PRO AGRO LECTORIUM

PRODUCTIVITY AND ADAPTABILITY OF POTATO VARIETIES WITH DIFFERENT ECOLOGICAL AND MORPHOLOGICAL CHARACTERISTICS

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- Potato (Solanum tuberosum) comes from Peru. It is widespread around the globe and has a very important role in the global crop production.
- FAOSTAT says it´s the fourth largest crop in the world (376 million tonnes) for human consumption after corn (over a billion tonnes), rice (787 million tonnes) and wheat (770 million tonnes).
- Potato is one of the highest yielding crops (tonnes per ha) and its short cycle garantees up to three harvests per year in areas with favourable climate.
- Potato represent a key solution to the problem of growing population and hunger in the world. It can be cultivated in different areas and almost in any soil and climate conditions (except the equatorial zone).
- Africa has increased its potato production in the last years. It accounts for 7,5% of the world production (over 28 million tonnes). Many West African countries have a great potential for producing this crop, such as Mali, Niger, Benin and Ivory Coast, according to FAOSTAT. It shows great potential. However, one of the major problems for the cultivation of potato in this region is the lack of or scarcity of seed material.
- We believe that Russia is a great partner when it comes to solving this issue. Russian scientific institutions have great experience of creating and adapting new varieties to different agricultural and climate conditions.

Potato in Benin

- Potato is a premium product for Benin with annual imports from neighbouring and European countries reaching up to $129,000.
- Potato imports have been growing in the last years. FAO says that the value of these imports to the country amounts to $530,000 despite the fact that the agricultural and climate conditions of several Benin regions (north and west) are perfect for potato growing. Benin lacks breeding achievements. So in order to make potato an accesible product in Benin, it needs introducing new resistant varieties from Europe and Russia.
- It´s particularly important to study the management of potato adaptability potential, to evaluate varieties agriculture- and climatewise, to develop techniques of increasing agroecosystem productivity. Nowadays, there has been an increase in gross yield of potato. These results have been achieved thanks to considerable progress in potato cultivation in developing countries and the introduction of new varieties in new climate conditions.
- Today, all countries discuss how to put in practice the biological potential of potatoes.
- This issue can be solved by studying the characteristics of varieties: their adaptability, plasticity, and stability.
- Based on this data, the crop production industry can fulfill its main task that is developing varietal technology of crop cultivation.

Scientific research of the problem

Many Russian scientists contributed to studying varietal characteristics of potato. For example, D. Pryanishnikov, A. Lorkh, P. Alsmik, A. Korshunov, A. Kustaryov, B. Anisimov, A. Butov, V. Starovoitov, A. Postnikov, Z. Usanova, etc. Scientists from other countries studied this topic as well, e.g., Fritz, Hillter, D. Spaar, Ellison, Hoopes and Plaisted, Carputo and Frusciante, Dean, Bradshaw, Howard, Karp and al., Firman and Allen, L. Gulluoglu and H. Aroglu, Bohl and Johnson, Dalton, Walther-Hellwig and Frankl, J. Hosseininejadian and Mohammadreza Naderidarbaghshahi, H. Abhra, D. Below and G. Woldegiorgis.

Purpose and objectives of the research

The purpose is to establish the impact of increasing potato production effectiveness through crop production management.

Achieving this purpose will help to pursue the following **objectives**:

- to establish the impact of ecological and morphological characteristics, as well as morpho-architectural traits of crops which guarantee adaptability to changes in heat and water conditions of agroecosystems, on yields and production quality;
- to adapt technological methods of cultivation to biological characteristics of potato (feeding area, seed tuber fraction);
- to increase photosynthetic activity, morphobiological indicators, and the productivity of agroecosystems due to the influence of biologically active substances;
- to establish the impact of ecological and morphological characteristics, as well as morpho-architectural traits of crops which guarantee adaptability to changes in heat and water conditions of agroecosystems, on yields and production quality;
- to study the economic viability of using the proposed techniques in potato production.

Scientific originality

consists in establishing promising methods of managing potato production which guarantee biologicalisation of the potato cultivation technology given the morphological and biological characteristics of the plant (ecomorphotypes) that will help increase significantly yields and quality.
It shows how particular elements of the potato productivity form depending on the phase of growth and development, and explains agrotechnical methods to control it.
The research shows a biological approach to the management of potato agroecosystems based on the adaptive response of varieties of different ecomorphotypes to the use of growth biostimulants. It revealed how main yield elements, its structural components and the quality of tubers form depending on agricultural methods used.

Practical relevance

consists in establishing practical recommendations on the development of agricultural technologies of potato varieties given their morpho-architectural traits, as well as methods of potato growing with the help of growth regulating compounds that help to boost crops and their quality.

The research allowed us to identify the most promising varieties for cultivation in areas with no black soils (Non-Chernozem areas) which have agricultural and climate requirements that can be found in Republic of Benin heat- and waterwise.

General provisions

- the scientific and practical basis for the effectiveness of the proposed agrotechnical methods for managing agroecosystem productivity;
- the pattern of photosynthetic apparatus forming and morpho-biological characteristics of the crops;
- parameters of yield formation and its structural components in potato varieties of different ecomorphotypes;
- evaluation of economic efficiency of growth regulators in potato cultivation.

Field experiment station, Russian State Agrarian University – Moscow Timiryazev Agricultural Academy

Research objects

Variety	Harvesting
 **Meteor** *A.G. Lorkh Institute*	First early (01)
 **Charoit** *Belogorka*	First early (01)
 **Zhukovsky Ranny** *A.G. Lorkh Institute*	Early-season (03)
 **Snegir** *Belogorka*	Early-season (03)
 **Red Scarlett** *HZPC Holland B.V.*	Early-season (03)
 **Krasavchik** *A.G. Lorkh Institute*	Second early (04)
 **Bryansky Delikates** *A.G. Lorkh Institute, Briansk test station*	Second early (04)
 **Resurs** *A.G. Lorkh Institute*	Mid-season (05)

Variety	Harvesting
 **Nadezhda** *A.G. Lorkh Institute*	Mid-season (05)
 **Kumach** *A.G. Lorkh Institute*	Mid-season (05)
 **Utro** *A.G. Lorkh Institute*	Mid-season (05)
 **Severnoye Siyaniye** *A.G. Lorkh Institute*	Mid-season (05)
 **Pamyati Lorkha** *A.G. Lorkh Institute*	Mid-season (05)
 **Vektor** *A.G. Lorkh Institute*	Mid-season (05)
 **Barin** *A.G. Lorkh Institute*	Mid-season (05)

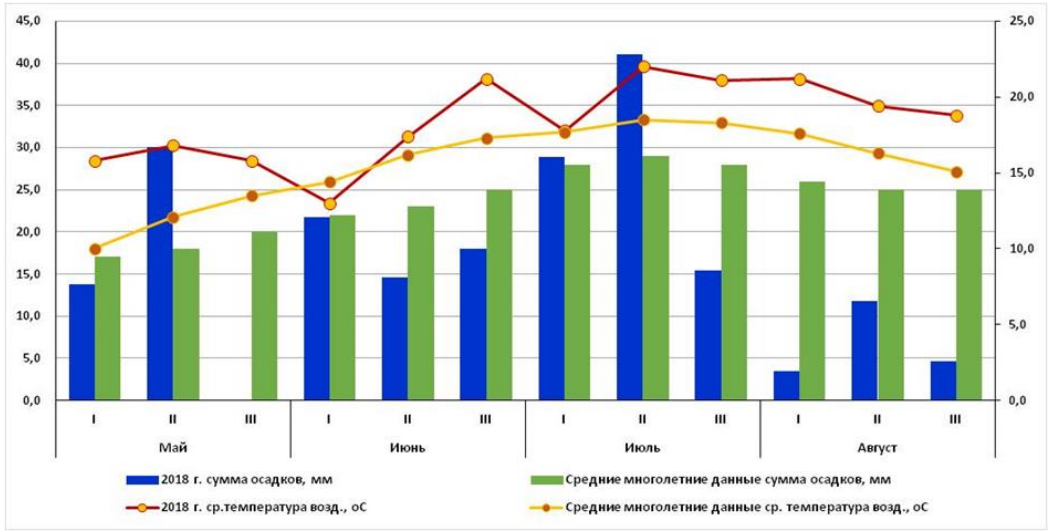
Experiments

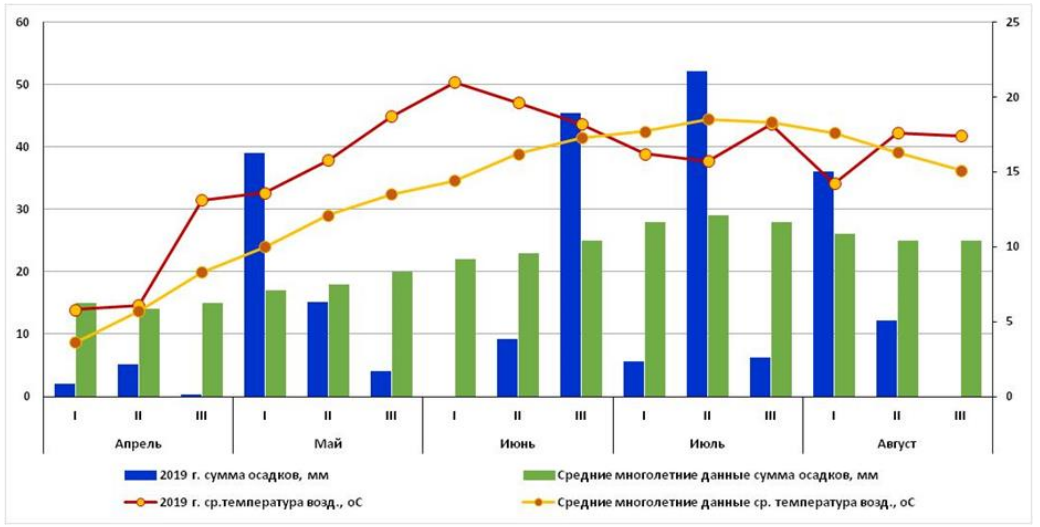
Experiment 1. Adapting potatoes of different ecomorphotypes to changing climate conditions. Research objects are varieties of different harvesting period: Meteor, Charoit (first early); Zhukovsky Ranny, Red Scarlett, Snegir (early-season); Krasavchik, Bryansky Delikates (second early); Kumach, Nadezhda, Utro, Resurs, Severnoye Siyaniye, Vektor, Pamyati Lorkha (mid-season). Crops varied in their morpho-architectural traits, plant habit, bush type, width and thickness of their leaf laminae, compound leaves, their colour and characteristics of donor/acceptor relations.

Experiment 2. Characteristics of potato productivity formation depending on feeding area and seed fraction control. Factor A - variety: A1- Utro, A2- Red Scarlett, A3- Meteor. Factor B – tuber size by cross section, мм: 35; 40; 45; 50. Factor C – feeding area, м2 : 75x20; 75x25; 75x30; 75x35.

Experiment 3. Managing potato production by organomineral fertilisers and growth biostimulants. Factor A - variety: A1- Zhukovsky Ranny, A2- Snegir, A3- Krasavchik, A4- Kumach. Factor B – growth stimulants (ml/ha, g/ha): B1 – control (water treatment); B2 - EcoTerrin (1,5 l/ha); B3-Zerebra Agro (75 ml/ha), B4 –Epin – Extra (80 ml/ha), B5-Cavita biocomplex (3 l/ha).

Heat and water conditions of the growing season in the years of study





Precipitation level, mm

Average precipitation level for several years, mm

Average air temperature, ◦ C

Average air temperature for several years, ◦ C

Enough moisture

(HTC -1,3)
2018
GDD, °C-1856,5

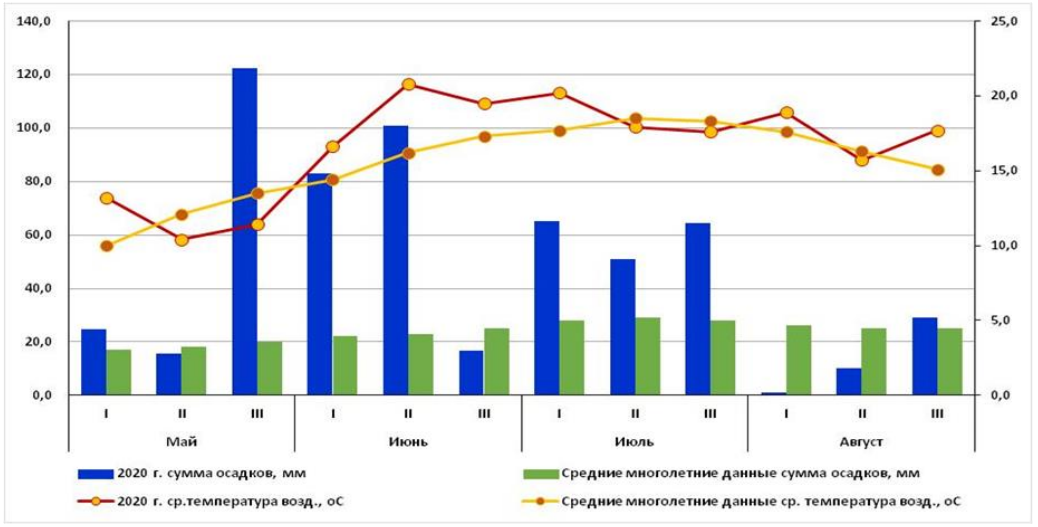
Insufficient moisure

(HTC -1,0)
2019
GDD, °C-2098,6

Overwatering

(HTC -2,7)

2020
GDD, °C-1930,2



Varieties by ecological and morphological traits

Ecomorphotype	***Hygromorphic***		***Xeromorphic***
Characteristics	Wide leaves	Rich foliage	Dark green with anthocyanin coloration
	Big wide leaves with medium venation. Branches are scarce, root system is poorly developed.	Medium to large leaves with medium-sized lobes, small or medium compounds, poor venation, needs a lot of water	High-stemmed bushes with scarce or medium foliage, well developed root system, anthocyanin coloration of the leaves, reddish tuber skin
Variety	Bryansky Delikates, Charoit, Pamyati Lorkha	Nadezhda, Snegir, Meteor, Red Scarlett	Kumach, Severnoye Siyaniye
Ecomorphotype	***Mesomorphic***		
Characteristics	Thick stems with meadium foliage	Thick-stemmed with small-lobed leaves	Medium foliage with many branches
	Medium foliage, bushes are medium or big-sized, well developed root system, big tubers with small eyes	Small-lobed leaves, many branches and well developed root system	Medium or tall bushes with many branches and well developed root system
Variety	Barin	Zhukovky Ranny	Resurs, Vektor, Krasavchik, Utro

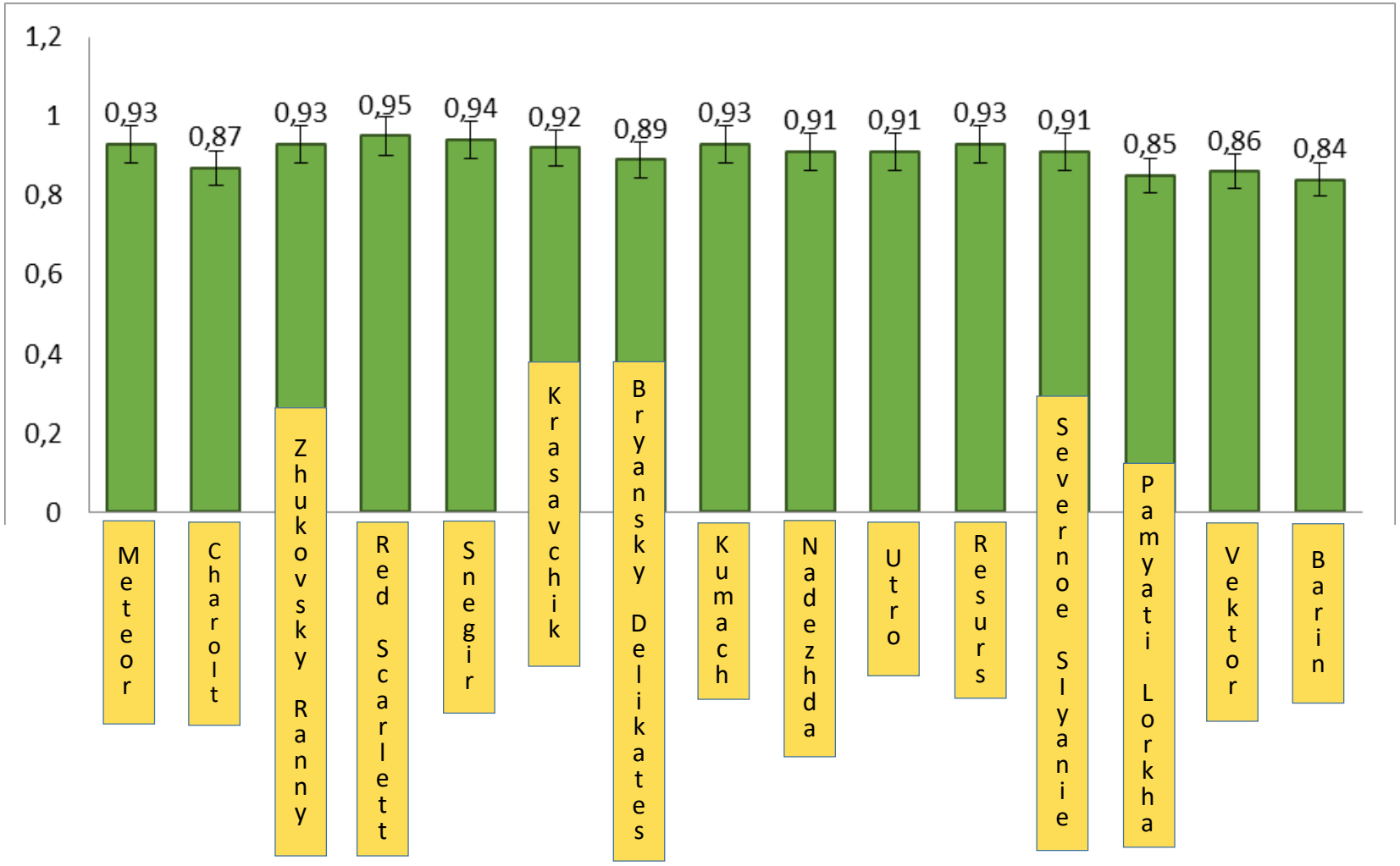
Varieties by ecological and morphological traits

Variety	Planting - sprouts				Sprouts – flower buds				Flower buds - flowering				Flowering – Fading			
	2018	2019	2020	Average	2018	2019	2020	Average	2018	2019	2020	Average	2018	2019	2020	Average
Meteor (01*)	15	14	29	19	10	8	4	7	14	14	9	12	30	19	32	27
Charoit (01)	15	12	28	18	10	8	5	7	13	15	4	11	30	21	31	27
Zhukovsky Ranny (03)	14	13	30	19	10	8	4	7	14	14	5	11	24	19	31	25
Red Scarlett (03)	16	15	31	21	9	9	4	7	14	14	8	12	30	15	33	26
Snegir (03)	17	16	31	21	8	9	3	7	12	13	7	11	31	18	30	26
Krasavchik (04)	16	16	32	21	9	9	3	7	13	15	9	12	30	18	30	26
Bryansky Delikates (4)	17	15	33	21	9	11	3	8	13	14	7	11	30	17	33	27
Kumach	15	14	33	21	12	10	3	8	13	14	6	11	29	15	30	25
Nadezhda (05)	16	16	32	21	9	8	3	7	15	14	11	13	30	16	30	25
Utro (05)	15	17	33	22	11	9	4	8	13	14	1	9	31	19	31	27
Resurs (05)	17	15	33	22	11	11	3	8	13	12	8	11	31	18	30	26
Severnoe Siyanie (05)	15	16	32	21	10	8	4	7	12	14	5	10	32	18	30	27
Pamyati Lorkha (05)	16	16	34	22	10	10	3	8	12	15	5	11	31	15	28	25
Vektor (05)	16	15	33	21	9	9	3	7	14	14	5	11	31	15	31	26
Barin (05)	16	16	34	22	8	9	4	7	15	16	7	13	17	16	30	21

Stem density of potato plants during flowering phase of the experiment, thousand pieces/ha

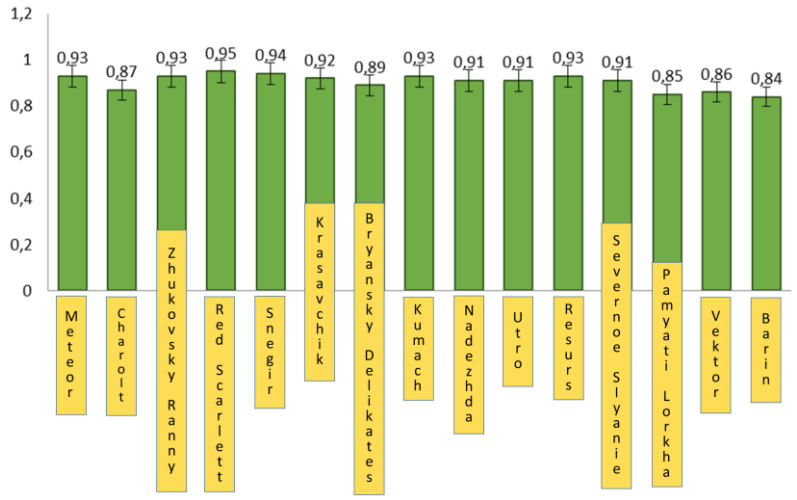
Variety	Year			3-year average
	2018	2019	2020	
Meteor	188,1	267,9	159,6	205,2
Charoit	250,8	165,3	376,2	264,1
Zhukovsky Ranny	262,2	199,5	245,1	235,6
Red Scarlett	307,8	267,9	473,1	349,6
Snegir	273,6	165,3	330,6	256,5
Krasavchik	199,5	142,5	324,9	222,3
Bryansky Delikates	210,9	205,2	307,8	241,3
Kumach	210,9	273,6	307,8	264,1
Nadezhda	188,1	256,5	381,9	275,5
Utro	171,0	153,9	222,3	182,4
Resurs	307,8	193,8	279,3	260,3
Severnoe Siyanie	222,3	250,8	222,3	231,8
Pamyati Lorkha	285,0	267,9	290,7	281,2
Vektor	222,3	142,5	324,9	229,9
Barin	239,4	165,3	410,4	271,7
HCP_{05}	12,98	12,47	17,08	-

NDVI (Normalized Difference Vegetation Index)



Chlorophyll content in potato leaves

Variety	atLEAF CHL, pcs	SPAD, pcs	Total chl, mg/cm²
Meteor	41,8	31,3	0,0262
Charoit	44,2	33,6	0,0292
Zhukovsky Ranny	38,1	27,6	0,0217
Red Scarlett	39,6	29,1	0,0236
Snegir	39,5	29,0	0,0234
Krasavchik	38,3	27,8	0,0219
Bryansky Delikates	41,0	30,5	0,0252
Kumach	43,4	32,8	0,0282
Nadezhda	45,1	34,6	0,0304
Utro	38,9	28,4	0,0226
Resurs	42,1	31,6	0,0266
Severnoe Siyanie	37,8	27,4	0,0214
Pamyati Lorkha	40,6	30,0	0,0247
Vektor	42,6	32,1	0,0272
Barin	43,4	32,8	0,0282



Above-ground biomass indices of potato plants of different ecomorphotypes

Variety	Harvesting	Ecomorphotype	Weight, g/bush		Ratio of leaf weight to stem weight
			Leaves	Stems	
Meteor	First early	Hygromorphic	173,4	165,4	1,0
Charoit	First early	Hygromorphic	221,5	196,0	1,1
Zhukovsky Ranny	Early-season	Mesomorphic	154,9	176,4	0,9
Red Scarlett	Early-season	Hygromorphic	252,1	182,1	1,4
Snegir	Early-season	Hygromorphic	168,5	198,4	0,8
Krasavchik	Second early	Mesomorphic	274,6	280,9	1,0
Bryansky Delikates	Second early	Hygromorphic	203,3	260,4	0,8
Kumach	Mid-season	Xeromorphic	204,9	360,0	0,6
Nadezhda	Mid-season	Hygromorphic	160,1	214,8	0,7
Utro	Mid-season	Mesomorphic	262,8	358,4	0,7
Resurs	Mid-season	Mesomorphic	292,7	191,9	1,5
Severnoe Siyanie	Mid-season	Xeromorphic	238,6	284,4	0,8
Pamyati Lorkha	Mid-season	Hygromorphic	173,6	213,0	0,8
Vektor	Mid-season	Mesomorphic	180,0	267,3	0,7
Barin	Mid-season	Mesomorphic	152,5	140,7	1,1
		HCP_{05}	11,42	12,80	0,05

Electrical conductivity of potato leaves of different ecomorphotypes in different stages, µS

Variety	Phase			Average
	Buds	Flowering	Fading	
Meteor	44,0	42,1	46,4	44,2
Charoit	66,2	55,6	51,0	57,6
Zhukovsky Ranny	51,1	45,2	43,7	46,7
Red Scarlett	49,4	50,2	42,9	47,5
Snegir	61,8	49,8	48,8	53,5
Krasavchik	53,6	47,2	38,2	46,3
Bryansky Delikates	57,0	60,0	40,8	52,6
Kumach	58,7	50,3	46,9	52,0
Nadezhda	68,4	56,1	49,9	58,1
Utro	49,8	48,4	42,7	47,0
Resurs	59,8	52,7	45,8	52,8
Severnoe Siyanie	37,4	40,1	35,8	37,8
Pamyati Lorkha	57,2	50,2	47,7	51,7
Vektor	60,1	50,3	45,0	51,8
Barin	51,2	46,5	39,4	45,7
HCP_{05}	3,03	2,73	2,44	2,73

Potato yield of the experiment, t/ha

Variety	Ecomorphotype	Year			3-year average
		2018	2019	2020	
Meteor	Hygromorphic	30,0	36,5	35,1	33,9
Charoit	Hygromorphic	17,4	49,8	24,2	30,5
Zhukovsky Ranny	Mesomorphic	18,6	31,9	28,8	26,5
Red Scarlett	Hygromorphic	21,2	31,7	34,5	29,1
Snegir	Hygromorphic	27,0	27,7	36,2	30,3
Krasavchik	Mesomorphic	21,9	29,7	54,7	35,4
Bryansky Delikates	Hygromorphic	26,7	26,3	13,5	22,2
Kumach	Xeromorphic	36,0	33,2	37,8	35,7
Nadezhda	Hygromorphic	21,3	40,6	42,0	34,6
Utro	Mesomorphic	23,1	23,6	36,2	27,6
Resurs	Mesomorphic	23,6	37,6	35,8	32,3
Severnoe Siyanie	Xeromorphic	18,4	32,4	26,2	25,7
Pamyati Lorkha	Hygromorphic	24,5	23,5	22,6	23,5
Vektor	Mesomorphic	16,1	29,6	35,4	27,1
Barin	Mesomorphic	34,6	32,2	35,0	33,9
	HCP_{05}	1,42	1,91	1,96	-

Yield structure in the experiment, 2018

Variety	Average per bush								Average weight of a tuber, g	Average number of tubers per bush, pcs	Average weight of tubers per bush, g	Yield t/ha
	Tuber weight, g				Number of tubers, pcs							
	< 30	30 - 50	50 - 80	< 80	< 30	30- 50	50- 80	< 80				
Meteor	24,5	59,3	179,0	511,3	7,00	1,30	2,70	5,30	47,5	16,3	774,1	31,0
Charoit	70,9	71,2	99,0	263,7	4,70	1,70	2,70	2,70	42,8	11,8	504,8	20,2
Zhukovsky Ranny	8,50	73,3	91,2	301,2	1,70	1,70	1,30	1,30	79,0	6,00	474,2	19,0
Red Scarlett	75,3	55,3	224,7	250,3	5,30	1,30	3,30	1,70	52,2	11,6	605,6	24,2
Snegir	42,7	80,0	170,5	425,2	4,00	2,00	2,70	3,30	59,9	12,0	718,4	28,7
Krasavchik	53,7	174,3	281,8	90,8	5,00	4,30	4,30	1,00	41,1	14,6	600,6	24,0
Bryansky Delikates	80,4	147,7	259,4	259,3	6,70	4,00	4,00	2,70	42,9	17,4	746,8	29,9
Kumach	6,90	240,5	195,2	465,2	8,00	1,00	2,00	1,70	71,5	12,7	907,8	36,3
Nadezhda	14,8	11,5	109,1	411,3	1,00	0,30	1,70	3,00	91,1	6,00	546,7	21,9
Utro	71,0	59,0	319,2	198,2	6,30	1,70	5,30	2,00	42,3	15,3	647,4	25,9
Resurs	23,6	252,1	215,3	122,8	9,30	6,70	3,30	1,30	29,8	20,6	613,8	24,6
Severnoe Siyanie	45,0	67,8	101,5	289,7	4,00	1,70	7,70	2,70	49,9	16,1	504,0	20,2
Pamyati Lorkha	63,5	130,0	400,0	82,30	5,70	3,30	6,30	0,70	42,2	16,0	675,8	27,0
Vektor	101,5	62,8	262,2	78,30	15,3	1,70	4,30	0,70	22,9	22,0	504,8	20,2
Barin	6,60	50,1	109,6	705,9	2,30	1,20	2,10	5,00	82,3	10,6	872,2	34,9
HCP_{05}	2,53	5,63	11,06	16,34	0,32	0,12	0,20	0,13	2,92	0,77	35,56	1,42

Yield structure in the experiment, 2019

Variety	Average per bush								Average weight of a tuber, g	Average number of tubers per bush, pcs	Average weight of tubers per bush, g	Yield t/ha
	Tuber weight, g				Number of tubers, pcs							
	< 30	30 - 50	50 - 80	< 80	< 30	30- 50	50- 80	< 80				
Meteor	15,7	65,1	281,0	567,5	0,70	1,70	4,00	4,30	86,9	10,7	929,3	37,2
Charoit	16,8	25,3	119,2	1100,5	1,00	0,70	1,70	5,00	150,2	8,40	1261,8	50,5
Zhukovsky Ranny	19,0	56,7	91,50	650,5	1,30	1,30	1,30	4,70	95,1	8,60	817,7	32,7
Red Scarlett	59,5	120,5	213,2	458,0	4,00	3,00	3,30	4,30	58,3	14,6	851,2	34,1
Snegir	10,0	182,5	163,3	346,5	1,00	4,00	2,30	3,30	66,3	10,6	702,3	28,1
Krasavchik	17,5	65,5	232,5	444,7	0,70	1,70	3,70	4,00	75,3	10,1	760,2	30,4
Bryansky Delikates	28,7	26,5	203,4	428,2	1,30	0,70	3,00	4,00	76,3	9,00	686,8	27,5
Kumach	63,7	73,5	83,30	673,3	3,70	2,00	1,30	4,70	76,4	11,7	893,8	35,8
Nadezhda	40,1	80,3	154,1	781,3	3,00	2,00	2,30	6,00	79,4	13,3	1055,8	42,2
Utro	22,8	54,7	199,7	336,3	1,30	1,30	3,00	3,30	68,9	8,90	613,5	24,5
Resurs	20,7	16,0	22,70	901,3	1,70	0,30	0,30	5,30	126,4	7,60	960,7	38,4
Severnoe Siyanie	46,3	49,7	80,60	680,7	3,70	1,30	1,30	5,00	75,9	11,3	857,3	34,3
Pamyati Lorkha	47,8	89,0	190,8	307,2	2,30	2,30	3,00	2,30	64,1	9,90	634,8	25,4
Vektor	14,0	151,7	220,3	368,3	1,00	4,00	3,30	3,70	62,9	12,0	754,3	30,2
Barin	4,20	35,4	113,5	656,7	0,30	1,00	1,70	5,70	93,1	8,70	809,8	32,4
HCP_{05}	1,56	4,01	8,69	31,90	0,10	0,10	0,13	0,24	4,60	0,57	46,16	1,85

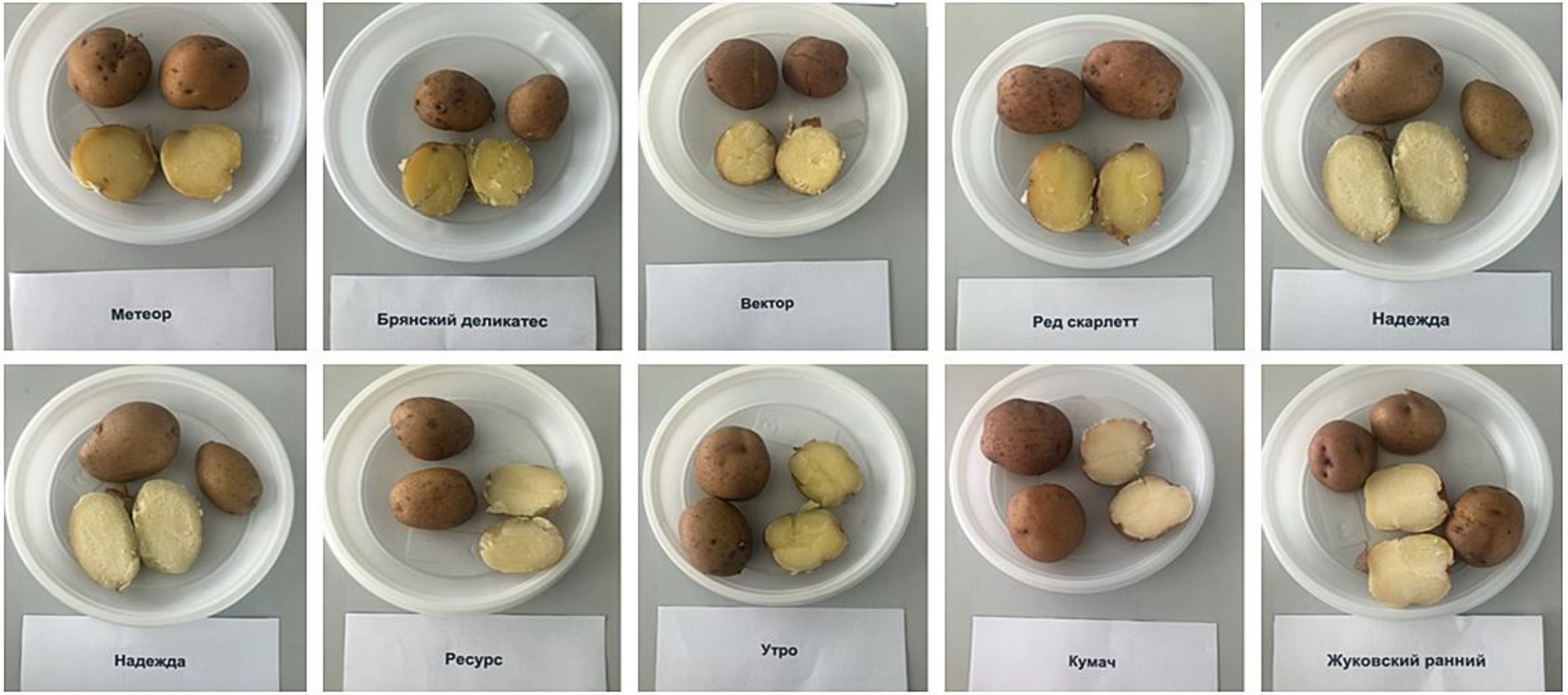
Yield structure in the experiment, 2020

Variety	Average per bush								Average weight of a tuber, g	Average number of tubers per bush, pcs	Average weight of tubers per bush, g	Yield t/ha
	Tuber weight, g				Number of tubers, pcs							
	< 30	30 - 50	50 - 80	< 80	< 30	30- 50	50- 80	< 80				
Meteor	75,2	50,1	211,5	614,7	4,30	1,30	3,00	5,00	70,0	13,6	951,5	38,1
Charoit	29,7	84,5	167,3	353,3	1,70	2,00	2,30	3,00	70,5	9,00	634,8	25,4
Zhukovsky Ranny	35,3	52,7	167,3	500,0	2,00	1,30	2,30	3,30	84,9	8,90	755,3	30,2
Red Scarlett	77,2	211,7	279,8	371,1	3,70	5,30	4,30	3,70	55,3	17,0	939,8	37,6
Snegir	48,0	92,2	209,8	602,3	3,00	2,00	3,00	5,00	73,3	13,0	952,3	38,1
Krasavchik	63,7	88,6	343,0	935,0	5,00	2,30	5,00	6,70	75,3	19,0	1430,3	57,2
Bryansky Delikates	8,20	79,1	87,70	171,5	0,70	2,00	1,30	1,30	65,4	5,30	346,5	13,9
Kumach	77,0	70,5	192,0	683,2	5,30	1,70	3,00	4,30	71,5	14,3	1022,7	40,9
Nadezhda	31,2	29,0	57,00	964,0	2,30	0,70	1,00	5,70	111,5	9,70	1081,2	43,2
Utro	48,0	62,8	158,3	684,0	2,30	1,30	2,30	5,30	85,1	11,2	953,1	38,1
Resurs	21,7	12,8	20,80	862,0	1,00	0,30	0,30	5,70	125,7	7,30	917,3	36,7
Severnoe Siyanie	49,3	94,8	225,7	333,7	2,70	2,30	3,30	2,70	64,0	11,0	703,5	28,1
Pamyati Lorkha	48,0	70,0	125,1	369,7	3,00	1,70	2,00	3,00	63,2	09,7	612,8	24,5
Vektor	90,5	92,8	215,5	577,0	5,30	2,30	3,30	4,70	62,6	15,6	975,8	39,0
Barin	3,70	63,7	141,0	669,1	0,30	1,70	2,30	5,00	94,4	9,30	877,5	35,1
HCP_{05}	2,59	4,24	9,54	31,87	0,16	0,10	0,14	0,24	4,30	0,64	48,23	1,93

Dry matter and starch content of the tubers, %

Variety	Dry matter content, %	Starch, %
Meteor	19,2	12,9
Charoit	22,4	15,1
Zhukovsky Ranny	18,4	11,5
Red Scarlett	20,7	13,5
Snegir	22,5	16,0
Krasavchik	24,2	16,9
Bryansky Delikates	20,9	13,8
Kumach	18,1	11,5
Nadezhda	23,6	16,3
Utro	24,5	17,2
Resurs	20,4	13,2
Severnoe Siyanie	24,0	16,7
Pamyati Lorkha	22,2	15,0
Vektor	23,7	16,3
Barin	20,9	13,7

Tasting characteristics of the tubers (A.G. Lorkh Institute method)



Tasting characteristics of the tubers after harvesting (A.G. Lorkh Potato Research Centre method)

Variety	Skin and flesh integrity	Density of the tuber's flesh	Tuber flesh crumbliness	Wateriness	Tuber smell	Tuber taste	Cooking type	Flesh darkening, raw and cooked
Meteor	9,0	6,2	1,8	5,8	7,8	7,8	1,8	9,0
Charoit	8,6	7,0	5,4	8,2	8,2	7,4	1,4	9,0
Zhukovsky Ranny	9,0	5,8	2,6	7,0	7,8	7,8	1,4	9,0
Red Scarlett	8,6	6,2	1,4	6,2	9,0	7,8	1,8	9,0
Snegir	9,0	4,2	1,8	6,6	7,0	6,2	1,0	9,0
Krasavchik	7,8	5,4	3,4	7,8	7,8	7,0	1,8	9,0
Bryansky Delikates	8,8	6,2	2,2	7,0	8,2	7,0	1,4	9,0
Kumach	8,6	5,0	1,8	7,0	7,8	8,2	1,0	9,0
Nadezhda	8,8	6,2	5,8	8,2	7,4	6,6	1,4	9,0
Utro	8,6	5,4	1,4	5,8	8,6	7,0	1,0	9,0
Resurs	8,6	6,6	1,8	6,2	7,8	7,8	1,4	9,0
Severnoe Siyanie	8,2	7,0	2,2	8,4	8,2	8,6	1,0	9,0
Pamyati Lorkha	9,0	4,2	2,2	7,0	8,2	7,4	1,0	9,0
Vektor	8,2	5,0	3,8	7,8	7,8	7,4	2,6	9,0
Barin	8,7	5,2	2,1	7,2	8,6	7,8	2,1	9,0

Experiment 2: Characteristics of potato productivity formation depending on feeding area and seed fraction control

Factor A – variety:

A_1 – Utro,

A_2 – Red Scarlett,

A_3 – Meteor

Factor B – tuber size by cross section, мм:

35; 40; 45; 50

Factor C – feeding area, $м^2$:

75x20; 75x25; 75x30; 75x35

Plant height, cm

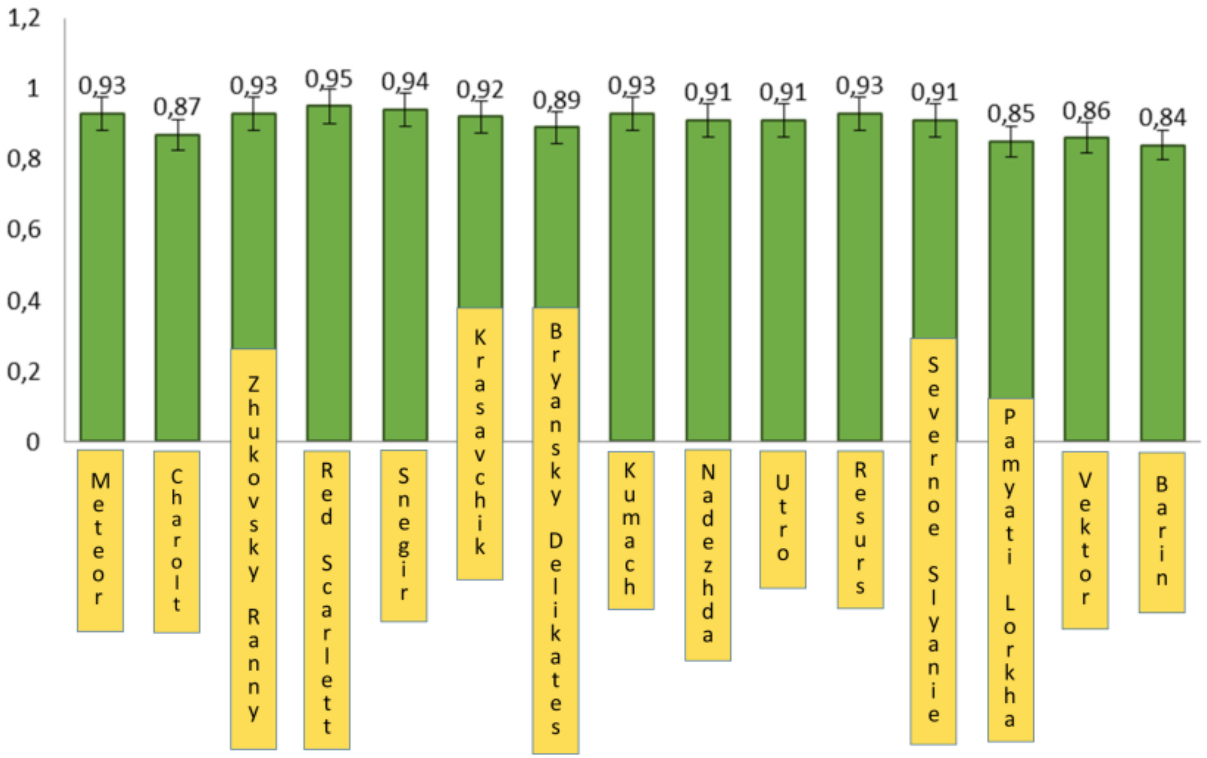
Variety		Utro				Red Scarlett				Meteor			
		2018	2019	2020	3-year average	2018	2019	2020	3-year average	2018	2019	2020	3-year average
Diameter	35	50,4	46,6	39,6	45,5	53,5	40,1	36,9	43,5	45,0	46,9	47,2	46,4
	40	51,7	48,4	52,7	50,9	54,0	43,0	38,0	45,0	58,6	43,6	48,0	50,1
	45	51,3	49,9	46,9	49,4	49,8	34,4	35,2	39,8	56,5	42,9	53,8	51,1
	50	55,2	50,6	48,2	51,3	50,9	35,0	34,6	40,2	59,3	41,3	50,3	50,3
Planting	75x20	52,2	43,0	49,7	48,3	53,5	38,6	33,7	41,9	45,0	42,3	48,1	45,1
	75x25	51,7	44,2	49,8	48,6	54,0	34,9	36,8	41,9	58,6	40,8	46,1	48,5
	75x30	51,3	44,8	47,9	48,0	49,8	34,0	38,4	40,7	56,5	39,6	46,4	47,5
	75x35	55,2	48,1	51,6	51,6	50,9	33,6	38,3	40,9	59,3	40,0	48,1	49,1
HCP_{05}		2,88	2,58	2,71	-	2,86	2,02	2,01	-	3,02	2,32	2,67	-

Number of stems, pieces per bush

Variety		Utro				Red Scarlett				Meteor			
		2018	2019	2020	3-year average	2018	2019	2020	3-year average	2018	2019	2020	3-year average
Diameter	35	2,2	2,0	2,6	2,3	3,6	2,8	3,9	3,4	3,9	3,5	3,6	3,7
	40	3,0	2,9	3,3	3,1	4,4	3,8	4,6	4,3	3,3	3,5	3,3	3,4
	45	3,5	3,8	4,4	3,9	5,4	4,8	5,2	5,1	3,8	3,3	3,2	3,4
	50	5,6	4,1	5,4	5,0	6,0	6,3	6,2	6,2	4,1	4,5	4,8	4,7
Planting	75x20	3,0	3,0	3,3	3,1	3,6	3,9	3,1	3,5	2,9	3,2	2,6	2,9
	75x25	3,0	3,2	3,3	3,2	5,4	4,6	3,8	4,6	3,3	4,1	3,7	3,7
	75x30	2,5	1,9	3,6	2,7	3,4	4,3	5,8	4,5	3,8	4,8	3,3	4,0
	75x35	2,6	2,7	3,9	3,1	4,0	4,7	8,3	5,7	4,1	4,7	4,8	4,5
HCP_{05}		0,17	0,16	0,20	-	0,25	0,24	0,28	-	0,20	0,22	0,20	-

NDVI (3-year average)

Variety		Utro	Red Scarlett	Meteor
Diameter	35	0,86	0,89	0,92
	40	0,91	0,93	0,92
	45	0,92	0,90	0,93
	50	0,88	0,89	0,94
Feeding area	75x20	0,93	0,89	0,92
	75x25	0,91	0,95	0,93
	75x30	0,93	0,94	0,95
	75x35	0,91	0,93	0,91



Yield quantities of the experiment, t/ha

Variety		Utro				Red Scarlett				Meteor			
		2018	2019	2020	3-year average	2018	2019	2020	3-year average	2018	2019	2020	3-year average
Diameter	35	26,3	25,7	26,3	26,1	32,8	30,9	33,9	32,5	28,3	29,3	27,3	28,3
	40	32,9	32,1	32,4	32,5	33,5	31,1	34,3	33,0	29,0	30,6	28,6	29,4
	45	33,5	31,9	33,0	32,8	34,2	36,4	37,1	35,9	27,1	27,1	29,4	27,9
	50	34,5	32,2	33,3	33,3	35,5	35,0	36,1	35,5	28,5	27,2	27,4	27,7
Planting	75x20	32,1	27,8	27,6	29,2	30,0	28,3	31,8	30,0	29,4	29,9	32,1	30,5
	75x25	32,4	33,2	34,0	33,2	30,3	29,7	32,0	30,7	33,7	32,7	31,3	32,6
	75x30	29,9	29,7	29,5	29,7	31,4	29,9	30,6	30,6	34,3	32,9	33,0	33,4
	75x35	30,2	29,3	30,4	30,0	32,8	32,3	33,2	32,8	35,8	33,3	34,3	34,5
HCP_{05}		1,73	1,66	1,69	-	1,79	1,74	1,85	-	1,69	1,67	1,67	-

Experiment 3: Managing potato production by organomineral fertilisers and growth biostimulants

Factor A – variety:

A_1 – Zhukovsky Ranny,

A_2 – Snegir,

A_3 – Krasavchik,

A_4 – Kumach

Factor B – growth stimulants (ml/ha, g/ha):

B_1 – control (water treatment),

B_2 – EcoTerrin (1,5 l/ha),

B_3 – Zerebra Agro (75 ml/ha),

B_4 – Epin – Extra (80 ml/ha),

B_5 – Cavita biocomplex (3 l/ha)

Effect of growth controlling compounds on INDVI, pcs (3-year average)

Variety	Zhukovsky Ranny	Snegir	Krasavchik	Kumach
1. Control	0,87	0,88	0,85	0,87
2. Zerebra Agro	0,92	0,90	0,96	0,91
3. Epin-Extra	0,89	0,89	0,98	0,89
4. Cavita biocomplex	0,93	0,97	0,86	0,95
5. EcoTerrin	0,90	0,94	0,89	0,96

Dry matter and starch content in tubers, % (2018-2020)

Dry matter content, %

Variety	Zhukovsky Ranny	Snegir	Krasavchik	Kumach
Control	22,1	21,9	23,6	20,0
Zerebra Agro	19,5	24,8	25,3	23,1
Epin-Extra	21,3	23,4	25,4	22,3
Cavita biocomplex	24,7	24,9	25,1	22,9
EcoTerrin	21,3	20,4	20,4	20,7

Starch, %

Variety	Zhukovsky Ranny	Snegir	Krasavchik	Kumach
Control	14,8	14,7	16,3	12,7
Zerebra Agro	12,2	17,5	18,0	15,9
Epin-Extra	14,1	16,2	17,8	15,0
Cavita biocomplex	17,4	17,7	17,8	15,6
EcoTerrin	14,1	14,5	18,1	13,4

Effect of using biostimulants on potato yields during the experiment, t/ha

Variety	Zhukovsky Ranny				Snegir				Krasavchik				Kumach			
	2018	2019	2020	3-year average	2018	2019	2020	3-year average	2018	2019	2020	3-year average	2018	2019	2020	3-year average
Control	33,0	32,7	30,2	33,0	28,7	28,1	28,8	28,7	28,0	30,4	29,2	28,0	28,3	27,8	30,9	28,3
Zerebra Agro	35,7	33,3	34,8	35,7	32,9	32,3	31,5	32,9	32,9	31,1	33,0	32,9	33,6	32,2	34,7	33,6
Epin-Extra	33,9	33,4	30,6	33,9	29,8	29,4	29,6	29,8	31,3	32,5	32,6	31,3	32,6	33,0	32,2	32,6
Cavita biocomplex	34,3	33,6	31,7	34,3	32,4	30,1	31,5	32,4	30,2	30,0	30,3	30,2	32,0	34,0	30,3	32,0
EcoTerrin	34,7	32,8	34,2	34,7	30,6	29,3	31,5	30,6	35,0	32,4	34,2	35,0	35,6	34,6	33,0	35,6
HCP_{05}	1,89	1,82	1,78	-	1,70	1,64	1,68	-	1,73	1,72	1,75	-	1,78	1,78	1,77	-

Economic efficiency of potato cultivation of different ecomorphotypes

Variety	Yield Production, t/ha, marketable productivity	Production price per ha, thousand roubles	Notional net income per ha, thousand roubles	Profitability, %	Energy achieved with the harvest, GJ/ha	Notional energy effect, GJ/ha	EER/COP
Meteor	33,86	609,48	396,2	235,8	123,9	36,0	1,41
Charoit	30,45	548,10	356,3	212,1	111,4	23,5	1,27
Zhukovsky Ranny	26,45	476,10	309,5	184,2	96,80	8,90	1,10
Red Scarlett	29,13	524,34	340,8	202,9	106,6	18,7	1,21
Snegir	30,3	545,40	354,5	211,0	110,9	23,0	1,26
Krasavchik	35,41	637,38	414,3	246,6	129,6	41,7	1,48
Bryansky Delikates	22,17	399,06	259,4	154,4	81,10	-6,80	0,92
Kumach	35,68	642,24	417,5	248,5	130,6	42,7	1,49
Nadezhda	34,64	623,52	405,3	241,2	126,8	38,9	1,44
Utro	27,63	497,34	323,3	192,4	101,1	13,2	1,15
Resurs	32,34	582,12	378,4	225,2	118,4	30,5	1,35
Severnoe Siyanie	25,66	461,88	300,2	178,7	93,90	6,00	1,07
Pamyati Lorkha	23,52	423,36	275,2	163,8	86,10	-1,80	0,98
Vektor	27,05	486,90	316,5	188,4	99,00	11,1	1,13
Barin	33,93	610,74	397,0	236,3	124,2	36,3	1,41

Economic effectiveness of growth controlling substances when cultivating the variety Zhukovsky Ranny

Variety	Yield Production, t/ha, marketable productivity	Production price per ha, thousand roubles	Notional net income per ha, thousand roubles	Profitability, %	Energy achieved with the harvest, GJ/ha	Notional energy effect, GJ/ha
Control	31,2	561,6	365,0	217,3	114,2	26,3
Zerebra Agro	33,4	600,8	390,5	232,5	122,2	34,3
Epin-Extra	31,7	570,1	370,5	220,6	115,9	28,0
Cavita biocomplex	31,9	574,4	373,3	222,2	116,8	28,9
EcoTerrin	32,5	584,5	379,9	226,1	118,8	30,9

Economic and bioenergy effectiveness of growth controlling substances when cultivating the variety Snegir

Variety	Yield Production, t/ha, marketable productivity	Production price per ha, thousand roubles	Notional net income per ha, thousand roubles	Profitability, %	Energy achieved with the harvest, GJ/ha	Notional energy effect, GJ/ha
Control	27,5	495,0	321,8	191,5	100,7	12,8
Zerebra Agro	31,2	561,1	364,7	217,1	114,1	26,2
Epin-Extra	28,5	512,5	333,1	198,3	104,2	16,3
Cavita biocomplex	30,3	546,1	355,0	211,3	111,0	23,1
EcoTerrin	28,6	514,8	334,6	199,2	104,7	16,8

Economic and bioenergy effectiveness of growth controlling substances when cultivating the variety Krasavchik

Variety	Yield Production, t/ha, marketable productivity	Production price per ha, thousand roubles	Notional net income per ha, thousand roubles	Profitability, %	Energy achieved with the harvest, GJ/ha	Notional energy effect, GJ/ha
Control	27,91	502,38	326,5	194,4	102,2	14,3
Zerebra Agro	31,03	558,54	363,1	216,1	113,6	25,7
Epin-Extra	30,83	554,94	360,7	214,7	112,8	24,9
Cavita biocomplex	29,18	525,24	341,4	203,2	106,8	18,9
EcoTerrin	32,69	588,42	382,5	227,7	119,6	31,7

Economic and bioenergy effectiveness of growth controlling substances when cultivating the variety Kumach

Variety	Yield Production, t/ha, marketable productivity	Production price per ha, thousand roubles	Notional net income per ha, thousand roubles	Profitability, %	Energy achieved with the harvest, GJ/ha	Notional energy effect, GJ/ha
Control	26,9	484,7	315,1	187,5	98,6	10,7
Zerebra Agro	31,2	561,4	364,9	217,2	114,2	26,3
Epin-Extra	30,4	546,3	355,1	211,4	111,1	23,2
Cavita biocomplex	31,2	561,2	364,8	217,1	114,1	26,2
EcoTerrin	34,1	614,2	399,2	237,6	124,9	37,0

Conclusions

1. The research was based on systematizing varieties according to their ecological and morphological characteristics and morpho-architectural traits. It showed the adaptability of different varieties to changing heat and water conditions.

2. The years of experiments varied in heat and water quantities. In 2018, the number of tubers per bush grew because of sufficient moisture, especially in Vektor, mesomorphic variety with many branches and medium-sized leaves (22.0 tubers per plant). In 2019, with its insiffucient moisture, it was Red Scarlett, hygromorphic variety with rich foliage, that registered a high number of tubers per bush (14.6 tubers). 2020 was an overwatering year that gave Krasavchik, mesomorphic variety with many branches and middle-sized leaves, 19,0 tubers per bush.

3. Chlorophyll content in potato leaves was determined by cultivation conditions and characteristics of the varieties. The highest rates of photosynthetic activity during the growing season were found in the hygromorphic strongly foliaged variety Nadezhda 0.0304 mg/cm^2.

4. Among the early-season varieties, the most promising for cultivation was the hygromorphic variety Meteor, which had a high marketable productivity (95.7%) but it´s worth saying that the number of stems per bush was rather low - 3.6 pieces/bush, while the productivity of one stem had an average of 3.8 tubers/stem. During growth and development, plants of the variety Meteor were characterized by a short period of planting-sprouting, fast and intensive tuber formation, despite the rather low values of the mass of crude haulm – 338.8 g/bush (leaf weight to stem weight ratio of 1:1).

5. The 3-year average weight of marketable tubers (mid-season varieties) was between 554 and 890 g/bush. The most prominent by this indicator was the xeromorphic dark green – anthocyanic variety Kumach (4.6 stems/bush) – 892.2 g/bush, mesomorphic mid-leaved variety Krasavchik – 885.4 g/bush, the hygromorphic leafy variety Nadezhda (865.9 g/bush) and the mesomorphic thick-stemmed variety Barin (848.3 g/bush).

6. The quality characteristics of potato tubers varied considerably: the highest dry matter content (24.5%) was observed in the mesomorphic medium-leaved variety Utro; the most intensive nitrate accumulation was noted in the mesomorphic thick-stemmed variety Zhukovsky Ranny (131 mg/kg), while the lowest nitrate content values were observed in the xeromorphic dark-green-anthocyanin variety Severnoye Siyaniye (60 mg/kg).

7. The relationship between electrical conductivity and the ecomorphotype of the variety was established: high electrical conductivity was observed in hygromorphic wide-leaved variety Charoit (50.1 µS), low electrical conductivity was observed in xeromorphic dark green anthocyanin variety Severnoye Siyaniye (35.3 µS) (this is associated with the coloration of the leaf surface and its thickness).

8. Tasting evaluation revealed the most valuable varieties in terms of taste: hygromorphic varieties with rich foliage Snegir and Meteor, hygromorphic broad-leaved variety Pamyati Lorkha and mesomorphic thick-stemmed variety Zhukovsky Ranny (9 points for each). In terms of tuber taste, the xeromorphic dark green anthocyanin variety Severnoye Siyaniye scored 8.6.

9. The relationship between seed size and yield production was established: increasing the size of seed tubers in the variety Utro from 40 mm to 45 mm and 50 mm led to an increase in yield by 0.3 and 0.8 t/ha; planting small tubers (up to 35 mm) led to a decrease in yield by 6.4 t/ha. For the variety Red Scarlett, a similar pattern was observed: increasing the size of planting material from 40 mm to 45 mm and 50 mm increased yield by 2.9 and 2.5 t/ha; reducing it from 40 mm to 35 mm reduced yield by 0.5 t/ha.

10. The peculiarities of phytohormones action was established but the nature of their action was largely determined by exogenous factors. The following varieties were responsive to the application of Cavita biocomplex: Krasavchik (2.2 t/ha); Snegir and Kumach (+3.7 t/ha). The variety Krasavchik was also distinguished by its good varietal response to the application of the growth regulator and adaptogen Epin-Extra, which translated into high values of the NDVI index - 0.98, yield production of 31.3 t/ha (an increase against the control was 3.3 t/ha). For the variety Kumach the biggest effect had the application of organomineral fertilizer EcoTerrin, which gave the highest yield for this variety of 35.6 t/ha (7.3 t/ha more than control). For the Zhukovsky Ranny variety, in three years, the use of Zerebra Agro for the treatment of vegetative plants resulted in a yield increase of 2.6 t/ha compared to the control; for the Snegir variety, the increase was 4.2 t/ha.

11. A cost-benefit analysis allows us to identify the most profitable varieties for production (over 200%): the hygromorphic varieties with rich foliage Meteor, Snegir, Red Scarlett and Nadezhda; the hygromorphic broad-leaved variety Charoit; the mesomorphic medium-leaved varieties Resurs and Krasavchik; the mesomorphic thick-stemmed medium-leaved variety Barin; and the xeromorphic dark green-anthocyanin stemmed variety Kumach. The use of Zerebra Agro to treat the plants of the Zhukovsky Ranny variety resulted in an increase in production profitability by 15.2 % and that of Snegir variety by 25.6 %.

Production proposals

1. It is recommended to cultivate varieties of different ecomorphotypes in order to have stable harvests of 30-35 t/ha in central Non-Chernozem areas: the hygromorphic Meteor (first early), Snegir (early-season); the mesomorphic Krasavchik (second early) and Barin (mid-season); the xeromorphic Kumach (mid-season).

2. To treat growing plants in the phase of full sprouting with Zerebra Agro (75 ml/ha) in order to increase yield production and potato quality, as well as reduce ecological burden on agroecosystems. The consumption of the solution is 300 l/ha.

Production proposals

- Developing cooperation between Russia and Western Africa in potato production can reduce unemployment, diversify economies, guarantee food security and develop science.
- We propose to create the Regional Potato Centre following the example of the Russian Potato Research Centre in Mali. This facility could work with African countries (Niger, Benin, Ivory Coast, Nigeria, etc.) and give an access to seed materials.
- The Centre should aim to create new regional varieties. To establish such a centre needs building of a key component in potato production, which is storage. It requires a big facility that would function on solar power. It is crucial to take into account all the details which could facilitate field works. Primarily, mecanisation of production. Russia could provide agricultural vehicles, such as MTZ-80 tractor, potatoplanters, etc.

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Thank you!