



Determination of Lands with Optimal Soil and Climate Conditions for Growing Potatoes (*Solanum tuberosum* L.) in Pazardzhik Region

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Abstract

Information from databases on soil diversity in Pazardzhik district was used for the report. On the basis of Large-scale soil mapping (M 1:10000 and 1:25000 - Fund ISSAPP "N. Poushkarov"), 671 soil differences have been identified, which cover the lands of all settlements in the district. Based on the soil properties and taking into account the climate conditions, relative evaluation was made for potatoes (*Solanum tuberosum* L.) by applying the "Methodology for working with the Cadastre of agricultural lands in the Republic of Bulgaria". The field ratings for the crop for all soil differences have been calculated. From the database, only soil differences, which receive 65-100 evaluation rating ("good" and "very good" lands) for growing potatoes are presented. The field ratings are under non-irrigated conditions. The name of soils, the physico-chemical properties and the settlements, in which they are distributed, are presented.

Optimal conditions for growing potatoes are available in the municipalities of Batak, Belovo, Bratsigovo, Panagyurishte, Rakitovo, Velingrad.

Keywords: Pazardzhik region, soil characteristics, potatoes, land evaluation, natural conditions

Introduction

Due to the high taste and nutritional value, potatoes (*Solanum tuberosum* L.) are used in a wide variety of forms for human and animal food. According to their purpose, they are: dining, feed, industrial, and universal. Potato tubers contain about 25% dry matter, 18-22% of which starch and about 2% protein. The culture is rich in vitamins B₁, B₂, C, P and K. Therefore, for some people it is indispensable source of these vitamins in the winter months of the year (Gorbanov, 2010).

In our country, potatoes have been grown since the end of the 19th century. The average yield per hectare in the 80s of the last century was 1000 kg. In 1990, the sown areas with potatoes were 41.2 thousand hectares, in 2012 -14.9 thousand hectares. The occupied area with potatoes for 2023 in the country is 7019 ha (*Agrarian Report for 2024 of the Ministry of Agriculture and Food*).

Bulgarian potato production ranks among the last places in the European Union, according to „Eurostat“(2023) statistics. Our country produced less than 119135 tones in 2023 (20.1% of total vegetable production), followed by tomatoes (*Solanum lycopersicum* L.) - 115.7 thousand tones (19.5%), watermelon (*Citrullus lanatus* Sch.), - 80.1 thousand tones (13.5%), pepper (*Capsicum annuum* L.) - 52 thousand tones (8.8%), cucumber (*Cucumis sativus* L.) - 50.1 thousand tones (8.4%) and head cabbage (*Brassica oleracea* var. *capitata* L.) - 45 thousand tones (7.6%).

By comparison, Germany, the country with the largest potato production in the EU, produced almost 10 times more. In our country, there is a trend of steady decline in production. In 2022, 172,200 tones were reported, and in 2021 this volume was almost 196 thousand tones. Within two years, the potato harvest has decreased by more than 76 thousand tones. Germany is the largest producer of potatoes in the EU in 2023, with a harvest of 11.6 million tones for the period tones. This is 24% of the total amount in the EU. France ranks second, and the Netherlands ranks third. Together, these three countries account for the majority (55.4%) of the EU's potato harvest in 2023.

The aim of the study is to determine the most suitable lands for growing potatoes in the Pazardzhik region through the values of the field ratings (65-100 evaluation rating), as well as to indicate the lands, in which these soils are located.

Materials and Methods

The relative evaluation for potatoes growing is determined on the basis of an assessment of soil and climate conditions.

The culture requires loose, sand-clay soils (physical clay (<0,01 mm) 20-30%), with slightly acid reaction (pH in H₂O 5.0-6.5). Clayey, compacted soils with alkaline reaction and high level of groundwater are unsuitable.

Table 1, part 1. Indicators of soil conditions and assessment (field rating) for potatoes

Indicators	Degree	Parameters	Evaluation (field rating)	note
Mechanical composition in arable soil layer (physical clay,%) -	Loose sand	0-5	0	The values of the indicator are doubled
	Bonded sand	5,1-10	30	
	clay-sandy	10,1-20	50	
	Slightly sandy-clayey	20,1-30	100	
	Medium sandy-clayey	30,1-45	80	
	Heavy sandy-clayey	45,1-60	60	
	Slightly clayey	60,1-75	30	
	Clay	over 75	1	

Table 1, part 2. *Indicators of soil conditions and assessment (field rating) for potatoes*

Indicators	Degree	Parameters	Evaluation (field rating)	note
Humus horizon thickness(cm)		0-20	80	
		21-30	90	
		over 30	100	
Soil thickness (cm)		0-30	1	Only for soils developed on hard rocks
		31-50	30	
Texture factor		under 1	100	
		1,01-1,3	90	
		1,31-2	85	
		over 2	60	
Soil reaction (pH in H ₂ O)		over 7,5	20	The values of the indicator are doubled
		6,5-7,49	60	
		5,0-6,49	100	
		under 5	90	
Humus content (%)		under 1	20	
		1,01-2	40	
		2,01-3	80	
		over 3	100	
Groundwater level (cm)		0-50	0	Only for soils with groundwater level of 0-150 cm. For layered meadow, gravel and sandy soils with groundwater level deeper than 100 cm, the indicator should not be evaluated.

The following indicators are included in the assessment of soil conditions for potatoes: mechanical composition (physical clay content in % (particles <0,01 mm) of the arable land; thickness of the humus horizon (cm); soil thickness (depth) in cm (applies only to soils formed on hard rocks); texture coefficient (the ratio of the amount of silt clay fraction from horizon B to its amount from horizon A); soil reaction of plough soil layer (pH in H₂O); humus content in arable soil layer (%); groundwater level (in cm from the soil surface). In the assessment of soil conditions for development of the crop, importance is given to two indicators - mechanical composition of the soil and soil reaction (their assessments are doubled).

For assessment of climate conditions (Table 2) the Selyaninov Hydrothermal Coefficient (HTC) was used. The developments were made on the basis of the heat and moisture requirements of varieties with medium-long and long growing season for the period June-August (during tuber formation). For moisturizing, HTC with optimal values of 1.4-2.0 was used. Areas with such humidification receive rating of 1 (the maximum assessment of climate suitability for growing the crop). For tubers formation, the presence of suitable, not very high temperatures is important. The assessment also includes the indicator of average

daily temperature for the same period, with the optimal being 14-18°C. Due to the use of both indicators, climate regions 2 and 3, although identical in terms of HTC values, differ in temperature conditions and therefore have different estimates for the production of late potatoes (Table 2). The HTC values are calculated on the basis of 40-50 annual averaged data from meteorological sources of National Institute of Meteorology and Hydrology (*Climate Guide for the People's Republic of Bulgaria*, 1979; *Climate reference book for the People's Republic of Bulgaria*, 1983; Koleva & Peneva. 1990; Sabev & Stanev, 1963; Hershkovich, 1984).

Calculation of the HTC is made according to the formula:

$$HTC = Sr / 0.1 \times St,$$

where:

HTC - Selyaninov's hydrothermal coefficient;

Sr - amount of precipitation for a period with average daily temperatures > 10 °C;

0.1 - equalization coefficient;

St - amount of average daily air temperatures > 10 °C for the period. HTC values < 0.5 indicate drought and > 2 – waterlogging.

Table 2. Assessment of climate conditions for growing potatoes. (Hydrothermal coefficient and average temperature for the tuber formation period).

District №	Indicators and their values	Climate coefficients
1	1,4-2,0	1,0
2	1,1-1,4	0,8
3	1,1-1,4 (in adverse temperature conditions)	0,5
4	0,8-1,1	0,2
5	Places with an altitude of more than 1800-2000 m	0

The relative evaluation for potatoes in the surveyed sites (characterized by the presented soil differences) was carried out according to the "Methodology for working with the cadastre of agricultural lands in the Republic of Bulgaria" (by assessing the indicators presented in Table 1 and Table 2), (Petrov et al., 1988).

The determination of field ratings is calculated on the basis of aggregated data on the soil difference. If it is characterized with more soil profiles, averaged data are used. The same approach is applied to physical and chemical properties of soil diversity, relief, soil-forming materials, climate, and the biological requirements of the crop..

The soil names are presented in accordance with the World Reference Base for Soil Resources – WRB (*IUSS Working Group WRB*, 2022).

Field rating

The field rating is a final estimate and is the sum of the estimates of each indicator (for each soil difference) presented below in the equation. The assessments of the individual indicators and the complex assessment of the EBN are with values from 0 to 100, under non-irrigated conditions. Optimal conditions receive a score of 100 ball, and unfavorable conditions, depending on the severity of the indicator, receive a lower score, and in certain cases 0 (unfavorable conditions).

The land evaluation is made by the following equation (Georgiev, 2006):

$$FR_X = \frac{2R_{TX+} R_{THH+} R_{TSP+} R_{CCR+} 2R_{pH+} R_{HC+} R_{GWT}}{nR} k_{EA} k_{SA} k_{ST} k_{FL} k_{CL}$$

where:

FR_X – Field Rating for a particular crop.

Ratings (from 0 to 100) for: R_{TX} - soil mechanical composition;

R_{THH} -thickness of the humus horizon;

R_{TSP} - soil profile thickness;

R_{CCR} - texture profile differentiation;

R_{pH} - soil reaction;

R_{HC} - content of organic matter (humus);

R_{GWT} - groundwater level.

Correction coefficients for:

k_{EA} - soil erosion or accumulation;

k_{SA} - soil salinity/alkalinity;

k_{ST} - stoniness of the arable soil layer;

k_{FL} - swamping; k_{CL} - climate;

n^R - number of characteristics involved ($R \dots$).

The climate conditions are evaluated by the indicator HTC (according to Selyaninov, 1958) and average temperature for the period of tuber formation.

Results and Discussion

This section presents the results of land evaluation for potatoes. Only sites with "good" and "very good" growing conditions for the crop are selected. There are the soil differences, which receive 65-100 evaluation rating.

Table 3, part 1. Settlements, main physical and chemical indicators of the suitable soils for growing potatoes, field rating values.

Municipality	Land	Soil (WRB, 2014)	Physical clay arable soil, %	Physical clay under arable soil, %	Thickness humus horizon, cm	Thickness soil profile, cm	Texture coefficient	pH / H ₂ O	Humus, %	Groundwater level, cm	Field rating for potatoes
Batak	Fotinovo	Umbrisols, no erosion	30	29	88	110	1.7	4.8	13.0	deep	95
Batak	Batak, Nova mahala	Cambisols, low erosion	29	26	30	70	1.4	4.8	3.8	deep	75
Batak	Batak, Nova mahala	Fluvisols – Aluvial, Fulvisols – Deluvial	19	14	20	80	0.9	5.2	4.0	deep	83
Batak	Batak, Nova mahala	Fluvisols – Deluvial	18	19	50	100	0.9	5.6	1.1	deep	77
Batak	Batak, Nova mahala	Fluvisols – Deluvial	28	22	50	100	0.9	5.3	4.4	deep	100
Batak	Batak, Nova mahala	Fluvisols – Deluvial	39	31	50	100	0.9	5.2	1.5	deep	86
Belovo	Belovo, Malko Belovo, Golyamo Belovo, Menenkyovo, Dybravite, Momina Klisura, Gabrovnitsa, Sestrimo	Cambisols, low erosion	20	21	25	35	1.0	4.9	3.5	deep	65

Table 3. part 2. *Settlements, main physical and chemical indicators of the suitable soils for growing potatoes, field rating values.*

Municipality	Land	Soil (WRB, 2014)	Physical clay arable soil, %	Physical clay under arable soil, %	Thickness humus horizon, cm	Thickness soil profile, cm	Texture coefficient	pH / H ₂ O	Humus, %	Ground water level, cm	Field rating for potatoes
Belovo	Belovo, Malko Belovo, Golyamo Belovo, Menenkyovo, Dybravite, Momina Klisura, Gabrovnitza, Sestrimo	Cambisols, secondary grass, no erosion	18	21	30	75	1.0	4.7	4.2	deep	81
Bratsigovo	Rozovo	Cambisols (Leptic)	28	34	35	85	2.2	4.5	1.5	deep	66
Bratsigovo	Rozovo	Cambisols, no erosion	15	18	25	80	0.9	4.6	2.5	deep	79
Bratsigovo	Ravnogor	Cambisols, no erosion	15	19	45	100	1.2	5.2	4.4	deep	84
Panagyurishte	Panagyurishte, Poibrene, Oborishte, Banya, Bata, Popitsa, Elshitsa, Dolno Levski	Umbrisols	16	13	60	90	0.9	5.1	8.0	deep	86
Panagyurishte	Panagyurishte, Poibrene, Oborishte, Banya, Bata, Popitsa, Elshitsa, Dolno Levski	Umbrisols, no erosion – low erosion	21	12	45	95	1.0	5.0	9.5	deep	100

Table 3, part 3. Settlements, main physical and chemical indicators of the suitable soils for growing potatoes, field rating values.

Municipality	Land	Soil (WRB, 2014)	Physical clay arable soil, %	Physical clay under arable soil, %	Thickness humus horizon, cm	Thickness soil profile, cm	Texture coefficient	pH / H ₂ O	Humus, %	Groundwater level, cm	Field rating for potatoes
Panagyurishte	Panagyurishte, Poibrene, Oborishte, Banya, Bata, Popitsa, Elshitsa, Dolno Levski	Umbrisols, no erosion - low erosion	16	14	40	80	1.1	5.0	7.5	deep	76
Panagyurishte	Panagyurishte, Poibrene, Oborishte, Banya, Bata, Popitsa, Elshitsa, Dolno Levski	Cambisols, (Chromic - Calcaric)	50	62	45	110	1.5	6.1	3.7	deep	69
Panagyurishte	Panagyurishte, Poibrene, Oborishte, Banya, Bata, Popitsa, Elshitsa, Dolno Levski	Fluvisols - Deluvial	22	27	110	160	0.9	5.3	2.1	deep	78
Panagyurishte	Panagyurishte, Poibrene, Oborishte, Banya, Bata, Popitsa, Elshitsa, Dolno Levski	Fluvisols - Deluvial	45	54	110	160	1.5	5.6	1.6	deep	67
Rakitovo	Rakitovo, Kostandovo, Dorkovo	Cambisol, no erosion	23	31	25	70	1.7	5.3	2.4	deep	75

Table 3, part 4. Settlements, main physical and chemical indicators of the suitable soils for growing potatoes, field rating values

Municipality	Land	Soil (WRB, 2014)	Physical clay arable soil, %	Physical clay under arable soil, %	Thickness humus horizon, cm	Thickness soil profile, cm	Texture coefficient	pH / H ₂ O	Humus, %	Groundwater level, cm	Field rating for potatoes
Rakitovo	Rakitovo, Kostandovo, Dorkovo	Fluvisols-Deluvial	26	23	60	100	1.0	5.4	6.3	100	68
Velingrad	Velingrad (Chepino, Kamenitsa, Lazhene), Dolene, Korovo, Grashevo, Vraninitsi, Dabeva mahala, Draginovo	Fluvisols-Deluvial	24	34	40	70	1.4	5.7	2.8	deep	76
Velingrad	Velingrad (Chepino, Kamenitsa, Lazhene), Dolene, Korovo, Grashevo, Vraninitsi, Dabeva mahala, Draginovo	Fluvisols-Aluvial	17	3	30	60	0.9	4.6	4.8	deep	65
Velingrad	Sarnitsa, Orlino, Barduche, Krushata, Pepeltsi, Medeni Polyani, Pobit Kamak	Cambisols	22	17	30	60	0.9	4.6	5.5	deep	96
Velingrad	Sarnitsa, Orlino, Barduche, Krushata, Pepeltsi, Medeni Polyani, Pobit Kamak	Cambisols, low erosion	27	20	20	50	0.9	4.6	5.0	deep	75

Table 3. Part 5. Settlements, main physical and chemical indicators of the suitable soils for growing potatoes, field rating values

Municipality	Land	Soil (WRB, 2014)	Physical clay arable soil, %	Physical clay under arable soil, %	Thickness humus horizon, cm	Thickness soil profile, cm	Texture coefficient	pH/H ₂ O	Humus, %	Groundwater level, cm	Field rating for potatoes
Velingrad	Sarnitsa, Orlino, Barduche, Krushata, Pepeltsi, Medeni Polyani, Pobit Kamak	Fluvisols - Auluvial	7	22	30	100	1.0	5.8	2.1	deep	68
Velingrad	Sarnitsa, Orlino, Barduche, Krushata, Pepeltsi, Medeni Polyani, Pobit Kamak	Fluvisols - Auluvial, Fluvisols - Deluvial	13	11	30	100	0.9	5.0	2.9	deep	73
Velingrad	Yundola, Sveta Petka, Tsvetino Station, Pashovi Kolibi, Batova, Ablanitsa, Bozovo, Draginovo	Cambisols	20	19	25	60	1.0	5.8	3.2	deep	76
Velingrad	Yundola, Sveta Petka, Tsvetino Station, Pashovi Kolibi, Batova, Ablanitsa, Bozovo, Draginovo	Cambisols	29	20	25	60	0.9	4.6	4.6	deep	86

The field ratings are calculated using the presented equation (Georgiev, 2006), and the estimates of individual indicators are entered according to the methodology specified in Tables 1 and 2. The assessment of climate conditions for the presented sites is in the range of 0.8-1.0. This are the optimal climate conditions for the crop.

Table 3 shows that the soils that have optimal conditions for cultivation of crops. In terms of mechanical composition (content of physical clay in the surface horizon %) the soils are light - clayey sandy to slightly sandy-loam (20-30% physical clay). The sub-horizon is also slightly sandy-clayey, in some soils to medium sandy-clayey (30-45% physical clay).

The thickness of the humus horizon is in range of 20-50 cm; profile depth ranges from 50 to 100 cm. The soil reaction (pH in H₂O) is medium to slightly acidic and has values of 4.5-6.1. The humus content is from 1.1 % to 5.5 % (weak to medium humus), and in some places in the Mountain meadow soils (*Umbrisols*), it has higher values of 7.5 % - 13 % (rich humus soils).

The soil differences with highest assessment of soil and climate conditions are Deluvial-meadow soils (*Fluvisols - Aluvial*, *Fluvisols - Deluvial*) in the land of the town of Sofia, which receive 100 field rating. Batak and the village of Nova Mahala; with a maximum score (100 evaluation rating) Mountain-meadow soils (*Umbrisols*) distributed in some lands of the municipality of Panagyurishte - the villages: Poibrene, Oborishte, Banya, Bata, Popina, Elshitsa, Dolno Levski. Soils with such indicators can be taken as criterion for growing potatoes. In the same municipality, with very good indicators for the culture, are Leached cinnamon forest (*Haplic Cambisols*) and Deluvial-meadow soils (*Fluvisols - Deluvial*), which have field rating in the range of 69-96 (Soil characteristics of the lands in the area - Panagyurishte, Pazardzhik District, 1976).

In the village of Fotinovo (Batak municipality) there are Mountain-meadow soils (*Umbrisols*), which are also very good lands for growing potatoes. In the area around the town of Batak and the village of Nova Mahala, there are very suitable conditions for the crop on Brown forest soils (*Cambisols*), Alluvial-deluvial meadow soils (*Fluvisols - Aluvial* (*Skeletal*)) and Deluvial-meadow soils (*Fluvisols - Deluvial*) with 75-100 field rating (Soil characteristics of the lands of the State Agricultural Farm - Fotinovo village, Pazardzhik district, 1977).

Brown forest soils (*Cambisols*) in the villages of Malko Belovo, Golyamo Belovo, Menenkyovo, Dabravite, Momina Klisura, Gabrovnitsa and Sestrimo (Belovo municipality) - have very good conditions for growing the crop (65-81 field rating) (Soil characteristics of the lands of the Agro-Industrial Complex - town of Belovo, Pazardzhik district, 1986).

The relative assessment of land in the village of Rozovo (Bratsigovo municipality) - with Cinnamon forest soils (*Cambisols - Rhodic*) and Brown forest soils (*Cambisols - Eutric*) shows that the field rating for potatoes is in the range of 66-84 (Soil characteristics of the lands of the town of Bratsigovo, Pazardzhik district, 1989).

In the lands of the town of Rakitovo (Rakitovo municipality) - and the villages of Dorkovo and Kostandevovo, the evaluation rating for potatoes is the highest for the areas occupied by Brown forest soils (*Cambisols - Eutric*) and Deluvial - Meadow soils (*Fluvisols*) with 68-75 field rating (Soil characteristics of the lands of the State Forestry Service-town of Rakitovo, Pazardzhik district, 1977).

In Velingrad municipality, on certain soils, there are very suitable conditions for growing potatoes. In the land of the town of Velingrad and the villages of Dolene, Korovo, Grashevo, Vranintsi, Dabeva Mahala and Draginovo, the distributed Deluvial-meadow soils (*Fluvisol - Deluvial*), Alluvial-deluvial soil (*Fluvisols - Aluvial*) and Brown forest soils (*Cambisols - Skeletic*) have high evaluation rates for the crop - (68-96 field rating) (Soil characteristics of the lands of the Cooperative Agricultural Farm - Velingrad, Pazardzhik District, 1977).

Conclusions

The lands of settlements in Pazardzhik region with good and very good conditions for growing potatoes under non-irrigated conditions are presented, using the values of the field ratings. The names and physico-chemical parameters of soils, which are connected with the relative assessment, are indicated. Soil differences, with 100 evaluation rating for cultivation

of potatoes, can serve as a criterion for potato growers who want to be successful in this production. The report aims to point out that there are good conditions for growing potatoes in Bulgaria. This is just one small area where potatoes can be grown successfully, and this has happened in the past. Although we are members of the EU, we believe that our country should have independent production for some vital crops that feed the population.

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