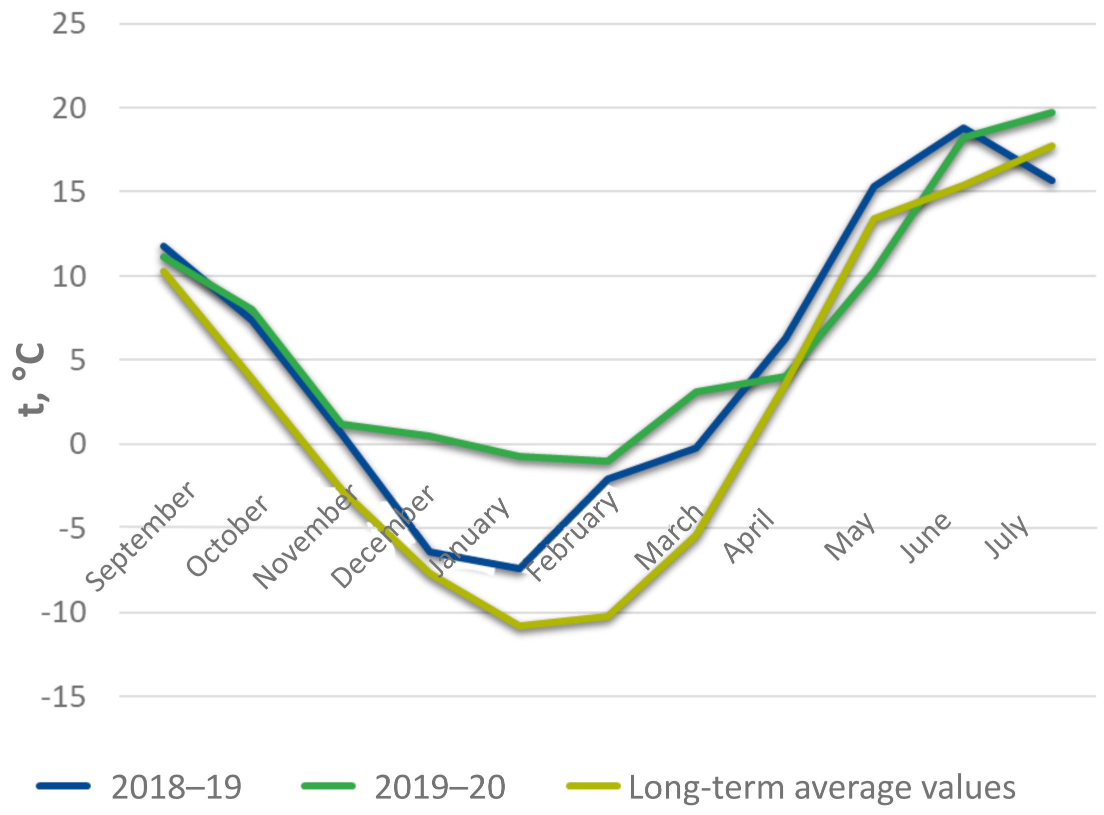
Increasing dosages

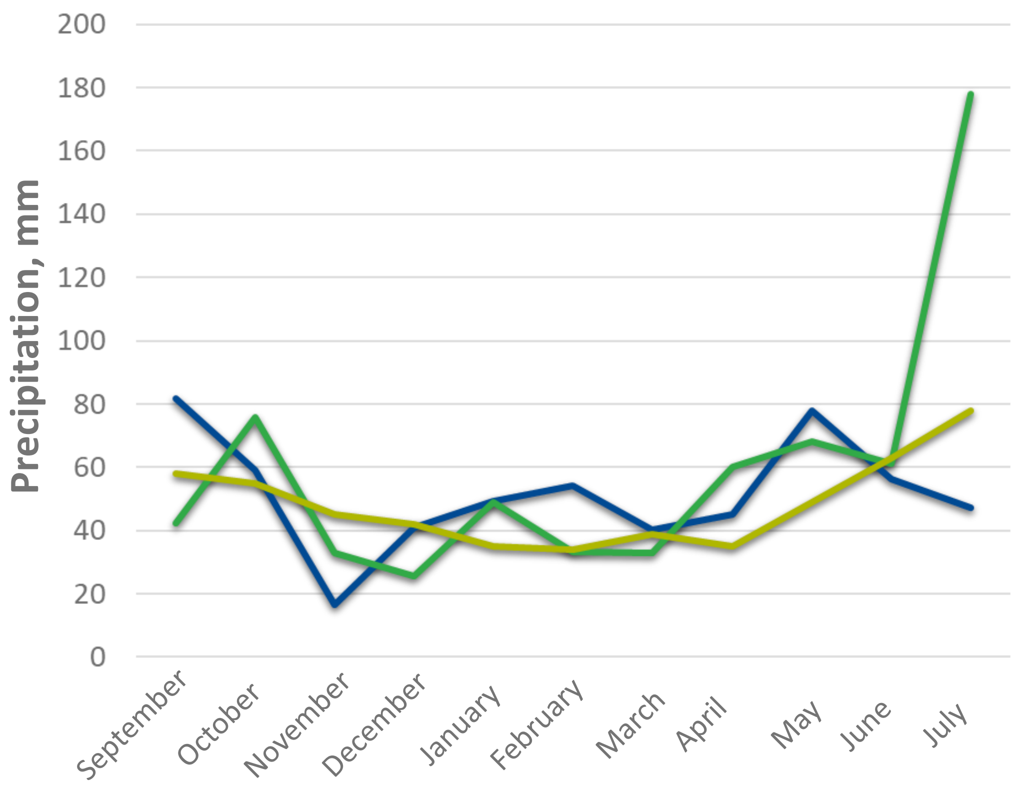
Increasing dosages

Dosages used:

- dressing: 100, 200, 300, 400, 500 g/t;
- spraying: 100, 200, 300, 400, 500 g/ha.

Meteorological conditions at the Central Experimental Station of D.N. Pryanishnikov All-Russian Research Institute of Agrochemistry (Barybino microdistrict, Moscow region) for 2018-2020.





Soil fertility in trials on winter wheat (Experimental field of the D.N. Pryanishnikov All-Russian Research Institute of Agrochemistry in Barybino microdistrict)

Year	Humus, %	pH_{KCl}	Hydrolytic acidity, mmol (eq)/100 g soil	Active forms, mg/kg of soil	
				P_2O_5*	K_2O*
2018	1.90	4.80	2.41	64	104
2019	1.28	5.34	-	82	116

The **soil** is sod-podzolic, heavy loamy, poorly cultivated, on covering clay. Agrochemical properties of soil prior to trials: very low humus content, mean acidic (2018) and slightly acidic (2019) reaction of soil medium; average content of active phosphorus and potassium.

Application of ApaSil agrochemical on winter wheat

48 and 27 g SiO_2/100 g chemical in 2019 and 2020, respectively.

No.	Trial case	2019		2020	
		SiO_2, g/ha	Grain yield, t/ha	SiO_2, g/ha	Grain yield, t/ha
1	Control (no fertilizer)	-	3.50	-	2.69
2	$N_{100\text{-}115}P_{30}K_{30}S_{20}$ – background	-	4.60	-	5.81
3	Background + ApaSil (50 g/t seed + 25 g/ha at the beginning of stem elongation phase + 25 g/ha at the beginning of heading phase)	31	5.10	18	6.01
4	Background + ApaSil (50 g/t seed + 50 g/ha at the beginning of stem elongation phase + 50 g/ha at the beginning of heading phase)	55	5.20	31	6.32
5	**Background + ApaSil (50 g/t seed + 100 g/ha at the beginning of stem elongation phase + 100 g/ha at the beginning of heading phase)**	**103**	**5.80**	**58**	**6.93**
LSD_{05}		-	0.60	-	0.40

D.N. Pryanishnikov All-Russian Research Institute of Agrochemistry (Central Experimental Station, Moscow region).

Winter wheat
Variety: Moskovskaya 56

Drowning without ApaSil application

Cost-effectiveness of ApaSil application on winter wheat in 2019 and 2020.

No.	Trial case	Grain yield, t/ha		Yield value, RUB/ha*		Increase in gross revenue to Case 2, RUB/ha	
		2019	2020	2019	2020	2019	2020
1	Control (no fertilizer)	3.51	2.69	38,610	32,280	-	-
2	$N_{100\text{-}115}P_{30}K_{30}S_{20}$ – background	4.64	5.81	51,040	69,720	-	-
3	Background + ApaSil (50 g/t seed + 25 g/ha at the beginning of stem elongation phase + 25 g/ha at the beginning of heading phase)	5.14	6.01	56,540	78,130	5,500	8,410
4	Background + ApaSil (50 g/t seed + 50 g/ha at the beginning of stem elongation phase + 50 g/ha at the beginning of heading phase)	5.23	6.32	57,530	75,840	6,490	6,120
5	**Background + ApaSil (50 g/t seed + 100 g/ha at the beginning of stem elongation phase + 100 g/ha at the beginning of heading phase)**	**5.84**	**6.93**	**64,240**	**83,160**	**13,200**	**13,440**

Note: grain cost in 2019 is 11,000 RUB/t;
in 2020. — 12,000 RUB/t (for class 3 grain in Case 3 - 13,000 RUB/t).

D.N. Pryanishnikov All-Russian Research Institute of Agrochemistry (Central Experimental Station, Moscow region).

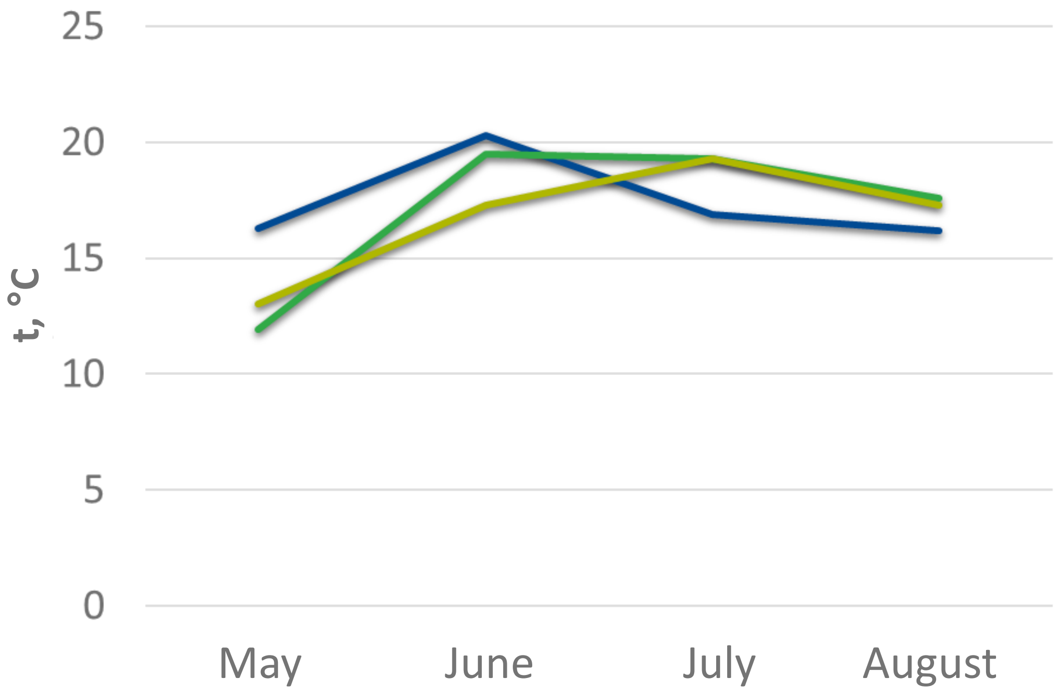
Application of ApaSil agrochemical on spring wheat and spring barley in 2020.

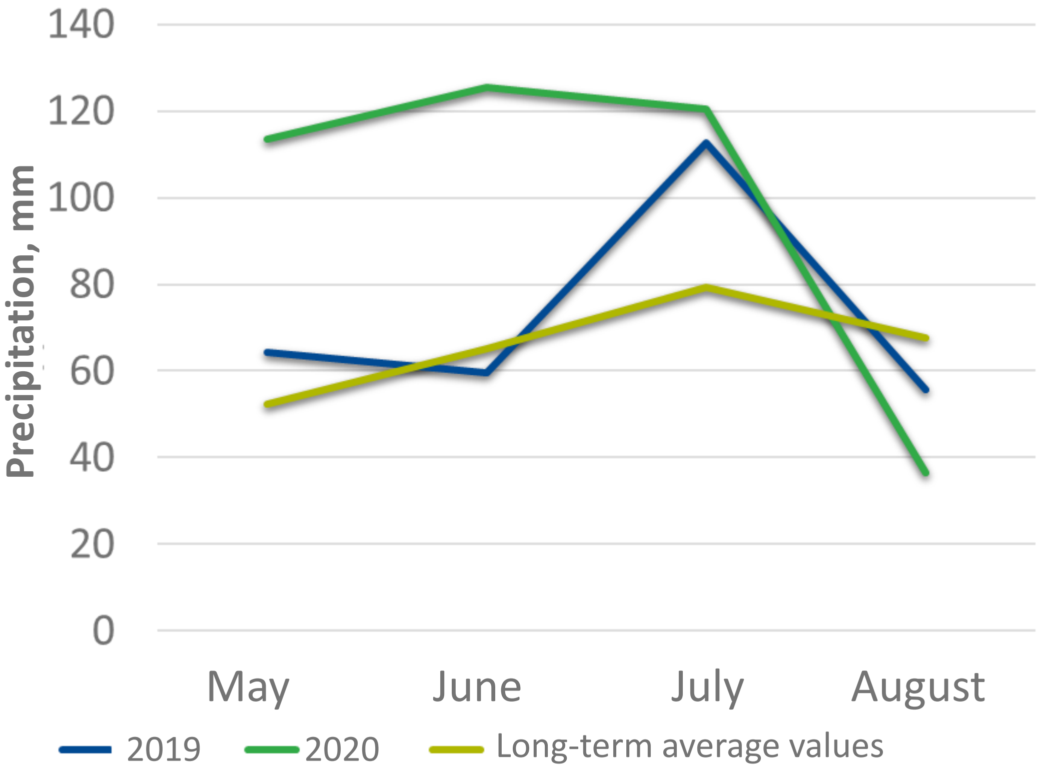
31 g SiO_2/100 g chemical

No.	Trial case	Spring wheat		Spring barley	
		SiO_2, g/ha	Grain yield, t/ha	SiO_2, g/ha	Grain yield, t/ha
1	$N_{90}P_{60}K_{90}$ – background	-	6.59	-	6.19
2	Background + ApaSil (50 g/t seed)	10	6.70	10	6.28
3	Background + ApaSil (100 g/ha at the beginning of stem elongation phase)	31	6.83	31	6.44
4	**Background + ApaSil (50 g/t seed + 100 g/ha at the beginning of stem elongation phase)**	**41**	**7.22**	**41**	**7.59**
LSD_{05}		-	0.38	-	0.65

Federal Research Center "Nemchinovka" (Experimental Base, Moscow)

Meteorological conditions at A.G. Lorkh Russian Potato Federal Research Center (Experimental Base, Moscow Region) for 2019-2020.





Soil fertility in potato trials

Year	Humus, %	V, %	pH_{KCl}	Mineral nitrogen, mg/kg soil	Active forms, mg/kg soil		
					P_2O_5*	K_2O*	S
2019	1.9	50.7	5.0	35.3	269	128	3.4
2020	1.9	49.2	4.9	36.7	368	130	3.1

The **soil** is sod-podzolic sandy loam. The soil showed relatively low humus content (1.9%); mean acidic reaction of the medium (rNKSl = 4.9–5.0); low amount and degree of saturation of absorbed bases (S = 3.1–3.4 mg-eq/100 g soil; V = 49–51%); very high content of active phosphorus (269–368 mg/kg soil) and high content of active potassium (128–130 mg/kg soil).

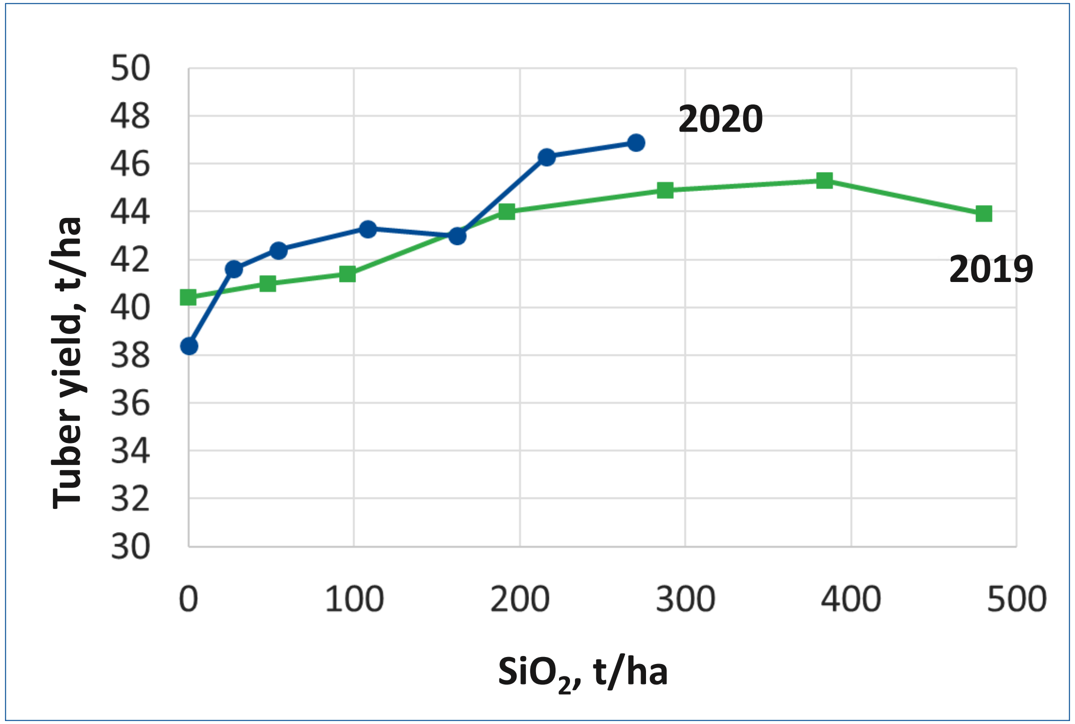
Scheme of potato treatment (for seed purposes) with ApaSil agrochemicals

No.	Trial case	SiO_2 dose, g/ha	
		2019	2020
1	Control (no fertilizer)	-	-
2	$N_{90}P_{90}K_{135}$ – background	-	-
3	Background + ApaSil 100 g/ha	48	27
4	Background + ApaSil 200 g/ha	96	54
5	Background + ApaSil 400 g/ha	192	108
6	Background + ApaSil 600 g/ha	288	162
7	Background + ApaSil 800 g/ha	384	216
8	Background + ApaSil 1,000 g/ha	480	270

Plants were sprayed at budding and early flowering phases
(operating solution flow rate: 300 l/ha)

A.G. Lorkh Russian Potato Federal Research Center (Experimental Base, Moscow Region)

Total potato tuber yield depending on SiO_2 doses in 2019 and 2020.



A.G. Lorkh Russian Potato Federal Research Center (Experimental Base, Moscow Region)

Harvesting the nutritionally valuable components of potatoes

No.	Trial case	Tuber yield >30 mm, t/ha		Dry matter harvest, t/ha		Starch harvest, t/ha		Vitamin C harvest, kg/ha	
		2019	2020	2019	2020	2019	2020	2019	2020
1	No fertilizer	26.8	28.9	7.1	8.3	5.6	6.7	5.3	6.5
2	$N_{90}P_{90}K_{135}$ – background	38.2	36.3	9.4	9.6	7.2	7.6	6.9	6.3
3	Background + ApaSil 100 g/ha	39.4	39.5	10.0	10.4	7.7	8.1	7.6	7.5
4	Background + ApaSil 200 g/ha	40.2	39.8	9.8	10.6	7.4	8.2	8.2	8.0
5	Background + ApaSil 400 g/ha	42.4	40.7	10.7	10.5	8.2	8.1	7.9	8.1
6	Background + ApaSil 600 g/ha	42.4	40.5	10.3	10.3	7.8	8.1	7.7	7.7
7	**Background + ApaSil 800 g/ha**	**42.7**	**43.7**	**11.1**	**11.1**	**8.6**	**8.6**	**7.9**	**8.2**
8	Background + ApaSil 1,000 g/ha	41.1	43.9	10.6	11.1	8.3	8.7	7.7	8.3
LSD_{05}		1.3	-	0.5	-	0.2	-	0.5	-

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Cost-effectiveness of ApaSil application on potatoes in 2019 and 2020

No.	Trial case	Tuber yield >30 mm, t/ha		Yield value, RUB/ha		Increase in gross revenue to Case 2, RUB/ha	
		2019	2020	2019	2020	2019	2020
1	Control (no fertilizer)	26.8	28.9	804,000	1,011,500	-	-
2	$N_{90}P_{90}K_{135}$ – background	38.2	36.3	1,146,000	1,270,500	-	-
3	Background + ApaSil 100 g/ha	39.4	39.5	1,182,000	1,382,500	36,000	112,000
4	Background + ApaSil 200 g/ha	40.2	39.8	1,206,000	1,393,000	60,000	122,500
5	Background + ApaSil 400 g/ha	42.4	40.7	1,272,000	1,424,500	126,000	154,000
6	Background + ApaSil 600 g/ha	42.4	40.5	1,272,000	1,417,500	126,000	147,000
7	**Background + ApaSil 800 g/ha**	**42.7**	**43.7**	**1,281,000**	**1,529,500**	**135,000**	**259,000**
8	Background + ApaSil 1,000 g/ha	41.1	43.9	1,233,000	1,536,500	87,000	266,000

Note: cost of seed potatoes: 2019 — 30 thousand RUB/t;
2020. — 35 thousand RUB/t.

A.G. Lorkh Russian Potato Federal Research Center (Experimental Base, Moscow Region)

Efficiency of ApaSil agrochemical application on crops

Spring and winter wheat (22 and 26%)

Peach +32%

Potato +22%

Tomato +28%

Spring rapeseed +136% (severe drought)

Grapes +84%

Spring barley +23%

Chrysanthemum

Table beets +11%

Snapdragon

Carrot +7%

Apple tree +16%

Caspian Agrarian Federal Scientific Center, Russian Academy of Sciences

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Thank you!